Ground-Water Flow and Ground- and Surface-Water Interaction at McBaine Bottoms, Columbia, Missouri—2000–02

Water-Resources Investigations Report 03–4234

Prepared in cooperation with the
Missouri Department of Conservation and
City of Columbia

U.S. Department of the Interior
U.S. Geological Survey

Cover Photograph: Looking south across a wetland pool at the Eagle Bluffs Conservation Area, May 2002.

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VERTICAL DATUM

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). **Altitude**, as used in this report, refers to the distance above or below NGVD 29. NGVD 29 can be converted to the North American Vertical Datum of 1988 (NAVD 88) by using the National Geodetic Survey conversion utility available at URL **http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html.**

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Abstract

McBaine Bottoms southwest of Columbia, Missouri, is the site of 4,269 acres of the Eagle Bluffs Conservation Area operated by the Missouri Department of Conservation, about 130 acres of the city of Columbia wastewater-treatment wetlands, and the city of Columbia municipal-supply well field. The city of Columbia wastewater-treatment wetlands supply treated effluent to the Eagle Bluffs Conservation Area.

The presence of a sustained ground-water high underlying the Eagle Bluffs Conservation Area has indicated that ground-water flow is toward the municipal well field that supplies drinking water to the city of Columbia. The U.S. Geological Survey, in cooperation with the Missouri Department of Conservation and the city of Columbia, measured the ground-water levels in about 88 monitoring wells and the surface-water elevation at 4 sites monthly during a 27-month period to determine the ground-water flow and the ground- and surface-water interaction at McBaine Bottoms.

Lateral ground-water flow was dominated by the presence of a ground-water high that was beneath the Eagle Bluffs Conservation Area and the presence of a cone of depression in the northern part of the study area. The ground-water high was present during all months of the study. Ground-water flow was radially away from the apex of the ground-water high; west and south of the high, flow was toward the Missouri River, east of the high, flow was toward Perche Creek, and north of the high, flow was toward the north toward the city of Columbia well field. The cone of depression was centered around the city of Columbia well field. Another permanent feature on the water-level maps was a ground-water high beneath treatment wetland unit 1.

Although the ground-water high beneath the Eagle Bluffs Conservation Area was present throughout the study period, the configuration of the high changed depending on hydrologic conditions. Generally in the spring, the height of the ground-water high began to decrease and hydraulic gradients around the high became more shallow than in the winter months. In early summer, the high was the least pronounced. During mid-summer, the high became more pronounced, and it continued to become higher, increasing until it reached its maximum height in late fall or early winter. Fluctuations in the ground-water high were partially produced by the cycle of flooding of the Eagle Bluffs Conservation Area wetland pools in the fall and subsequent drainage so crops could be planted in many of the wetland pools.

The cone of depression in the northern part of the study area generally extended from the base of the ground-water high in the northern part of the Eagle Bluffs Conservation Area throughout the rest of the study area. The depth of the cone primarily was affected by the altitude of the Missouri River and the quantity of water being pumped from the alluvial aquifer by the city of Columbia well field.

Ground-water flow in the alluvial aquifer in McBaine Bottoms in the late 1960's before the development of the city of Columbia well field and the Eagle Bluffs Conservation Area was from northwest to southeast approximately parallel to the Missouri River. The ground-water high beneath the Eagle Bluffs Conservation Area and the cone of depression around the city of Columbia well field were not present in water-level maps for 1968 and 1978.

The Missouri River can be a source of recharge to the alluvial aquifer. Generally the altitude of the river in the northern part of the study area was higher than the water table in the aquifer. Ground-water flow in this area was from the river into the alluvial aquifer. In the southern part of the study area adjacent to the Eagle Bluffs Conservation Area, the Missouri River was lower than the water table in the alluvial aquifer, indicating that the river was receiving water from the alluvial aquifer beneath the Eagle Bluffs Conservation Area.

INTRODUCTION

McBaine Bottoms, part of the Missouri River alluvial valley near McBaine (fig. 1), 7 miles southwest of Columbia, Missouri, is an 8.7-square-mile area bounded to the south and west by the Missouri River and to the north and east by Missouri River bluffs. In the McBaine Bottoms is the municipal-supply well field for the city of Columbia (hereinafter referred to as the city of Columbia well field), the city of Columbia wastewater-treatment wetlands (hereinafter referred to as treatment wetlands), and the Missouri Department of Conservation Eagle Bluffs Conservation Area. The city of Columbia treatment wetlands consist of four units with a total surface area of about 130 acres; the units were designed to treat an average flow of about 20 million gallons per day and peak flows of as much as 60 million gallons per day (Richards, 1999). Wastewater entering the treatment wetlands consists of blended primary and secondary treated effluent from the city wastewater-treatment facility. The Missouri Department of Conservation agreed to accept the treated effluent from the treatment wetlands as the primary water source for a 1,300-acre managed wetland on the 4,269-acre Eagle Bluffs Conservation Area.

As of 2000, the population of the city of Columbia was 84,531 (U.S. Census Bureau, 2000). The city uses the alluvial aquifer in McBaine Bottoms for its municipal water supply and currently (2003) pumps water from seven well sites. The well sites are north of the Eagle Bluffs Conservation Area and between the treatment wetlands and the Missouri River. Each well site consists of two, 4-foot diameter wells with pumps rated at approximately 2,000 gallons per minute. Wells were drilled through the entire thickness of the alluvium and into the underlying bedrock to a depth of about 100 feet.

Operation of the treatment wetlands began in late 1994. The Eagle Bluffs Conservation Area began accepting treated effluent in 1994, but at that time flows generally were confined to a distribution canal that is immediately west of the gravel road shown on figure 1. Full wetland management at the Eagle Bluffs Conservation Area began in late 1995. After effluent discharge began in 1994, a shallow monitoring well about 30 feet deep near treatment wetland unit 1 (fig. 1) began showing gradual but marked concentration increases of various water-quality constituents. Soon after, several wells on the Eagle Bluffs Conservation Area began showing similar trends. The water-quality constituents showing the most substantial changes were sodium, potassium, calcium, sulfate, and chloride (Richards, 1999).

Discharge from the city of Columbia treatment wetlands averaged about 24 cubic feet per second in 1994 through 1998 (M.F. Knowlton and J.R. Jones, University of Missouri, Columbia, written commun., 1999). From September through December 1999, a total of about 5,300,000 cubic feet per day of discharge from the treatment wetlands and water from the Missouri River was pumped onto the Eagle Bluffs Conservation Area (M.F. Knowlton and J.R. Jones, written commun., 2001). This value is about 61 cubic feet per second each day and includes the approximate 24 cubic feet per second of discharge from the treatment wetlands.

The detection of increased concentration of several constituents indicated the possibility that contaminated ground water could migrate into the city of Columbia well field. However, the movement of ground water in the Eagle Bluffs Conservation Area and surrounding area was not completely understood. Because of uncertainties regarding the ground-water flow, a study was begun in McBaine Bottoms in July

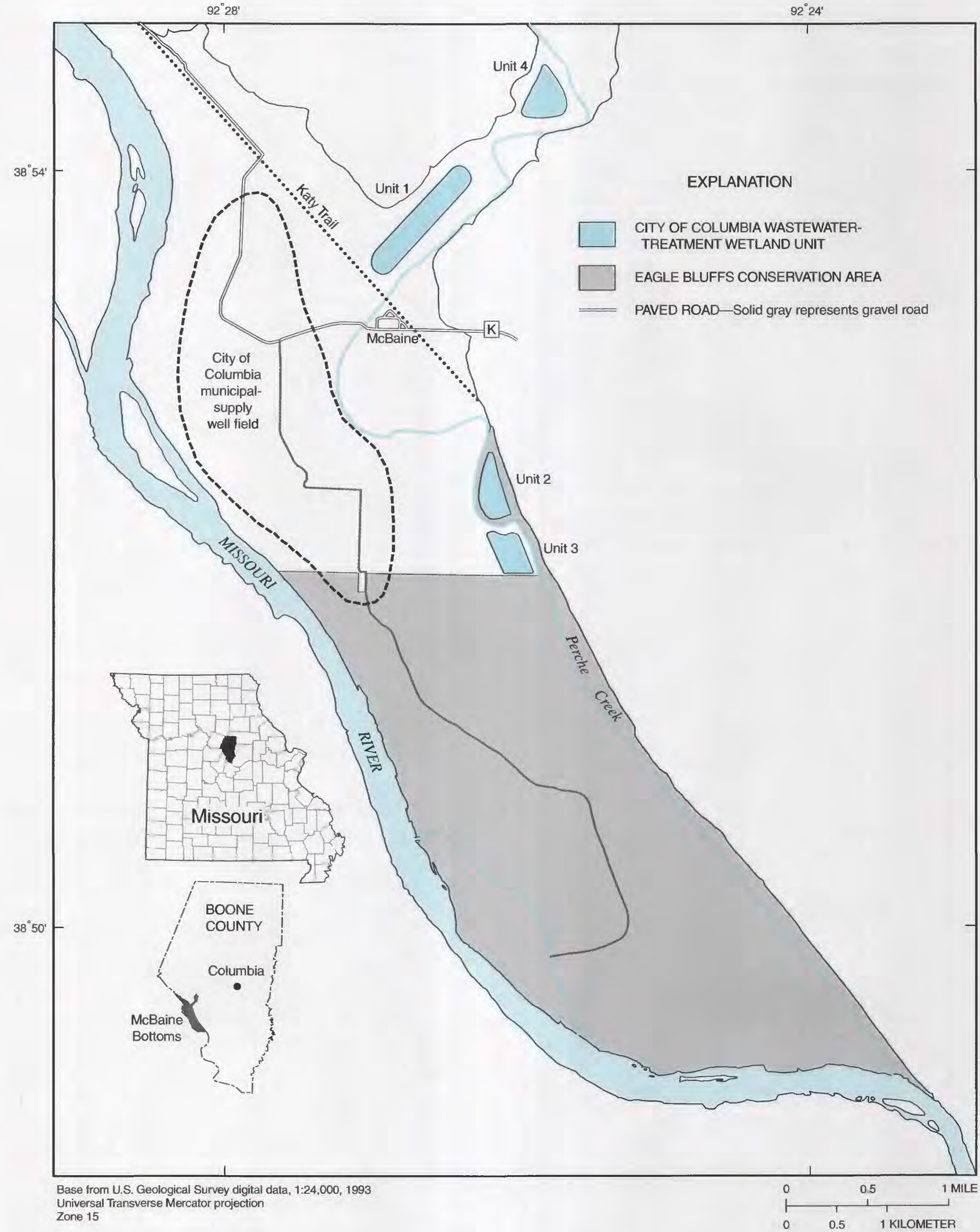

Figure 1. Location of McBaine Bottoms, Columbia, Missouri.

2000 by the U.S. Geological Survey, in cooperation with the Missouri Department of Conservation and the city of Columbia, to address these concerns.

Purpose and Scope

This report discusses vertical and lateral ground-water flow in McBaine Bottoms and assesses the ground- and surface-water interaction between McBaine Bottoms and the Missouri River and Perche Creek. Data were collected from October 2000 through December 2002.

This report provides data that can aid in the construction and calibration of a digital ground-water flow model to simulate ground-water flow in the area. The geohydrologic data were collected from a monitoring network consisting of monitoring wells and surface-water staff gages (fig. 2).

Study Area

Land-surface altitudes in the study area range from 580 feet above the National Geodetic Vertical Datum of 1929 (NGVD 29) in the northwestern part of the study area to 550 feet above NGVD 29 in the extreme southeastern part of McBaine Bottoms. A bluff west of McBaine Bottoms overlooks the Missouri River and the Missouri River alluvial plain. The altitude of the bluff is as much as 800 feet above the NGVD 29. A bluff also is present along the eastern edge of the study area overlooking Perche Creek. Numerous seeps have been observed along Perche Creek in the vicinity of the Eagle Bluffs Conservation Area (M.F. Knowlton, oral commun., 2002).

Unconsolidated sediment forming the Missouri River alluvium generally is composed of fine-grained silt and clay and coarse-grained sand. The maximum thickness of the alluvium is about 95 feet; the average saturated thickness is about 60 feet. Sand and gravel are present in the lower part of the alluvium (Emmett and Jeffery, 1969). During drilling of monitoring wells in the alluvial aquifer, a layer of blue-gray viscous clay was noted in several locations.

Previous Investigations

The city of Columbia drilled 24 observation wells in the area from the northern part of McBaine Bottoms south to the Missouri River. These wells, drilled during the summer of 1967, completely penetrated the alluvium and generally were about 100 feet deep.

In 1968, the Layne-Western Company, Inc. (Nuzman, 1969) used an electric analog model to analyze ground-water flow in the McBaine Bottoms. Wells drilled in 1967 were used in the simulation. From an aquifer test, the transmissivity was about 58,000 feet squared per day; the hydraulic conductivity was computed to be about 1,000 feet per day, with an average value of 700 feet per day based on normal saturated thickness. Ground-water flow generally was north to south within McBaine Bottoms and nearly parallel to the flow of the Missouri River.

Foreman and Sharp (1981) used river altitude and water-level data, aquifer test analyses, and three-dimensional simulations to investigate the hydrologic properties of the alluvial aquifer in McBaine Bottoms. Ground-water levels were primarily controlled by the altitude of the Missouri River and quantity of water pumped from the aquifer. Other factors affecting ground-water levels were recharge from precipitation, seepage into and out of streams, and recharge from the underlying bedrock. Average values of transmissivity were about 54,400 and 63,300 feet squared per day, and hydraulic conductivity values were 679 and 791 feet per day. Both were obtained from an aquifer test from a well and six piezometers that were completed in bedrock.

Metcalf & Eddy (1990) prepared a report on the hydrogeologic evaluation of future water supplies from the alluvium in McBaine Bottoms. In the report, city wells were recommended to be spaced 2,600 feet apart, and to be at least 1,600 feet from the Missouri River or the treatment wetlands to ensure no direct influence of surface water; travel times for treated effluent to reach simulated city wells (two scenarios—four well sets in the northern part of McBaine Bottoms and three well sets in the northern part of McBaine Bottoms and one set adjacent to the treatment wetlands) were estimated at 17.6 and 15.4 years. Infiltration rates based on soil types and borehole data were estimated for the wetlands; the rates ranged from 0.000833 to 0.00166 foot per day.

CH2M Hill (1996) evaluated future water-supply sources for the city of Columbia. Several alternative water-supply sources were discussed, including the expansion of the existing well field in McBaine Bot-

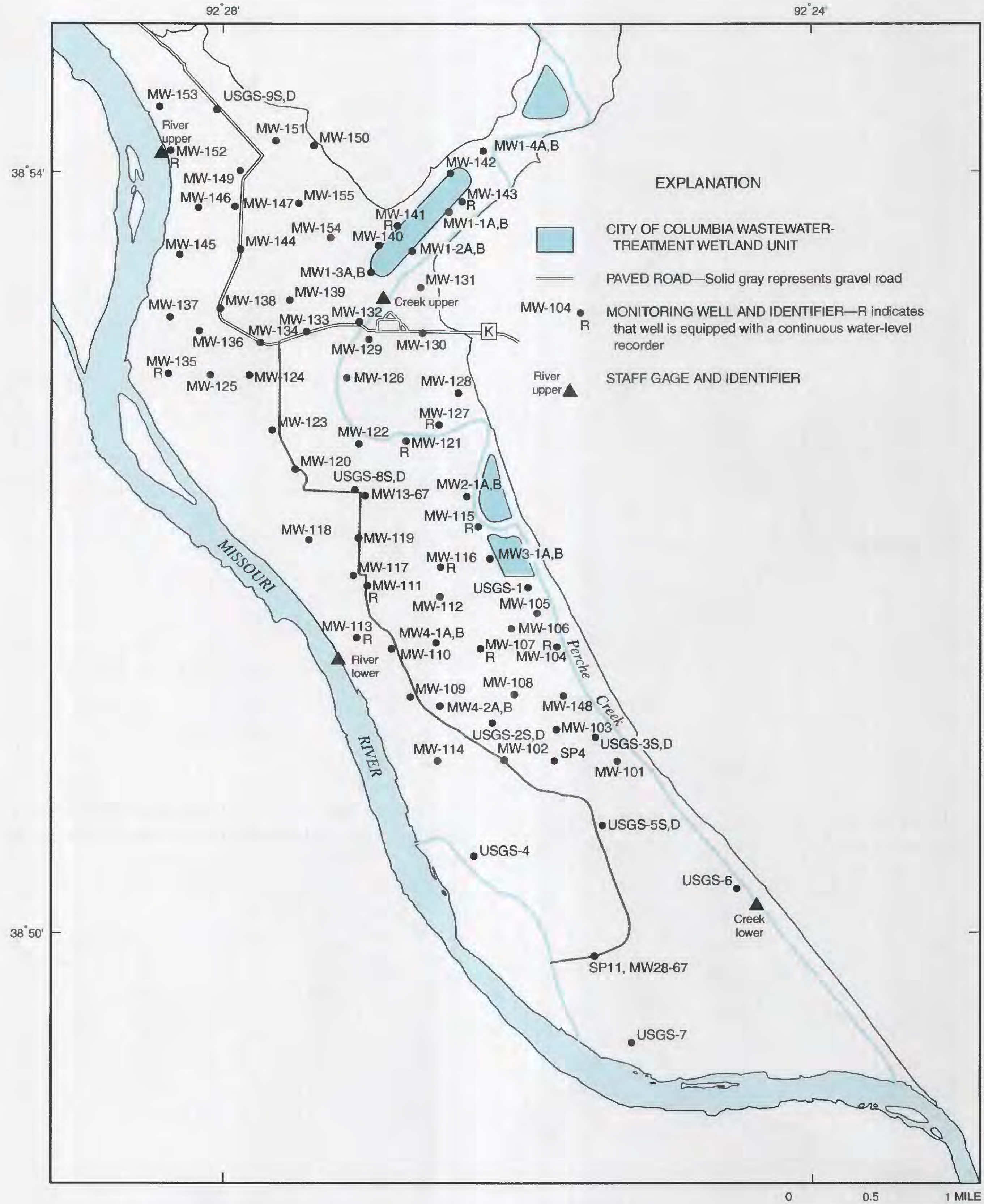

Figure 2. Location of monitoring wells and staff gages.

toms, obtaining water from the Eagle Bluffs Conservation Area, and using surface water from the Missouri River.

The U.S. Geological Survey has collected water-quality samples and measured the water level in monitoring wells in McBaine Bottoms since August 1992 (Richards, 1995, 1999, 2002). Samples were collected and measurements were made quarterly and semi-annually. Samples from wells were analyzed for physical properties, major ions, nutrients, and trace elements. Selected samples were analyzed for volatile organic compounds, semi-volatile organic compounds, organochlorine compounds, and pesticides.

The U.S. Geological Survey has operated continuous streamflow gaging stations to determine the stage of the Missouri River. Upstream from McBaine Bottoms, the gaging station at Boonville (station number 06909000), about 20 river miles upstream, has been collecting data since 1925, downstream at Jefferson City (stage only) since about 1940, and at Hermann (station number 06934500), about 80 river miles downstream, since 1897. From October 2000 through September 2001, the annual mean discharge at Boonville was 72,900 cubic feet per second and at Hermann was 85,200 cubic feet per second (Hauck and Nagel, 2002).

Acknowledgments

The author acknowledges the cooperation of the Missouri Department of Conservation and the Missouri Department of Natural Resources for permission to install monitoring wells on public land. The author thanks John S. Williamson, Jr. for permission to install monitoring wells on private land. Without this cooperation, the data could not have been collected. The author also thanks numerous individuals who assisted in data collection efforts—personnel at the city of Columbia Water Treatment Plant including John E. Betz and Barry Kirchhoff; Joel Gambill and Craig J. Cuvellier of the Columbia Regional Wastewater Treatment Plant; the former Manager of Water Operations Donald R. Sisson; and James Loveless and Tim James, Missouri Department of Conservation.

GROUND-WATER FLOW

The distinct boundary between the bedrock at land surface and bluffs along the Missouri River adjacent to the Missouri River alluvial plain and the presence of the Missouri River, smaller tributary streams, the thick alluvial deposits, the Eagle Bluffs Conservation Area, the treatment wetlands, and the city of Columbia well field add to the complexity of ground-water flow in McBaine Bottoms. Because of the combined effects of these factors, the movement of ground water was not well understood. Therefore, a monitoring well and staff-gage network was designed to determine both the lateral and vertical ground-water flow directions for the area.

Methodology

The monitoring well and staff-gage network (fig. 2) was designed to monitor water levels at various depths (as deep as 60 feet) in the alluvial aquifer and in the underlying bedrock (about 100 feet deep) and in surface-water bodies. This section describes techniques and the rationale that were used to create the network and collect the data. The network was designed to be flexible and monitor ground- and surface-water levels throughout differing seasonal and hydrologic conditions.

Monitoring Well and Staff-Gage Network Design

Monitoring wells and staff gages were installed by U.S. Geological Survey personnel in 2000 for the study described in this report. Because monitoring wells already existed in parts of the study area, the monitoring network was designed to incorporate these existing wells. Construction data for monitoring wells that were installed by the U.S. Geological Survey for this study are summarized in table 1; construction data for existing monitoring wells that were incorporated into the network are included in Richards (1995).

Monitoring wells installed by U.S. Geological Survey personnel specifically for this study were drilled with hollow-stem augers and ranged from 22 to 40 feet deep. These depths were selected so that the bottom of the well screen would not extend more than about 5 feet below the lowest expected water level.

The well riser pipe and screen consisted of flush-wall, 2-inch nominal schedule 40 polyvinyl chloride pipe with O-rings inserted at each pipe joint. The slot size used for the screen was 0.010 inch. A natural filter pack was used around the well screen to a depth of about 5 feet above the screen. The filter pack was formed by allowing the alluvium around the auger flights to collapse around the screen as the augers were

Table 1. Site location and construction data for monitoring wells in the water-level monitoring network at McBaine Bottoms

[dddmmss, degrees, minutes, seconds; ft, feet; NGVD 29, National Geodetic Vertical Datum of 1929]

Site (fig. 2)	Latitude Longitude (ddmmss dddmmss)	Reference-point altitude (ft above NGVD 29)	Total depth (ft)	Depth to top of screen (ft)
MW-101	385054 0922519	572.63	30	20
MW-102	385055 0922605	573.53	30	20
MW-103	385105 0922544	572.33	30	20
MW-104	385131 0922544	572.05	35	25
MW-105	385141 0922552	569.97	30	20
MW-106	385136 0922603	571.09	30	20
MW-107	385130 0922615	574.38	30	20
MW-108	385116 0922601	574.23	30	20
MW-109	385115 0922644	573.27	30	20
MW-110	385130 0922651	576.57	30	20
MW-111	385150 0922701	576.81	30	20
MW-112	385146 0922632	572.05	30	20
MW-113	385133 0922706	576.54	35	25
MW-114	385055 0922633	574.51	30	20
MW-115	385208 0922616	570.94	35	25
MW-116	385156 0922632	568.94	30	20
MW-117	385153 0922707	575.27	35	25
MW-118	385204 0922725	570.02	35	25
MW-119	385205 0922705	575.68	35	25
MW-120	385226 0922731	573.83	35	25
MW-121	385235 0922646	576.08	35	25
MW-122	385235 0922705	578.42	30	20
MW-123	385239 0922740	576.24	35	25
MW-124	385256 0922749	581.14	35	25
MW-125	385256 0922805	579.12	35	25
MW-126	385255 0922710	575.31	35	25
MW-127	385240 0922632	574.21	35	25
MW-128	385251 0922624	570.70	35	25
MW-129	385307 0922701	575.21	35	25
MW-130	385309 0922639	570.44	35	25
MW-131	385324 0922640	576.37	35	25
MW-132	385313 0922705	574.10	30	20
MW-133	385310 0922726	582.47	40	30
MW-134	385306 0922745	580.01	35	25
MW-135	385257 0922822	575.82	30	20
MW-136	385310 0922810	574.73	35	25

Table 1. Site location and construction data for monitoring wells in the water-level monitoring network at McBaine Bottoms—Continued

Site (fig. 2)	Latitude Longitude (ddmmss dddmmss)	Reference-point altitude (ft above NGVD 29)	Total depth (ft)	Depth to top of screen (ft)
MW-137	385314 0922822	577.65	35	25
MW-138	385317 0922801	581.44	35	25
MW-139	385320 0922733	581.58	35	25
MW-140	385337 0922657	576.58	30	20
MW-141	385343 0922649	577.27	30	20
MW-142	385400 0922628	580.62	30	20
MW-143	385351 0922623	574.74	30	20
MW-144	385336 0922753	578.77	35	25
MW-145	385334 0922818	578.16	35	25
MW-146	385349 0922810	577.56	35	25
MW-147	385349 0922755	579.58	35	25
MW-148	385115 0922542	572.05	35	25
MW-149	385358 0922752	579.12	35	25
MW-150	385408 0922723	582.45	22	12
MW-151	385410 0922739	587.05	35	25
MW-152	385407 0922822	574.26	35	25
MW-153	385421 0922826	578.36	35	25
MW-154	385339 0922716	578.66	30	20
MW-155	385350 0922729	578.86	35	25

slowly removed from the hole. The bentonite seal and annular seal were installed by placing bentonite chips above the filter pack and hydrating the bentonite in place to the base of the protective casing. Each well was secured with a metal protective casing that extended about 3 feet above land surface.

Because small hydraulic-head differences in monitoring wells and a shallow water-table gradient were expected in the alluvial aquifer, all wells in the network were surveyed using global positioning system (GPS) to determine a reference-point altitude and location (table 1). The altitude of the reference point was determined to be accurate within 0.10 foot. The reference point was marked on the top of the casing at each well, and all subsequent water-level measurements were made from the indicated point.

Thirty-four existing monitoring wells were used to measure the water-table altitude near wetland treatment units 1, 2, and 3 (fig. 1) and in the southern part of the Eagle Bluffs Conservation Area. Twenty-six of these wells were in well pairs; the well pairs are identified with the suffix A, B, S, or D. For each well pair, the shallow well (identified by A or S) was about 30 feet deep and the deep well (identified by B or D) was about 60 feet deep. The rest of these wells were single monitoring wells; USGS-1 and USGS-6 were about 30 feet deep, SP11 was 35 feet deep, USGS-4 and USGS-7 were about 60 feet deep, and wells MW13-67, MW28-67, and SP4 were drilled to bedrock at a depth of about 100 feet. Wells around treatment wetland units 1, 2, and 3 and wells MW4-1A and 1B, MW4-2A and 2B, MW13-67, SP4, SP11, and MW28-67 were drilled by the city of Columbia, whereas all other wells were drilled by the U.S. Geological Survey.

Staff gages were installed on surface-water bodies to monitor stage (the height of the water surface of the stream above NGVD 29) and provide data for comparison with ground-water levels in the alluvial aquifer. Staff gages along the Missouri River and Perche Creek were installed to help assess the potential for movement between ground water and surface water in the alluvial aquifer in the study area. A gage was installed along the Missouri River in the northern part of the study area (fig. 2, river upper) along a bank adjacent to the river by installing 0.5-inch steel bars at intervals in the bank and surveying the altitude of the points. In the southern part of the study area, a staff gage was incorporated using sheet pilings that had been placed on the bank of the river in conjunction with riprap (fig. 2, river lower). This gage is adjacent to the site of a pump station along the river. The altitude of Perche Creek was measured using a steel tape from a bridge over the creek on the Katy Trail at McBaine (fig. 2, creek upper). The Missouri Department of Conservation boat ramp was used to determine the altitude of Perche Creek (fig. 2, creek lower) in the southern part of the study area. The boat ramp was calibrated by surveying the altitude of expansion joints in the concrete ramp and constructing a table for interpolation of stage based on the water-surface distance from a specific expansion joint.

Ground- and Surface-Water Level Measurements

Monthly water-level measurements were made in monitoring wells and at staff gages in the study area from October 2000 through December 2002 (tables 2-28, at the back of this report). This period included conditions of low and high Missouri River stage, flooding and draining of pools at the Eagle Bluffs Conservation Area, and varying quantities of local precipitation. The water-level measurements were made from the reference point using an electric tape that was read to the nearest 0.01 foot. Water-level measurements generally were made on 2 consecutive days, except in December 2000 (10 days during which the reference-point altitude of the wells was surveyed), February and July 2001 (4 days), August 2001 (3 days), and November and December 2002 (1 day). Water-table maps (figs. 3-29, at the back of this report) were constructed for each set of water-level measurements.

Water-level measurements used for the water-table maps did not include water levels from the wells completed in bedrock (SP4, MW13-67, and MW28-67). For well pairs, the water level for the shallow well (depth of about 30 feet) was used in the construction of the water-table maps. The depth of the shallow wells was similar to the depth of the 55 wells installed throughout the study area by the U.S. Geological Survey in 2000. A few exceptions included the use of the water level in the deep well USGS-9D for March through June 2001 and October 2001 when shallow well USGS-9S could not be measured; deep well MW1-3B in December 2001; deep well MW4-1B in June 2002; and deep well USGS-5D in July 2002. During the study period, the water levels in deep wells generally were within 0.25 foot of the water levels in the adjacent shallow wells.

Twelve monitoring wells were instrumented with continuous recorders to monitor daily water-table fluctuations. The recorders were installed in the fall of 2001 and were used until the end of the study in December 2002. The recorder within each well was a vented pressure transducer with an accuracy of 0.01 foot. Time and water levels were recorded every 4 hours by a data logger. Water-level recordings were checked with monthly manual measurements made using an electric water-level measuring tape divided into increments of 0.01 foot.

Lateral Flow Interpreted from Water-Table Maps

The water-level measurements were collected during 27 months from October 2000 through December 2002. Observing the resulting water-table maps in chronological order provides insight about the response of water levels in the alluvial aquifer to changing hydrologic conditions.

All of the water-table maps display certain similarities. Generally, recharge to the aquifer was from precipitation that infiltrated through the root zone and percolated to the water table. Induced recharge from the Missouri River caused by pumpage from the city of Columbia well field occurred along much of the northern one-half of the study area. In the southern part of the study area, recharge occurred from infiltration of water through the bottom of the Eagle Bluffs Conservation Area wetland pools.

A ground-water high was apparent in the southern one-half of the study area beneath the Eagle Bluffs Conservation Area throughout the entire study period. Flow was radially away from the center of the high. Northerly flow was toward the city of Columbia well field, the westerly, southerly, and southeasterly flow was toward the Missouri River, and easterly flow was toward Perche Creek. This ground-water high was noted in 1992 before the wastewater effluent from the treatment wetlands was used on the Eagle Bluffs Conservation Area and has been a persistent feature since the wastewater effluent has been used (Richards, 2002).

Ground-water flow in the extreme northeastern part of the study area was to the southwest away from the city of Columbia treatment wetland unit 1. The water surface was higher beneath the treatment wetland than beneath other parts of the study area, possibly caused by infiltration of surface water from the wetland unit into the underlying ground-water system.

Lateral ground-water flow was dominated by the presence of a ground-water high beneath the Eagle Bluffs Conservation Area and the presence of a cone of depression in the northern part of the study area. The ground-water high was present during all months of the study. Ground-water flow was radially away from the apex of the ground-water high; west and south of the ground-water high, flow was toward the Missouri River, east of the ground-water high, flow was toward Perche Creek, and north of the ground-water high, flow was to the north toward the city of Columbia well field. The cone of depression was centered around the city of Columbia well field. Flow toward the well field was from the south in the vicinity of the Eagle Bluffs Conservation Area, from the west from the Missouri River, flow from the north downgradient through the alluvial aquifer, from the northeast beneath treatment wetland unit 1, and from the east through the alluvial aquifer in the vicinity of Perche Creek.

In October 2000, water levels were measured in 53 wells, in November 2000, 71 wells, in December 2000, 82 wells, and in January 2001, 77 wells. Water levels in December 2000 were measured during the 10 days when the reference point for each well was being surveyed. This is a considerable time in an alluvial environment where water-level fluctuations generally are rapid, and the time frame is a consideration for interpreting the water levels. During that time, the altitude of the Missouri River was fairly constant (fig. 30), and precipitation at the Columbia Regional Airport was about 0.45 inch (0.34 inch was recorded on December 13; National Oceanic and Atmospheric Administration, 2000b). The airport is about 10 miles east of the study area. All precipitation values in this report are from this station. Pumpage from the city of Columbia well field was constant and the same wells were pumped.

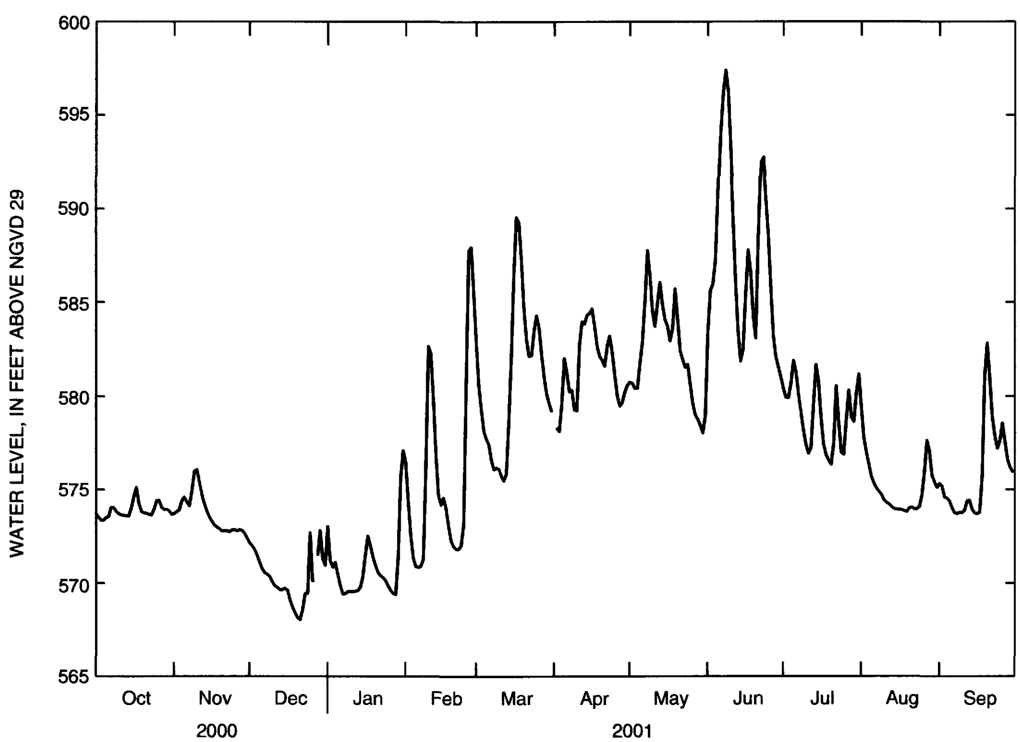

Figure 30. Altitude of the Missouri River at the U.S. Geological Survey gaging station at Boonville, October 2000 through September 2001.

Water-level altitudes during these 4 months (tables 2-5, figs. 3-6) showed that lateral ground-water flow in the Eagle Bluffs Conservation Area was north and northwest from an area of highest measured altitude, which was about 565 to 567 feet from October through December and about 558 feet in January. Water-table contours indicated that the hydraulic gradient from the area of highest measured altitude in the Eagle Bluffs Conservation Area increased from October to December, but decreased in January. The increased hydraulic gradient can be attributed to the flooding of the wetland pools in the fall to support the annual migratory bird population. Measured water levels decreased in January throughout the northern part of the Eagle Bluffs Conservation Area by as much as 9 feet. The decrease in water levels probably reflected the drainage of the wetland pools.

North of the Eagle Bluffs Conservation Area, ground-water flow was radially toward the northern one-half of McBaine Bottoms. Near Perche Creek in the northeast part of the study area, the ground-water flow direction as interpreted from water-table contours was to the southwest in the vicinity of treatment wetland unit 1, where a ground-water high existed (Richards, 2002). Water from this area flowed from a water-level altitude of about 575 feet in October and November and about 570 feet in December and January. The water-table altitude in monitoring well MW-140 (fig. 2) was about 3 feet higher than that in monitoring well MW-141, which is immediately to the northeast of monitoring well MW-140. The high water-level altitude in monitoring well MW-140 probably reflected perched water that was trapped by lenses of sticky, blue-gray clay encountered in the borehole during drilling. The low permeability clay impedes the downward movement of infiltrated precipitation that recharges the alluvial aquifer, causing a small mound of ground water to form. The relation of water levels in these two wells remained constant throughout this study.

Along the northern extent of the Missouri River in the study area, ground-water flow was to the southeast. Ground-water flow along the Missouri River in the center of the study area was to the east and northeast. The hydraulic gradient in the vicinity of the city of Columbia well field in October and November was similar and decreased in December and January. Localized depressions in the water-table surface were present in the cone of depression beneath the city of Columbia well field. The small depressions occurred because large quantities of ground water were pumped from the alluvial aquifer by high-capacity wells in the city of Columbia well field. The location of the ground-water depressions generally coincided with the centroid of wells that were being pumped. Precipitation in September, November, and December was more than 1 inch less than normal (fig. 31) and in October was slightly greater than normal. In January, water levels were measured before most of the precipitation of the month occurred (National Oceanic and Atmospheric Administration, 2000a, 2000b) at the climatological station at the Columbia Regional Airport.

In February 2001, additional water levels were measured in the southern one-half of the Eagle Bluffs Conservation Area. Water levels indicated that the ground-water high extended beneath most of the Eagle Bluffs Conservation Area (table 6, fig. 7). The apex of the mound was in the central part of the Eagle Bluffs Conservation Area adjacent to Perche Creek. The high was asymmetrical and truncated along the bluffs that form the eastern edge of the floodplain along Perche Creek. To the west and south of the apex, the ground-water high sloped steeply, especially to the west toward the Missouri River. The hydraulic gradient in the northern part of the Eagle Bluffs Conservation Area slightly increased from January to February, and the measured water levels increased about 7 feet in the vicinity of monitoring well MW-101 (fig. 2). Localized depressions observed around city wells in January were not evident. Instead, a broad depression (enclosed by the 552-foot contour) was mapped in the city of Columbia well field. Precipitation in February was more than 2 inches greater than normal (National Oceanic and Atmospheric Administration, 2001). The altitude of the Missouri River increased about 11 feet immediately before water levels were measured in February.

The ground-water high beneath the Eagle Bluffs Conservation Area was similar for March, April, May, and June 2001 (tables 7-10, figs. 8-11). This period corresponded to the time when the quantity of water in the Eagle Bluffs Conservation Area is decreased because the seasonal migration of waterfowl is over, preparations have been made for spring planting, and crops were growing in some of the wetland pools. The relief of the ground-water high was small during these months as was the gradient. In June the ground-water high beneath the Eagle Bluffs Conservation Area was poorly defined in the northern part of the Eagle Bluffs Conservation Area. Water-table contours indicated that the Missouri River was supplying water to the alluvial aquifer in the northern one-half of the Eagle Bluffs

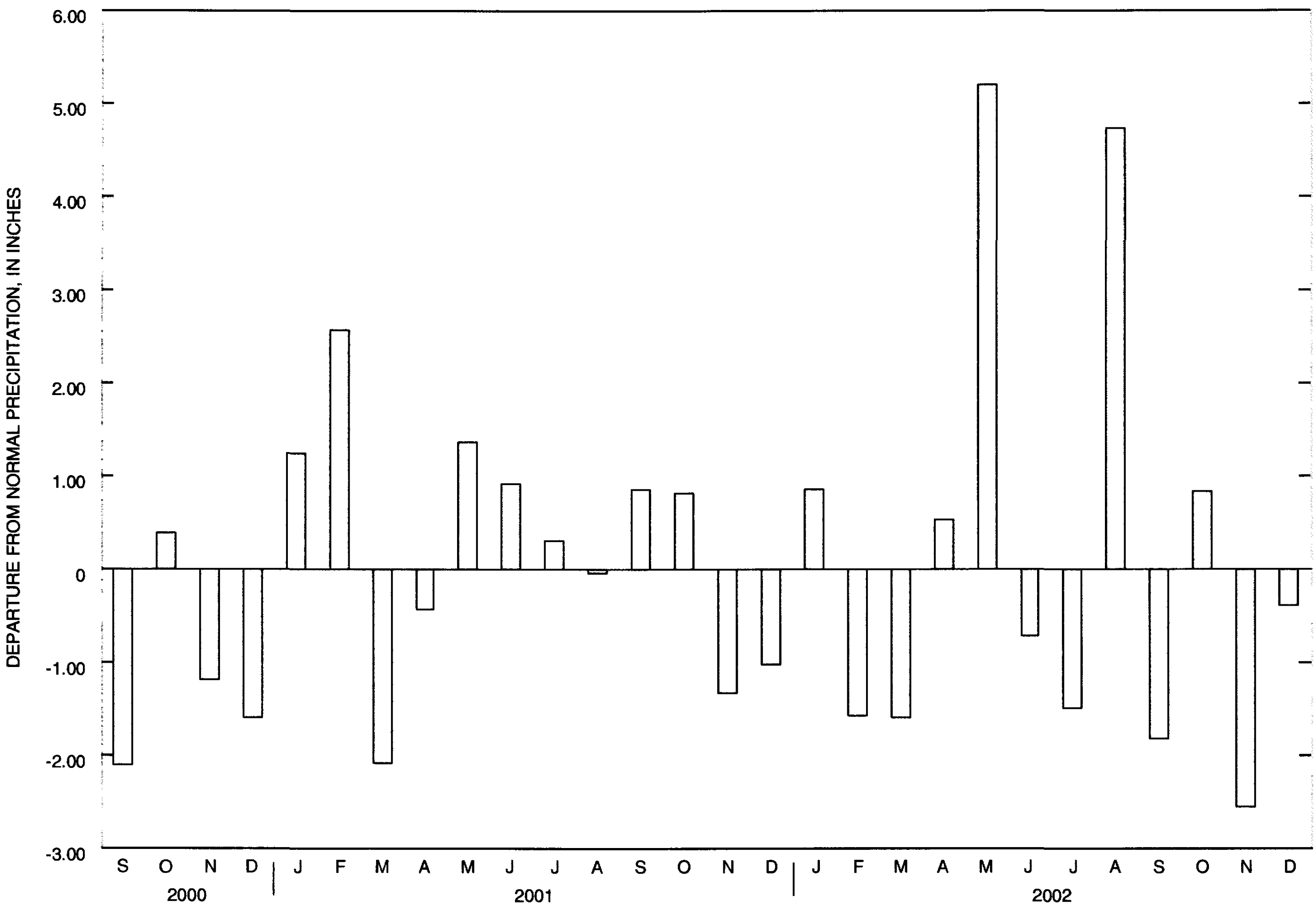

Figure 31. Departure from normal precipitation at the Columbia Regional Airport, 2000–02 (data from the National Oceanic and Atmospheric Administration, 2000–02).

Conservation Area. At the time water-level measurements were made, the Missouri River was receding from its highest water level during the entire month (fig. 30). Measured water levels in March in the Eagle Bluffs Conservation Area generally had increased from those measured in February. In April and May, measured water levels generally were comparable to those measured in March, but in June they tended to increase slightly.

Beginning in March 2001, the hydraulic gradient associated with the cone of depression around the city of Columbia well field increased and was similar in April, May, and June. Measured water levels in wells adjacent to the Missouri River increased as much as 10 feet in March from those measured in February; the water level in wells adjacent to the Missouri River west of the well field were more than 10 feet higher than those in wells in the center of the study area west of McBaine (fig. 1). Water levels were measured during the falling limb of the hydrograph of the Missouri River; however, the altitude of the water in the river had increased from that of the previous months (fig. 30). The altitude of the Missouri River in June 2001 was reflected in water levels that were the highest measured to date in wells along the river and in the northern one-half of the study area. The ground-water high beneath treatment wetland unit 1 was especially pronounced because of the high water levels.

The ground-water high beneath the Eagle Bluffs Conservation Area appeared to be in transition in July, August, and September 2001 (tables 11-13, figs. 12-14). This period corresponded to the time between the draining of the wetland pools in the spring and the subsequent re-flooding of the pools in the fall. Measured water levels decreased in wells in the Eagle Bluffs Conservation Area from about 3 to 5 feet from June to July. Measured water levels decreased slightly from July to August and generally were similar in August and September. The relief of the ground-water high was moderate—less than in the fall of 2000 and early winter of

2001, but more than in the preceding summer months. In July, the hydraulic gradient of the ground-water high was steep to the southwest toward the Missouri River and flattened toward the north; however, in August and September, the hydraulic gradient became uniform from the ground-water high toward the Missouri River on the south and southwest.

Around the city of Columbia well field, the cone of depression in July 2001 became separated into two areas—in the northwestern part of the study area around two of the city of Columbia public-supply wells and in the east-central part of the study area around Perche Creek where water levels in both areas were less than 560 feet. In August 2001, the cone of depression in the vicinity of the city of Columbia well field had shifted to the southwest from that of the preceding month and was centered south of Perche Creek. A localized area of drawdown was centered around a public-supply well in the northern part of the study area adjacent to the paved road. Localized changes were noted around the cone of depression in September in the vicinity of some of the public-supply wells. The changes in the cone of depression likely reflect changes in pumpage at individual public-supply wells.

In October, November, and December 2001 (tables 14-16, figs. 15-17), the relief of the ground-water high beneath the Eagle Bluffs Conservation Area increased from that of the previous months. An increase of about 9 feet from previous months was measured from the highest water level near the apex of the ground-water high to the water level in the extreme southern part for these months. The hydraulic gradient from the ground-water high increased toward the Missouri River to the south and the southwest. The change in the appearance of the ground-water high reflected the flooding of the wetland pools on the Eagle Bluffs Conservation Area.

The cone of depression around the city of Columbia well field and the measured water levels in wells did not change substantially during October, November, and December and were not substantially different from those in September. Localized changes were noted around some of the public-supply wells.

In January, February, and March 2002 (tables 17-19, figs. 18-20), the subsurface expression of the ground-water high beneath the Eagle Bluffs Conservation Area changed from that of the previous months. The relief of the ground-water high generally decreased slightly, and the apex of the ground-water high had shifted to the south. The ground-water high had a gradual hydraulic gradient to the north and became extremely steep in the southern part of the Eagle Bluffs Conservation Area between wells SP11 and USGS-7 (fig. 2). Measured water levels in January decreased in the Eagle Bluffs Conservation Area as much as 8 feet from those measured in December. Measured water levels in February and March were similar to those measured in January.

In February 2002 measured water levels beneath the southern one-half of the Eagle Bluffs Conservation Area generally were about 4 feet less than those measured in February 2001. Water levels in the rest of the area were similar. This decrease in water levels produced a ground-water high that had a steeper gradient toward the south than the one in February 2001. Water levels in the northern part of the study area generally were about 2 feet lower in February 2002 than in February 2001. Small localized cones of depression were noted in February 2002 instead of the large, generalized area around several of the public-supply wells.

From March 2001 to March 2002, the measured water levels in the Eagle Bluffs Conservation Area decreased from about 2.5 to more than 10 feet. The hydraulic gradient in March 2002 was steeper to the south than that in March 2001. The cone of depression around the city of Columbia well field was more pronounced in March 2001 than it was in the following year. Water levels in the northern part of the study area along the Missouri River were as much as 11 feet lower in 2001 than they were in 2002. The altitude of the Missouri River was as much as 20 feet higher in 2002 than it was in 2001 (figs. 30, 32).

In the late spring and early summer months of April, May, and June 2002 (tables 20-22, figs. 21-23), the ground-water high beneath the Eagle Bluffs Conservation Area was characterized by low relief and a small ground-water gradient. In April, the highest ground-water level measured in a well in the Eagle Bluffs Conservation Area was about 562 feet, which was about 3 feet higher than the preceding month, and water levels at the northern edge of the area increased at least 2 feet. In May, water-table contours immediately north of the ground-water high indicated inflow to the alluvial aquifer from the Missouri River. During the time of water-level measurements in May, the altitude of the river was high (fig. 32), and monitoring well MW-118 (fig. 2) could not be accessed because water covered the well.

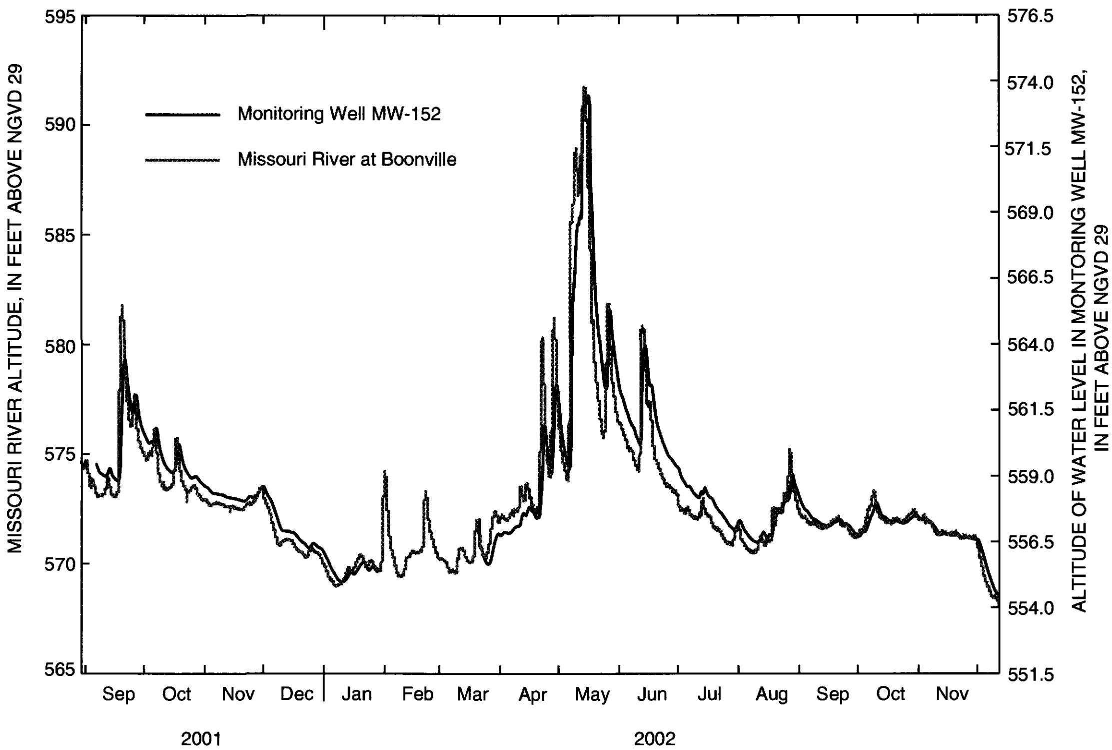

Figure 32. Altitude of the Missouri River at the U.S. Geological Survey gaging station at Boonville and water-level altitude in monitoring well MW-152, September 2001 through December 11, 2002.

The hydraulic gradient of the cone of depression around the city of Columbia well field increased in April 2002 compared to that of the previous months. The altitude of the water levels in wells adjacent to the Missouri River increased as much as 6 feet. Water levels in the northern part of the study area increased as much as 11 feet from April to May 2002. The gradient from the Missouri River toward the city of Columbia well field did not substantially change. However, the center of the cone of depression shifted in May to the north and the east from its location in April 2002.

The ground-water high beneath the Eagle Bluffs Conservation Area in July, August, and September 2002 (tables 23-25, figs. 24-26) was intermediate between the low relief measured after the wetlands pools were drained during the late spring and early summer and when the pools were filled in the fall. In July, measured water levels decreased as much as 3 feet in the Eagle Bluffs Conservation Area from those measured in June. Measured water levels generally decreased further in August, but generally increased slightly in September.

In July, August, and September 2002, the hydraulic gradient of the cone of depression around the city of Columbia well field was similar for the 3 months, but had decreased substantially from that in April, May, and June, when the altitude of the Missouri River generally was high.

The appearance of the ground-water high beneath the Eagle Bluffs Conservation Area in October, November, and December 2002 (tables 26-28, figs. 27-29) was consistent with that of the same months in the preceding year, when the ground-water high was at its maximum relief and the hydraulic gradient was steep. Measured water levels in wells in the Eagle Bluffs Conservation Area had increased in several wells from September to October. In November, measured water levels were about 2 to 6 feet higher in November than they were in October. In December, the highest measured water level in the ground-water high beneath the Eagle Bluffs Conservation Area was more than 566 feet. The lowest water level was about 553 feet in the extreme southern well. The difference in these water levels produced a ground-water high that had the steepest hydraulic gradient during the study period. Water levels in December on the periphery of the ground-water high generally decreased as much as 3 feet from water levels in November. In the northern part of the study area, water levels decreased less than 3 feet from those in November.

The hydraulic gradient of the generalized cone of depression associated with the city of Columbia well field increased from the Missouri River toward the well field from September to October 2002. The hydraulic gradient of the generalized cone of depression around the city of Columbia well field remained about the same in November as in October, but decreased in December 2002.

Vertical Ground-Water Flow

The fourteen well pairs included in the monitoring well network provided an opportunity to estimate vertical hydraulic-head differences in the alluvial aquifer. The wells in each well pair are within a few feet of one another and are completed in the alluvial aquifer, except for wells MW13-67 and MW28-67 that are completed in bedrock.

Four well pairs are around treatment wetland unit 1. These pairs are identified as MW1-1, MW1-2, MW1-3, and MW1-4. Available data indicated the vertical hydraulic gradients for three of the four well pairs to be downward toward the base of the alluvial aquifer; gradients in well pair MW1-2A and MW1-2B were both downward and upward during the study period. However, the differences between the measured water levels in the two wells were less than 0.03 foot. Differences in the measured water levels for the MW1-3 well pair ranged from 0.04 to 0.14 foot. Water levels in well MW1-1A (31 feet deep) ranged from 3.19 to 7.43 feet higher than the water levels in well MW1-1B (60 feet deep). Water levels in well MW1-4A (29.5 feet deep) ranged from about 1 to more than 11 feet higher than the water levels in well MW1-4B (60 feet deep). The large differences in the water levels for these two well pairs probably were because low-permeability clay at these locations impedes the downward movement of water.

The direction of the vertical hydraulic gradient could not be determined conclusively for the well pairs adjacent to treatment wetland units 2 and 3 and two well pairs in the northern part of the Eagle Bluffs Conservation Area (well pairs MW4-1 and MW4-2). Measured water levels in these well pairs generally varied by less than 0.20 foot. For well pairs MW2-1, MW3-1, and MW4-1, the vertical hydraulic gradients generally were downward for at least 20 of the 27 months when water levels were measured.

Three well pairs are located in the central part of the Eagle Bluffs Conservation Area. The vertical hydraulic gradient for well pairs USGS-2S and USGS-2D and USGS-5S and USGS-5D varied, but the difference in the measured water levels generally was less than 0.2 foot. The gradient for well pair USGS-3S and USGS-3D near Perche Creek was downward, and the differences in the measured water levels ranged from 0.19 to 0.35 foot. However, the vertical hydraulic gradient was upward in December 2000.

Well pair USGS-9S and USGS-9D is in the northern part of the study area. The hydraulic gradient for all months with water levels available for both wells was upward. Differences in water levels in these well ranged from 0.01 to 0.10 foot.

Well pair USGS-8S and USGS-8D, both completed in the alluvial aquifer, are near well MW13-67, which was drilled by the city of Columbia in 1967 and was completed in bedrock to a depth of 105 feet. Water levels were measured in all 3 wells for 23 months. For 19 months, the measured water levels were highest in well USGS-8S, lower in well USGS-8D, and were lowest in well MW13-67. These measurements indicated that the potential for ground-water movement was downward toward bedrock. For the months that did not follow the aforementioned pattern, measured water levels for August and November 2002 were highest in well USGS-8D and decreased by 0.02 foot in well MW13-67. In October 2002, the water level in well USGS-8S was the highest (552.52 feet), and it decreased slightly in well USGS-8D to 552.49 feet, and increased slightly in well MW13-67 (552.51 feet). The water levels in December 2002 ranged from 549.74 feet (well USGS-8S) to 549.70 feet (well USGS-8D) to 549.77 feet (well MW13-67). The differences in measured water levels ranged from 0.01 to more than 1.5 feet. The largest differences in water levels were measured from June through November 2001 and in July 2002.

In June 2001, the water levels throughout the study area had increased with a corresponding increase in the altitude of the Missouri River, which likely affected the differences in water levels in the well pairs. Water levels from July through August 2001 declined, and they were fairly constant through November 2001 throughout the study area.

Wells SP11 and MW28-67, in the extreme southern part of the Eagle Bluffs Conservation Area, form another well pair. Well SP11 is 35 feet deep (Richards, 1995) and well MW28-67 is about 100 feet deep. In February through April 2001, October through December 2001, and September through November 2002, vertical hydraulic gradients were upward in well MW28-67, indicating potential recharge to the alluvial aquifer from the underlying bedrock. From February through April 2001, the stage of the Missouri River was increasing, and during the other two times, pools were filled or being filled with water for the flooding cycle of wetland management at the Eagle Bluffs Conservation Area. Also, the vertical hydraulic gradient was upward in April and May 2002, a period of increasing stage in the Missouri River. The gradient was downward June through September 2001 and June through August 2002. These times corresponded to decreasing river stage, lack of water in pools in the Eagle Bluffs Conservation Area, and generally lower water levels throughout the study area. The vertical hydraulic gradient also was downward January through March 2002. The Missouri River stage during this time was among the lowest in the study period.

Differences in Pre- and Post-Development Water Levels

Water-table contours from measurements on July 23, 1968 (fig. 33; Nuzman, 1969) before the existence of the Eagle Bluffs Conservation Area and the city of Columbia well field indicated that ground-water flow primarily was southeast downgradient through McBaine Bottoms. Recharge to the alluvial aquifer from the river occurred in the northwestern and western part of the study area, and discharge occurred from the aquifer to the river in the southern part of the study area. Water levels used in this map were measured in more than 20 wells completed in bedrock that were drilled in 1967. The hydrograph of the Missouri River during the time of the water-level measurements indicated that the altitude was declining after a slight rise, but the discharge was less than the annual mean discharge from October 1957 through September 2001 (U.S. Geological Survey, 1969; Hauck and Nagel, 2002).

Water levels changed somewhat in the water-table map of August 1978 compared to those in 1968 (fig. 33; Foreman and Sharp, 1981). In addition to water levels from the wells that were measured for the July 1968 water-table map, water levels from shallow wells that were installed in 1978 were included. Water levels from the shallow wells and from wells completed in bedrock produced a mapped water surface that was essentially the same. Water levels in the shallow wells and in wells completed in bedrock varied substantially after a rapid rise in the Missouri River stage. The altitude of the Missouri River rose substantially in March 1978, and in August it was still much higher than it was in January and February 1978. The discharge in August 1978 was slightly larger than the annual mean discharge from October 1957 through September 2001 (U.S. Geological Survey, 1979; Hauck and Nagel, 2002). Flow directions and areas of recharge and discharge were similar to those of the 1968 map.

Water levels measured for several months before the introduction of treated effluent to the Eagle Bluffs Conservation Area in October 1994 indicated a ground-water high beneath the Eagle Bluffs Conservation Area. Water levels in August and December 1992, March 1993, and August 1994 (Richards, 2002) indicated ground-water highs that were similar to the ground-water highs that were previously discussed in this report. The ground-water highs for these months in 1992 through 1994 tended to have low relief with less than 7 feet of difference between the highest and lowest measured water level in the Eagle Bluffs Conservation Area.

Major differences between pre- and post-development water levels were apparent in three locations in the study area. The first of these locations is represented by a ground-water high that has continuously been present beneath the Eagle Bluffs Conservation Area since before the introduction of treated effluent to the Eagle Bluffs Conservation Area in October 1994 and full management of the area in late 1995. Changes in the ground-water high were related to the flooding of the wetland pools and the Missouri River stage.

A cone of depression has developed in the central part of the study area because of pumpage from the city of Columbia well field. Production from the well field began in the early 1970's, and 14 wells presently (2003) are in use. Localized cones of depression varied from month to month based on which well pairs are being used for production. The use of the well pairs is rotated monthly.

The third area where changes have occurred is in the northeastern part of the study area. A ground-water high is present beneath treatment wetland unit 1. The ground-water high on the water-table maps (figs. 3-29)

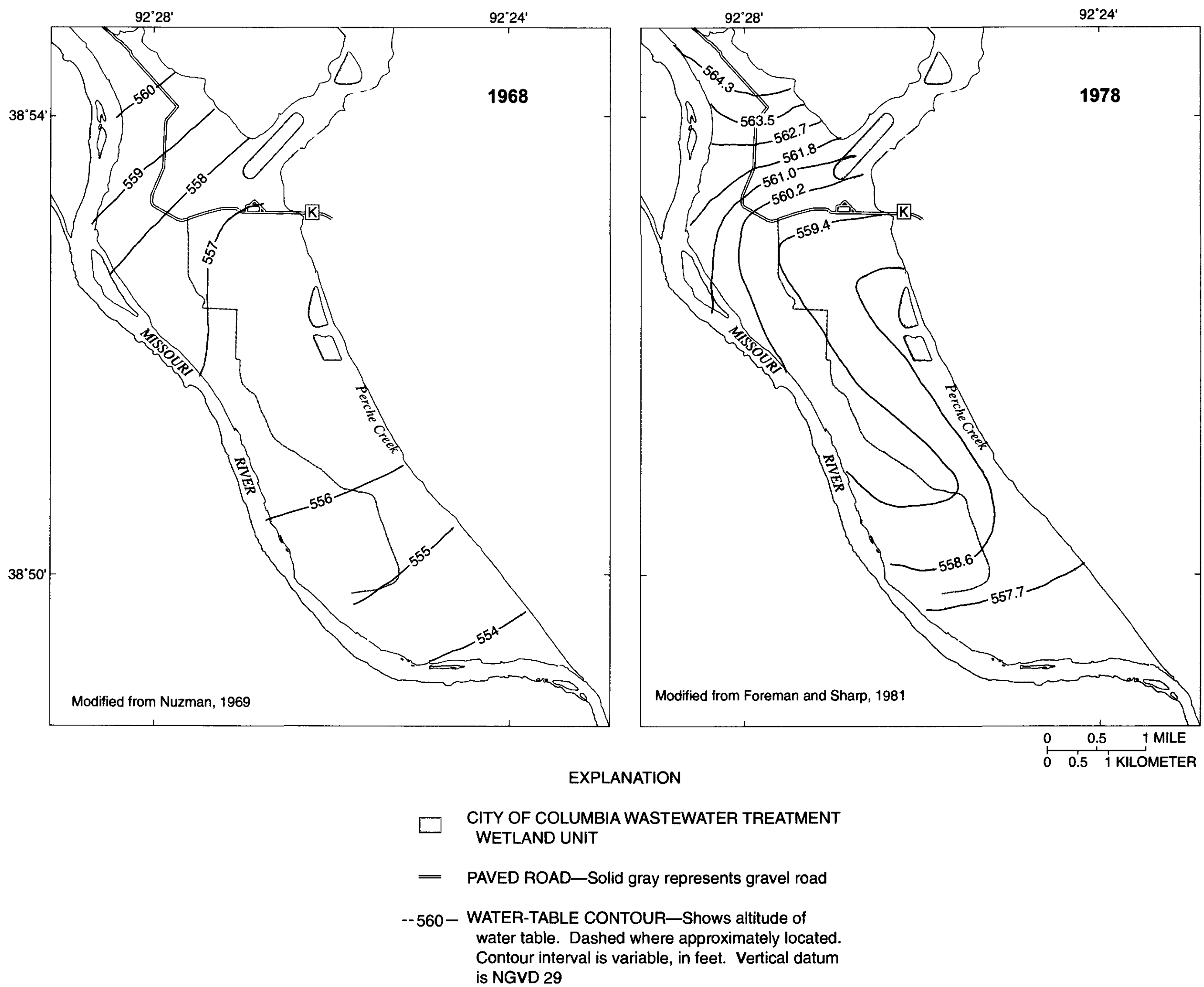

Figure 33. Pre-development altitude of the water table, July 1968 and August 1978.

was not well defined because a large contour interval was used in that area to better display the large differences in water levels upgradient from unit 1 to the southwest extension of the unit and because of water possibly perched around the unit. Water levels in the shallow well of well pairs MW1-1 and MW1-4 generally were several feet higher than water levels in the deep well of the pair.

Differences between measured water levels for pre-effluent conditions in the Eagle Bluffs Conservation Area and also before the city of Columbia well field (July 1968; Nuzman, 1969) and present conditions (June 2002 and December 2002) were determined. Water levels for June 2002 were used because the ground-water high beneath the Eagle Bluffs Conservation Area had small relief with a small gradient, the deepest part of the cone of depression around the city of Columbia well field also had small relief, and the stage of the Missouri River was not high. Water levels for December 2002 were used because the wetland pools on the Eagle Bluffs Conservation Area were flooded, thereby causing maximum extent and gradient of the ground-water high. The stage of the Missouri River in December was among the lowest during the study period. Because limited data are available for McBaine Bottoms, the comparisons between the pre-effluent conditions and those in this report are valid for the specified time and may not necessarily be true for extended times.

Water levels in June 2002 beneath the Eagle Bluffs Conservation Area were higher than water levels in July 1968—from 4 feet around the base of the ground-water high to 7 feet at the apex of the ground-water high. In the northern part of the study area, water levels beneath part of the city of Columbia well field were 2 feet lower than they were in 1968. Throughout the rest of the well field, water levels were the same or about 1 foot lower in June 2002 than they were in 1968. Water levels in the alluvial aquifer near the Missouri River were as much as 2 feet higher in 2002 than they were in 1968. Another area of difference between the two measurements was in water levels northwest of treatment wetland unit 1 and near the edge of the alluvial aquifer. Water levels were as much as 7 feet higher in 2002 than they were in 1968.

In December 2002, water-level differences probably were at a maximum throughout the study area. Beneath the Eagle Bluffs Conservation Area, water levels were as much as 10 feet higher than they were in 1968. Water levels along the Missouri River were about 2 feet less than those in 1968. Water levels in the areas around some of the public-supply wells were as much as 9 feet lower in December 2002 than in 1968. In December 2002, an area of water levels 7 feet lower than those in 1968 encompassed the entire city of Columbia well field. In the northeastern part of the study area adjacent to the edge of the alluvial aquifer northwest of treatment wetland unit 1, water levels in a small area were as much as 6 feet higher in 2002 than they were in 1968. Water levels adjacent to unit 1 were about 2 feet higher in 2002 than they were in 1968.

GROUND- AND SURFACE-WATER INTERACTION

The proximity of the Missouri River and perennial Perche Creek to McBaine Bottoms allows for the possibility that these surface-water bodies may either supply water to or remove water from the ground-water system in this area. The ground- and surface-water interaction was assessed by monitoring the altitude of the Missouri River and Perche Creek at several locations and comparing the altitude with nearby ground-water levels. Because of the apparent interdependence of surface- and ground-water levels in the alluvial aquifer, a description of hydrologic conditions is only valid for a short time during which water levels were measured.

The altitude of the Missouri River in the northern part of the study area (fig. 2, river upper) was higher than the water table in the aquifer (MW-152, fig. 2), except for one measurement. Therefore, the potential for ground-water flow was from the river toward McBaine Bottoms. At the time of water-level measurements, the altitude of the river generally was less than 1.5 feet higher than that of the water table, but it was as much as 10 feet higher in April 2002, when the altitude of the river was increasing. The only month when the measured stage was less than the water table was in July 2001, when the altitude of the river was about 0.6 foot lower than the water table.

Another staff gage along the Missouri River was about 0.5 river mile downstream from the northern edge of the Eagle Bluffs Conservation Area (fig. 2, river lower). The Missouri River generally was lower at this location than the water table in the alluvial aquifer, and the potential for ground-water flow was from the alluvial aquifer toward the river during these times. The Missouri River was higher than the water table during times when the altitude of the river was high or increasing, such as during the spring and early summer of 2001 and 2002.

At all times during the study, except under backwater conditions caused by the Missouri River, water levels in Perche Creek at the staff gage in the northeast part of the study area (fig. 2, creek upper) lower than the water table in the alluvial aquifer, indicating that Perche Creek was receiving ground water from the aquifer. The higher water levels in the alluvial aquifer adjacent to Perche Creek indicated that the aquifer was supplying water to the creek. This is consistent with the observation of numerous seeps in the streambanks along this reach of Perche Creek (M.F. Knowlton, oral commun., 2002).

Water levels in Perche Creek near the downstream reach of the study area at the Missouri Department of Conservation boat ramp (fig. 2, creek lower) were lower than those measured in the alluvial aquifer except in March 2001. In March 2001, the water level in Perche Creek was slightly higher than the water level in the aquifer. The altitude of the Missouri River was higher than normal and the water level in Perche Creek reflected backwater from the Missouri River.

Water levels in Perche Creek generally were a few feet lower than water levels in the alluvial aquifer. Generally, the differences between the water level in Perche Creek and in the alluvial aquifer were largest during the late fall and winter when the pools were filled in the Eagle Bluffs Conservation Area. However, the difference in the water levels could be fairly large, as in May 2002 when the altitude of the Missouri River was high and water levels in the alluvial aquifer increased.

Continuous water-level recorders were installed in 12 monitoring wells during the study to monitor daily fluctuations in ground-water levels. Four of the recorders were installed approximately east-west from Perche Creek to the Missouri River, and the rest of the recorders were installed near Perche Creek, the Missouri River, and treatment wetland unit 1. Hydrographs for these wells are shown in figures 32 and 34 through 44 (at the back of this report).

The hydrographs for the Missouri River (figs. 30, 32) show typical changes in stage during the year. In spring and summer, the altitude of the river was relatively high because of increased releases from dams upstream and increased rainfall. In the fall and winter, river stage was low because of decreased releases from dams upstream and decreased rainfall. Water levels in monitoring wells in the northern part of the study area adjacent to the Missouri River [MW-152 (fig. 32) and MW-135 (fig. 42)] closely followed the trend of the river stage. Water-level variations in these wells were almost identical to those of the Missouri River.

Aligning river-stage peaks for the Missouri River at Boonville (continuous streamflow gaging station 06909000 at river mile 196.6) and water-level peaks for monitoring well MW-152 (near river mile 179) by shifting the time scale for the water levels illustrated a lag time of less than 3 days. For some river stage increases, the lag time was substantially less than 3 days.

Monitoring well MW-113 (fig. 2) also was drilled adjacent to the Missouri River. Water levels for this well (fig. 37) generally followed the trend of the Missouri River. When pools on the Eagle Bluffs Conservation Area were flooded annually in the fall before the waterfowl migratory season, the water level in monitoring well MW-113 reflected this increase. No flooded pools are north of this monitoring well, so the changes in the water level reflected the northward flow of ground water from the ground-water high beneath the Eagle Bluffs Conservation Area. In late October or early November 2001, the water level increased in this well and remained high relative to the altitude of the Missouri River until the end of December, when the water level in the well declined substantially. After that date, the water level followed the trend of the Missouri River until October 2002, when the water level increased because of the flooding of the pools.

Monitoring wells MW-121, MW-127, and MW-143 (fig. 2) are adjacent to Perche Creek, and water levels in these wells reflected the trend of the altitude of Perche Creek. No gaging station exists on Perche Creek, and the only data available throughout this study were collected at two staff gages that were installed for this study. The water level in MW-143 (fig. 44) varied by about 1.5 feet for the first 8 months the recorder was in the well. In May 2002, a rise in the water level corresponded to an increase in the Missouri River and was reflected in a water level increase from MW-121 (fig. 40) and MW-127 (fig. 41). However, the rise in the water level in MW-143 was an extremely narrow spike of more than 4 feet followed immediately by a period of fluctuating water levels that culminated in the deepest water levels in August 2002 that were measured during the time the recorder was in the well. Water levels in MW-121 and MW-127 increased in May 2002, and the peaks remained fairly constant for about a month.

Monitoring wells MW-115 and MW-116 (fig. 2) are west of treatment wetland units 2 and 3; MW-115 is adjacent to Perche Creek. Water levels in both wells reflected the trend of Perche Creek as shown for MW-121 and MW-127 for the rise in May through June 2002. The water levels for MW-115 (fig. 38) and especially MW-116 (fig. 39) showed the effect of flooding of the pools in the Eagle Bluffs Conservation Area in the fall of 2001 and 2002. Monitoring well MW-116 is immediately north of the Eagle Bluffs Conservation Area, and MW-115 is about 0.3 mile north of the Eagle Bluffs Conservation Area.

Recorders were placed in three wells in the Eagle Bluffs Conservation Area, but not adjacent to the Missouri River. These wells were MW-104, MW-107, and MW-111 (fig. 2); MW-104 is adjacent to Perche Creek, MW-107 is in the north central part of the area, and MW-111 is at the northern edge of the area. Water levels in these wells (figs. 34-36), including MW-104, reflected the trend of the Missouri River during the rise in May and June 2002. The water levels also reflected the flooding of the pools on the Eagle Bluffs Conservation Area in the fall of 2001 and 2002 and the subsequent drying of the pools between December 2001 and January 2002. The effects of the pools on the water levels in MW-111 were less apparent compared to the water levels in MW-104 and MW-107.

The remaining recorder was placed in MW-141 (fig. 2) on the northern edge of treatment wetland unit 1. The water level in this well (fig. 43) declined gradually from September 2001 to about the end of April 2002. At the beginning of May 2002, the water level increased gradually and toward the middle of May, the water level increased about 2.5 feet. The water level increased to its peak in mid-June and began decreasing gradually to the end of the study period, except for a rise in mid-August, which probably corresponded to a similar rise in Perche Creek. Clay was encountered throughout the drilling of this borehole, which possibly contributed to the slow response of the water level.

SUMMARY

The Missouri Department of Conservation uses the treated effluent from the 130-acre city of Columbia wastewater-treatment wetland as a primary water source for managing about 1,300 wetland acres on the Eagle Bluffs Conservation Area at McBaine Bottoms. The treatment wetland is designed to treat an average flow of about 20 million gallons of effluent per day. The area is located on the Missouri River alluvium and is bounded to the south and west by the Missouri River and to the north and east by Missouri River bluffs. The city of Columbia pumps water from the alluvial aquifer for its municipal supply using seven pairs of wells located upstream (north) from the Eagle Bluffs Conservation Area and adjacent (west) to the treatment wetland.

The presence of a sustained ground-water high underlying the Eagle Bluffs Conservation Area indicates potential for ground-water flow toward the city of Columbia well field. Elevated concentrations of several constituents in water samples from monitoring wells within or near the well field, including sodium, potassium, calcium, sulfate, and chloride, indicated flow of water from the Eagle Bluffs Conservation Area toward the well field. The U.S. Geological Survey, in cooperation with the Missouri Department of Conservation and the city of Columbia, measured the ground-water levels in about 88 monitoring wells and the surface-water altitude at 4 sites monthly from October 2000 through December 2002 to determine the ground-water flow and the ground- and surface-water interaction in McBaine Bottoms.

Lateral ground-water flow was dominated by the presence of a ground-water high beneath the Eagle Bluffs Conservation Area and the presence of a cone of depression in the northern part of the study area. The ground-water high was present during all months of the study. Ground-water flow was radially away from the apex of the ground-water high; west and south of the ground-water high, flow was toward the Missouri River, east of the ground-water high, flow was toward Perche Creek, and north of the ground-water high, flow was to the north toward the city of Columbia well field. The cone of depression was centered around the city of Columbia well field. Flow toward the well field was from the south in the vicinity of the Eagle Bluffs Conservation Area, from the west from the Missouri River, flow from the north downgradient though the alluvial aquifer, from the northeast beneath treatment wetland unit 1, and from the east through the alluvial aquifer in the vicinity of Perche Creek.

Another permanent feature on the water-table maps was a ground-water high beneath treatment wetland unit 1. Ground-water flow was downgradient through the alluvial valley that contains units 1 and 4. Around unit 1 perched water was present because ground-water flow was impeded by low permeability clay that traps the ground water at a higher altitude than the nearby water table.

Although the ground-water high beneath the Eagle Bluffs Conservation Area was present throughout the study period, the configuration of the ground-water high changed depending on hydrologic conditions. Generally in March, the height of the ground-water high began to decrease. In April, the high had become more shallow and gradients around the high more gentle. In May and June, the high was the least pronounced. In July, the high began to become more pronounced, and it continued to become more shallow, increasing until it reached its minimum depth in November or December. Fluctuations in the ground-water high corresponded to the cycle of flooding of the wetland pools in the fall and subsequent drainage in the spring so crops could be grown in many of the pools. Changes in the Missouri River stage also caused simultaneous changes in the ground-water high.

The cone of depression in the northern part of the study area generally extended from the base of the ground-water high in the northern part of the Eagle

Bluffs Conservation Area throughout most of the northern part of the study area. The depth of the cone was dependent on the altitude of the Missouri River and the quantity of water pumped from the alluvial aquifer from the city of Columbia well field. During times of higher Missouri River flow, the gradient from the river toward the city of Columbia well field became steeper, but the measured water levels near the central part of the study area tended to increase, probably from induced surface-water flow into this area. Localized cones of depression were apparent around public-supply wells; the location of these localized cones was dependent on which public-supply well was being pumped.

The direction of vertical ground-water flow based on measurements at well pairs could not be determined with certainty throughout the study area. For well pairs around treatment wetland units 1, 2, and 3, the direction of vertical ground-water flow varied. Differences in measured water levels generally were small (less than 0.5 foot). The vertical hydraulic gradient for a well pair in the northern part of the study area was upward. The vertical hydraulic gradient at a well pair completed in the alluvial aquifer and a well completed in bedrock was downward, and the differences in measured water levels in these three wells ranged from 0.01 to 1.5 feet.

Ground-water flow in the alluvial aquifer in McBaine Bottoms in the late 1960's before the development of the city of Columbia well field and the Eagle Bluffs Conservation Area was from northwest to southeast approximately parallel to the Missouri River. The ground-water high beneath the Eagle Bluffs Conservation Area and the cone of depression around the city of Columbia well field were not present in water-level maps for 1968 and 1978.

The Missouri River can be a source of recharge to the alluvial aquifer. Generally, the altitude of the river in the northern part of the study area was higher than the water table in the aquifer. Ground-water flow was from the river to the alluvial aquifer. In the southern part of the study area adjacent to the Eagle Bluffs Conservation Area, the Missouri River was lower than the water table in the alluvial aquifer, indicating that the river was receiving water from the Eagle Bluffs Conservation Area. Water levels in wells that were instrumented with a continuous recorder tended to follow the trend of the Missouri River. Water levels in wells in the Eagle Bluffs Conservation Area responded to the seasonal flooding of the pools.

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TABLES AND ILLUSTRATIONS

Table 2. Altitude of water levels in monitoring wells, October 12–13, 2000

[Altitudes are in feet above NGVD 29; ft, feet]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	564.35	MW-119	553.41	MW-137	555.29
MW-102	564.95	MW-120	551.43	MW-138	551.29
MW-103	563.91	MW-121	552.19	MW-139	552.41
MW-104	560.95	MW-122	551.20	MW-140	557.17
MW-105	558.06	MW-123	551.79	MW-141	553.97
MW-106	559.33	MW-124	552.64	MW-142	574.74
MW-107	559.65	MW-125	553.81	MW-143	567.31
MW-108	562.21	MW-126	551.73	MW-144	552.85
MW-109	561.69	MW-127	552.58	MW-145	555.96
MW-110	558.88	MW-128	553.00	MW-146	555.56
MW-111	554.78	MW-129	552.68	MW-147	551.63
MW-112	556.75	MW-130	553.67	MW-148	561.27
MW-113	557.52	MW-131	554.61	MW-149	554.05
MW-114	561.64	MW-132	551.69	MW-150	566.03
MW-115	554.23	MW-133	552.42	MW-151	555.22
MW-116	555.56	MW-134	552.33	MW-152	558.24
MW-117	554.25	MW-135	555.69	MW-153	558.70
MW-118	554.23	MW-136	553.18		

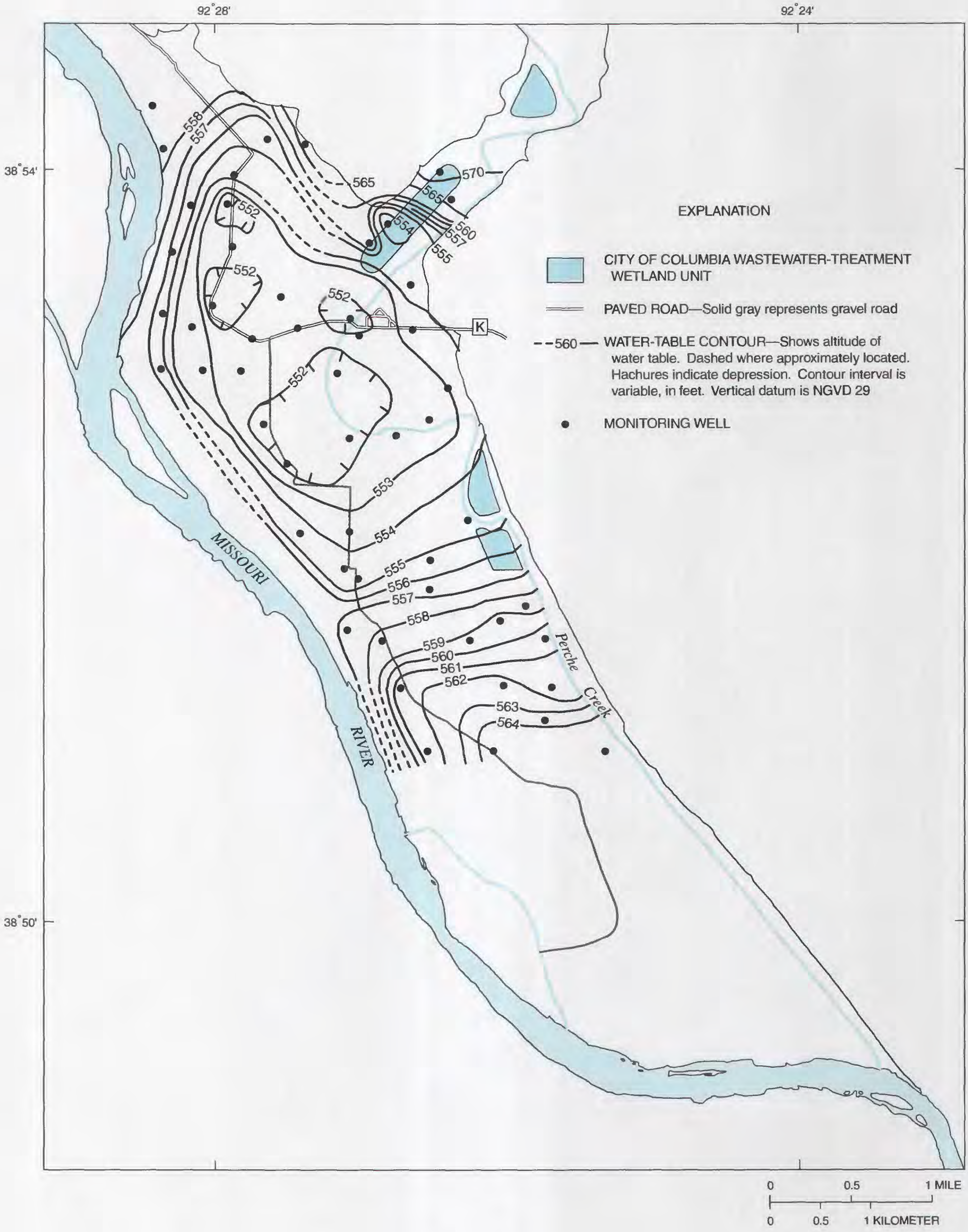

Figure 3. Altitude of the water table in the alluvial aquifer, October 12–13, 2000.

Table 3. Altitude of water levels in monitoring wells, November 6–7, 2000

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	567.40	MW-124	552.45	MW-147	550.45	MW4-2A	563.84
MW-102	566.86	MW-125	553.63	MW-148	562.96	MW4-2B	563.86
MW-103	566.18	MW-126	--	MW-149	553.17	USGS-1	558.33
MW-104	561.13	MW-127	--	MW-150	567.26	USGS-2S	565.74
MW-105	559.76	MW-128	--	MW-151	554.88	USGS-2D	565.71
MW-106	561.26	MW-129	552.74	MW-152	558.61	USGS-3S	564.65
MW-107	561.88	MW-130	553.72	MW-153	559.06	USGS-3D	564.39
MW-108	564.75	MW-131	554.41	MW-154	--	USGS-4	--
MW-109	564.27	MW-132	552.66	MW-155	--	USGS-5S	--
MW-110	561.64	MW-133	551.90	MW1-1A	568.12	USGS-5D	--
MW-111	556.87	MW-134	552.02	MW1-1B	561.00	USGS-6	--
MW-112	558.64	MW-135	555.82	MW1-2A	553.81	USGS-7	--
MW-113	559.57	MW-136	552.82	MW1-2B	553.79	USGS-8S	551.90
MW-114	563.35	MW-137	555.30	MW1-3A	553.21	USGS-8D	552.10
MW-115	555.09	MW-138	550.22	MW1-3B	553.10	USGS-9S	557.36
MW-116	557.13	MW-139	552.05	MW1-4A	--	USGS-9D	557.40
MW-117	555.64	MW-140	557.80	MW1-4B	--	SP11	--
MW-118	555.18	MW-141	553.71	MW2-1A	554.45	SP4	--
MW-119	554.89	MW-142	575.20	MW2-1B	554.44	MW13-67	--
MW-120	552.10	MW-143	567.79	MW3-1A	557.23	MW28-67	--
MW-121	552.96	MW-144	552.23	MW3-1B	557.19		
MW-122	552.26	MW-145	555.97	MW4-1A	--		
MW-123	552.15	MW-146	555.24	MW4-1B	--		

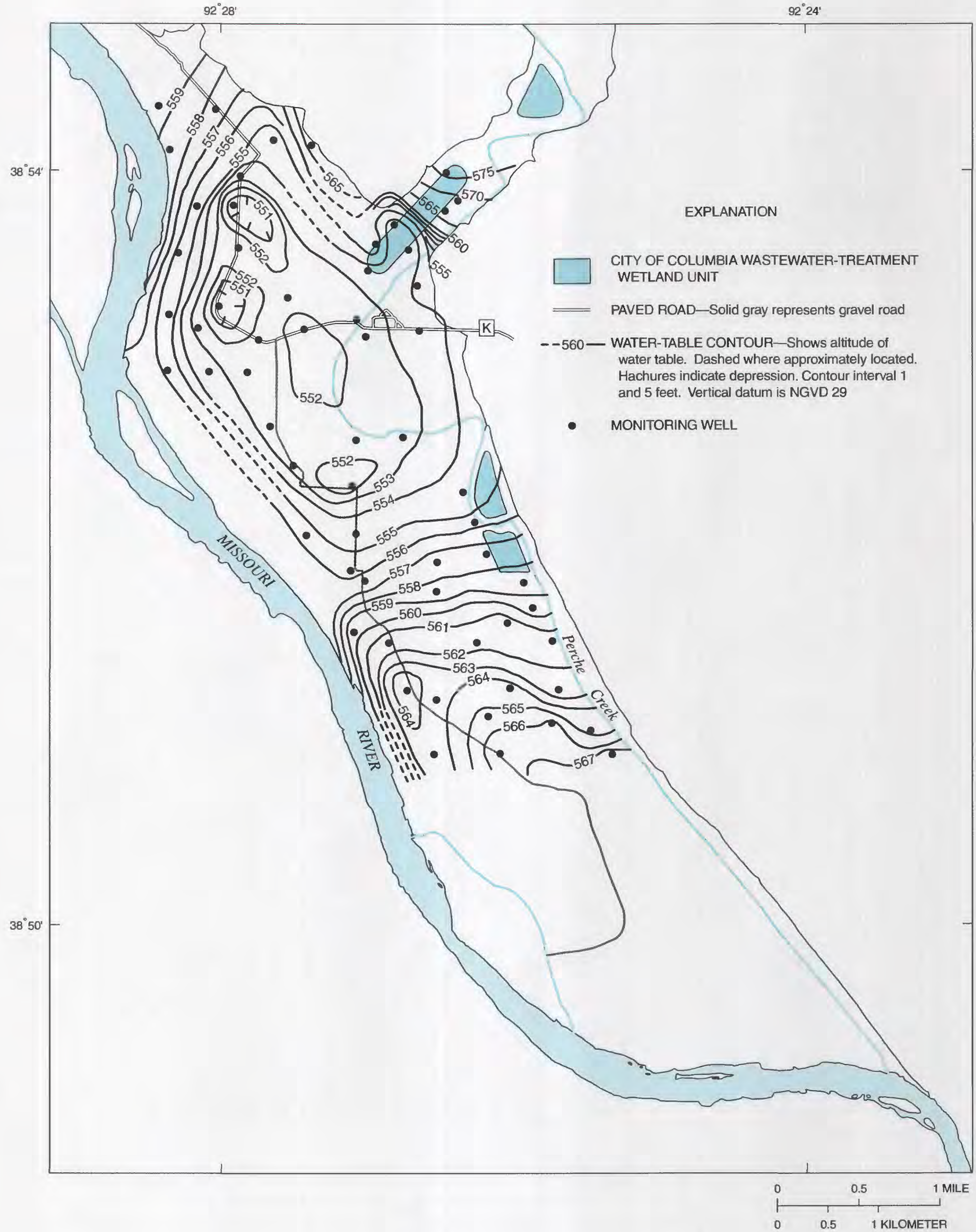

Figure 4. Altitude of the water table in the alluvial aquifer, November 6–7, 2000.

Table 4. Altitude of water levels in monitoring wells, December 6–15, 2000

[Altitudes are in feet above NGVD 29; ft, feet]

Site (fig. 2)	Date measured	Altitude (ft)	Site (fig. 2)	Date measured	Altitude (ft)	Site (fig. 2)	Date measured	Altitude (ft)	Site (fig. 2)	Date measured	Altitude (ft)
MW-101	12-14-2000	567.11	MW-122	12-06-2000	552.46	MW-143	12-08-2000	567.45	MW2-1A	12-06-2000	553.95
MW-102	12-14-2000	565.86	MW-123	12-06-2000	552.29	MW-144	12-14-2000	552.42	MW2-1B	12-06-2000	553.92
MW-103	12-15-2000	565.04	MW-124	12-06-2000	552.62	MW-145	12-08-2000	554.36	MW3-1A	12-06-2000	556.83
MW-104	12-15-2000	560.26	MW-125	12-06-2000	553.37	MW-146	12-08-2000	554.23	MW3-1B	12-06-2000	556.79
MW-105	12-15-2000	557.90	MW-126	12-15-2000	552.60	MW-147	12-14-2000	551.79	MW4-1A	12-06-2000	561.03
MW-106	12-15-2000	559.92	MW-127	12-15-2000	553.15	MW-148	12-15-2000	561.11	MW4-1B	12-06-2000	560.81
MW-107	12-15-2000	560.44	MW-128	12-15-2000	553.31	MW-149	12-14-2000	553.45	MW4-2A	12-06-2000	562.72
MW-108	12-15-2000	563.24	MW-129	12-15-2000	552.82	MW-150	12-14-2000	567.08	MW4-2B	12-06-2000	562.72
MW-109	12-06-2000	562.61	MW-130	12-15-2000	553.54	MW-151	12-14-2000	554.69	USGS-1	12-15-2000	556.54
MW-110	12-15-2000	557.98	MW-131	12-15-2000	553.99	MW-152	12-08-2000	556.08	USGS-2S	12-06-2000	565.15
MW-111	12-06-2000	555.65	MW-132	12-14-2000	552.74	MW-153	12-08-2000	556.89	USGS-2D	12-06-2000	565.12
MW-112	12-06-2000	558.51	MW-133	12-14-2000	551.87	MW-154	12-14-2000	552.81	USGS-3S	12-15-2000	563.64
MW-113	12-15-2000	555.06	MW-134	12-14-2000	551.90	MW-155	12-14-2000	552.87	USGS-3D	12-15-2000	563.83
MW-114	12-15-2000	560.87	MW-135	12-08-2000	554.51	MW1-1A	12-08-2000	567.84	USGS-8S	12-06-2000	552.27
MW-115	12-06-2000	554.31	MW-136	12-08-2000	552.25	MW1-1B	12-08-2000	560.70	USGS-8D	12-06-2000	551.66
MW-116	12-06-2000	556.96	MW-137	12-08-2000	553.72	MW1-2A	12-08-2000	553.66	USGS-9S	12-14-2000	556.47
MW-117	12-06-2000	554.78	MW-138	12-14-2000	550.03	MW1-2B	12-08-2000	553.68	USGS-9D	12-14-2000	556.50
MW-118	12-06-2000	554.10	MW-139	12-08-2000	552.41	MW1-3A	12-14-2000	553.25	SP4	12-14-2000	567.37
MW-119	12-06-2000	554.24	MW-140	12-14-2000	556.59	MW1-3B	12-14-2000	553.14	MW13-67	12-08-2000	550.71
MW-120	12-06-2000	563.92	MW-141	12-14-2000	553.60	MW1-4A	12-08-2000	571.31			
MW-121	12-06-2000	553.04	MW-142	12-14-2000	574.45	MW1-4B	12-08-2000	559.78			

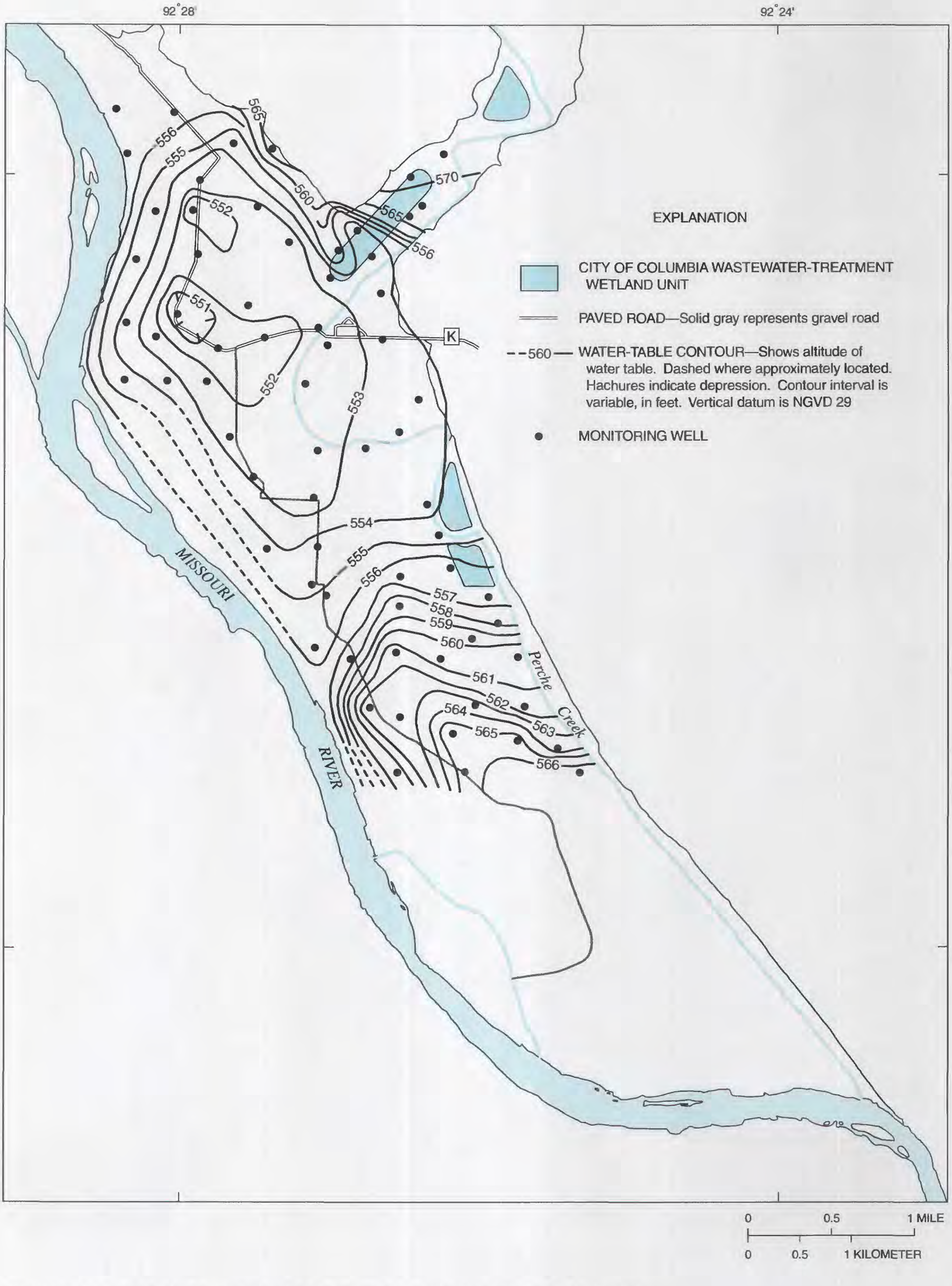

Figure 5. Altitude of the water table in the alluvial aquifer, December 6–15, 2000.

Table 5. Altitude of water levels in monitoring wells and staff gages, January 11–12, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	557.01	MW-125	551.92	MW-149	552.06	USGS-2S	556.77
MW-102	557.85	MW-126	--	MW-150	567.50	USGS-2D	556.77
MW-103	556.83	MW-127	552.48	MW-151	553.94	USGS-3S	556.04
MW-104	555.28	MW-128	552.82	MW-152	554.58	USGS-3D	555.80
MW-105	554.67	MW-129	552.27	MW-153	554.93	USGS-4	--
MW-106	555.43	MW-130	553.06	MW-154	552.40	USGS-5S	--
MW-107	555.28	MW-131	553.93	MW-155	552.60	USGS-5D	--
MW-108	556.20	MW-132	552.15	MW1-1A	567.59	USGS-6	--
MW-109	554.28	MW-133	550.85	MW1-1B	560.46	USGS-7	--
MW-110	553.08	MW-134	550.84	MW1-2A	553.33	USGS-8S	551.92
MW-111	550.45	MW-135	--	MW1-2B	553.32	USGS-8D	551.91
MW-112	553.58	MW-136	551.03	MW1-3A	552.88	USGS-9S	554.83
MW-113	552.00	MW-137	552.40	MW1-3B	552.70	USGS-9D	554.87
MW-114	555.08	MW-138	549.19	MW1-4A	571.23	SP11	--
MW-115	552.29	MW-139	551.37	MW1-4B	559.56	SP4	565.08
MW-116	553.10	MW-140	556.02	MW2-1A	552.51	MW13-67	551.90
MW-117	550.38	MW-141	553.29	MW2-1B	552.50	MW28-67	--
MW-118	551.70	MW-142	574.39	MW3-1A	553.50	River upper	566.04
MW-119	551.50	MW-143	567.18	MW3-1B	553.49	River lower	552.23
MW-120	550.70	MW-144	551.57	MW4-1A	--	Creek upper	553.44
MW-121	--	MW-145	552.99	MW4-1B	--		
MW-122	551.89	MW-146	552.80	MW4-2A	555.35		
MW-123	551.18	MW-147	550.37	MW4-2B	555.34		
MW-124	551.30	MW-148	555.29	USGS-1	554.06		

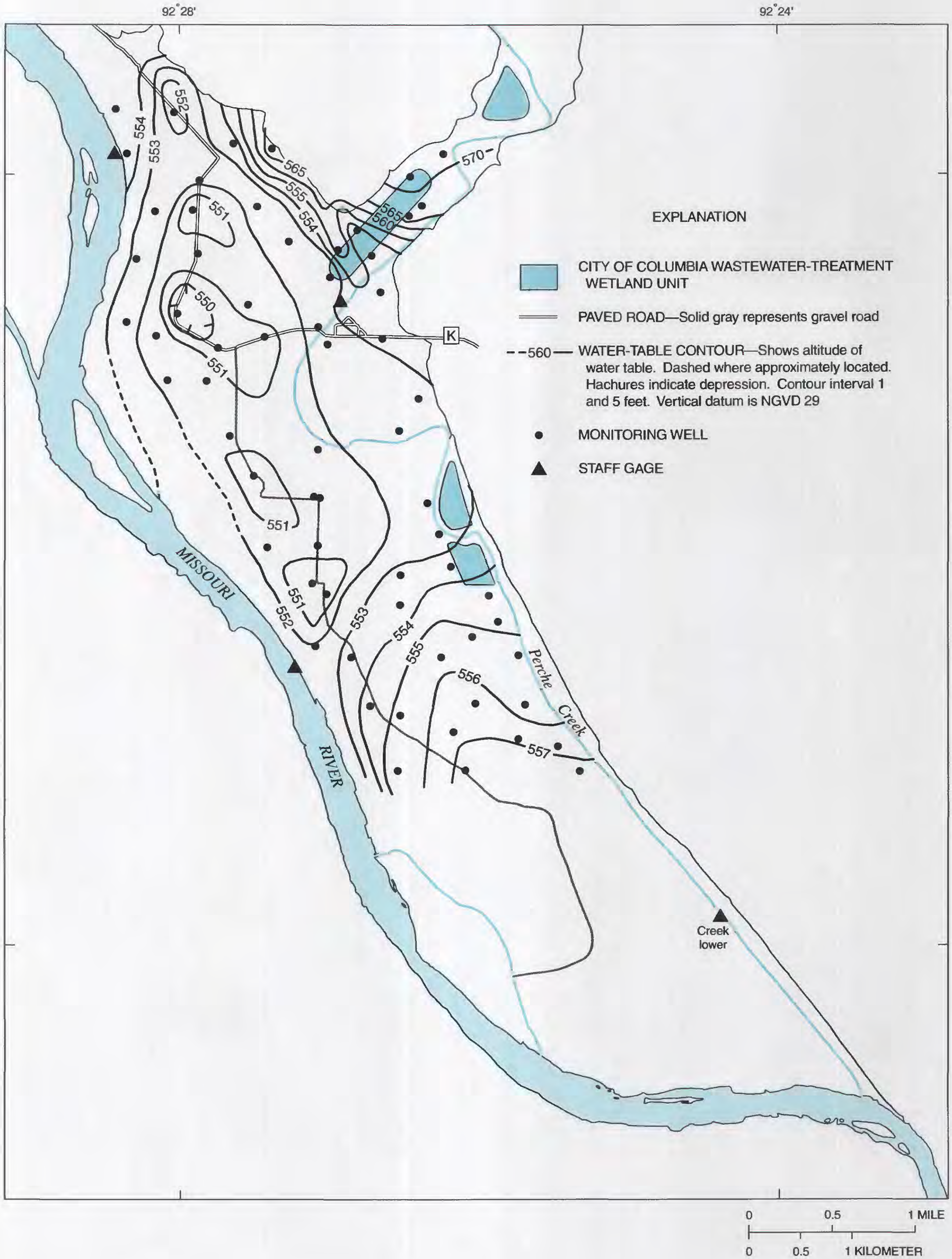

Figure 6. Altitude of the water table in the alluvial aquifer, January 11–12, 2001.

Table 6. Altitude of water levels in monitoring wells and staff gages, February 20–23, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	565.50	MW-125	553.90	MW-149	--	USGS-2S	560.03
MW-102	562.40	MW-126	551.74	MW-150	567.75	USGS-2D	560.02
MW-103	561.70	MW-127	552.87	MW-151	554.14	USGS-3S	562.21
MW-104	557.76	MW-128	553.52	MW-152	557.19	USGS-3D	561.86
MW-105	556.62	MW-129	552.68	MW-153	557.92	USGS-4	558.84
MW-106	557.27	MW-130	553.96	MW-154	552.82	USGS-5S	565.56
MW-107	557.34	MW-131	554.96	MW-155	552.82	USGS-5D	565.57
MW-108	559.78	MW-132	552.69	MW1-1A	568.56	USGS-6	558.77
MW-109	556.85	MW-133	551.24	MW1-1B	562.69	USGS-7	556.30
MW-110	555.42	MW-134	551.77	MW1-2A	553.97	USGS-8S	551.81
MW-111	552.55	MW-135	555.48	MW1-2B	553.96	USGS-8D	551.57
MW-112	554.93	MW-136	553.88	MW1-3A	553.35	USGS-9S	556.79
MW-113	554.12	MW-137	555.26	MW1-3B	553.24	USGS-9D	556.82
MW-114	559.00	MW-138	552.49	MW1-4A	572.06	SP11	560.41
MW-115	553.30	MW-139	551.96	MW1-4B	562.17	SP4	564.00
MW-116	554.26	MW-140	560.90	MW2-1A	553.21	MW13-67	551.51
MW-117	552.50	MW-141	553.86	MW2-1B	553.20	MW28-67	561.63
MW-118	553.69	MW-142	575.59	MW3-1A	554.65	River upper	558.05
MW-119	552.78	MW-143	568.19	MW3-1B	554.59	River lower	554.43
MW-120	551.77	MW-144	553.18	MW4-1A	556.13	Creek upper	553.04
MW-121	552.42	MW-145	555.65	MW4-1B	556.02	Creek lower	551.94
MW-122	551.61	MW-146	555.21	MW4-2A	557.80		
MW-123	552.07	MW-147	552.04	MW4-2B	557.80		
MW-124	552.39	MW-148	558.94	USGS-1	555.69		

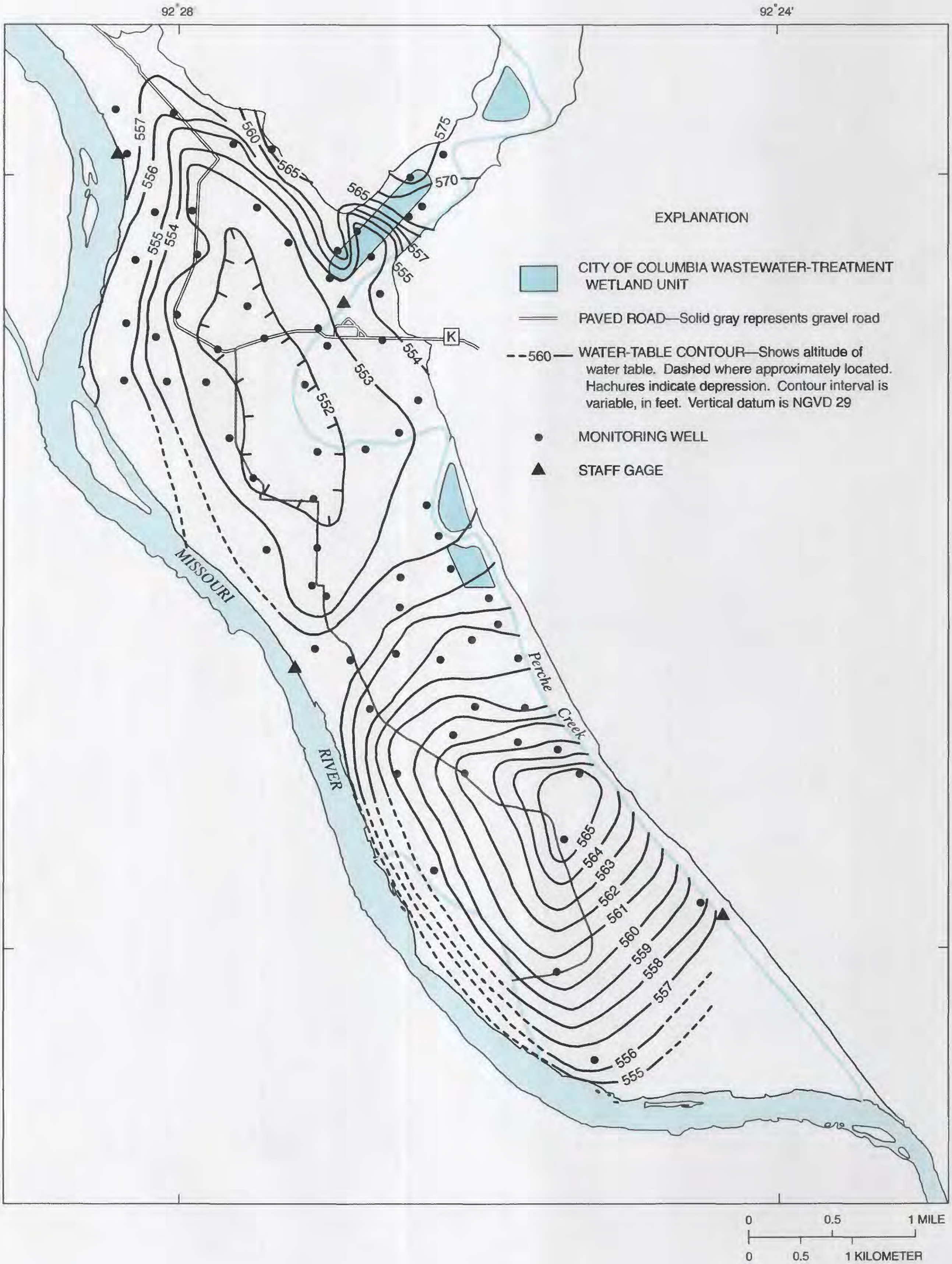

Figure 7. Altitude of the water table in the alluvial aquifer, February 20–23, 2001.

Table 7. Altitude of water levels in monitoring wells and staff gages, March 19–20, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	566.28	MW-125	558.05	MW-149	--	USGS-2S	--
MW-102	567.70	MW-126	553.98	MW-150	567.66	USGS-2D	--
MW-103	567.16	MW-127	555.94	MW-151	556.03	USGS-3S	565.85
MW-104	564.71	MW-128	557.70	MW-152	568.34	USGS-3D	565.65
MW-105	562.44	MW-129	554.75	MW-153	567.84	USGS-4	566.39
MW-106	563.13	MW-130	555.77	MW-154	554.06	USGS-5S	566.57
MW-107	563.78	MW-131	556.24	MW-155	554.08	USGS-5D	566.56
MW-108	567.35	MW-132	554.66	MW1-1A	569.02	USGS-6	564.62
MW-109	565.39	MW-133	552.95	MW1-1B	564.52	USGS-7	564.85
MW-110	563.08	MW-134	553.97	MW1-2A	555.55	USGS-8S	554.92
MW-111	557.96	MW-135	563.87	MW1-2B	555.54	USGS-8D	554.77
MW-112	559.97	MW-136	558.14	MW1-3A	554.77	USGS-9S	--
MW-113	563.15	MW-137	563.66	MW1-3B	554.67	USGS-9D	560.26
MW-114	567.26	MW-138	555.55	MW1-4A	572.39	SP11	--
MW-115	559.09	MW-139	553.51	MW1-4B	564.76	SP4	564.19
MW-116	558.65	MW-140	561.57	MW2-1A	557.57	MW13-67	554.66
MW-117	558.13	MW-141	555.03	MW2-1B	557.55	MW28-67	565.82
MW-118	560.69	MW-142	576.23	MW3-1A	559.77	River upper	572.14
MW-119	557.21	MW-143	568.80	MW3-1B	559.73	River lower	569.09
MW-120	555.43	MW-144	556.28	MW4-1A	562.71	Creek upper	565.09
MW-121	555.44	MW-145	564.26	MW4-1B	562.63	Creek lower	564.65
MW-122	554.34	MW-146	562.47	MW4-2A	566.07		
MW-123	554.91	MW-147	556.11	MW4-2B	566.09		
MW-124	554.70	MW-148	565.86	USGS-1	561.51		

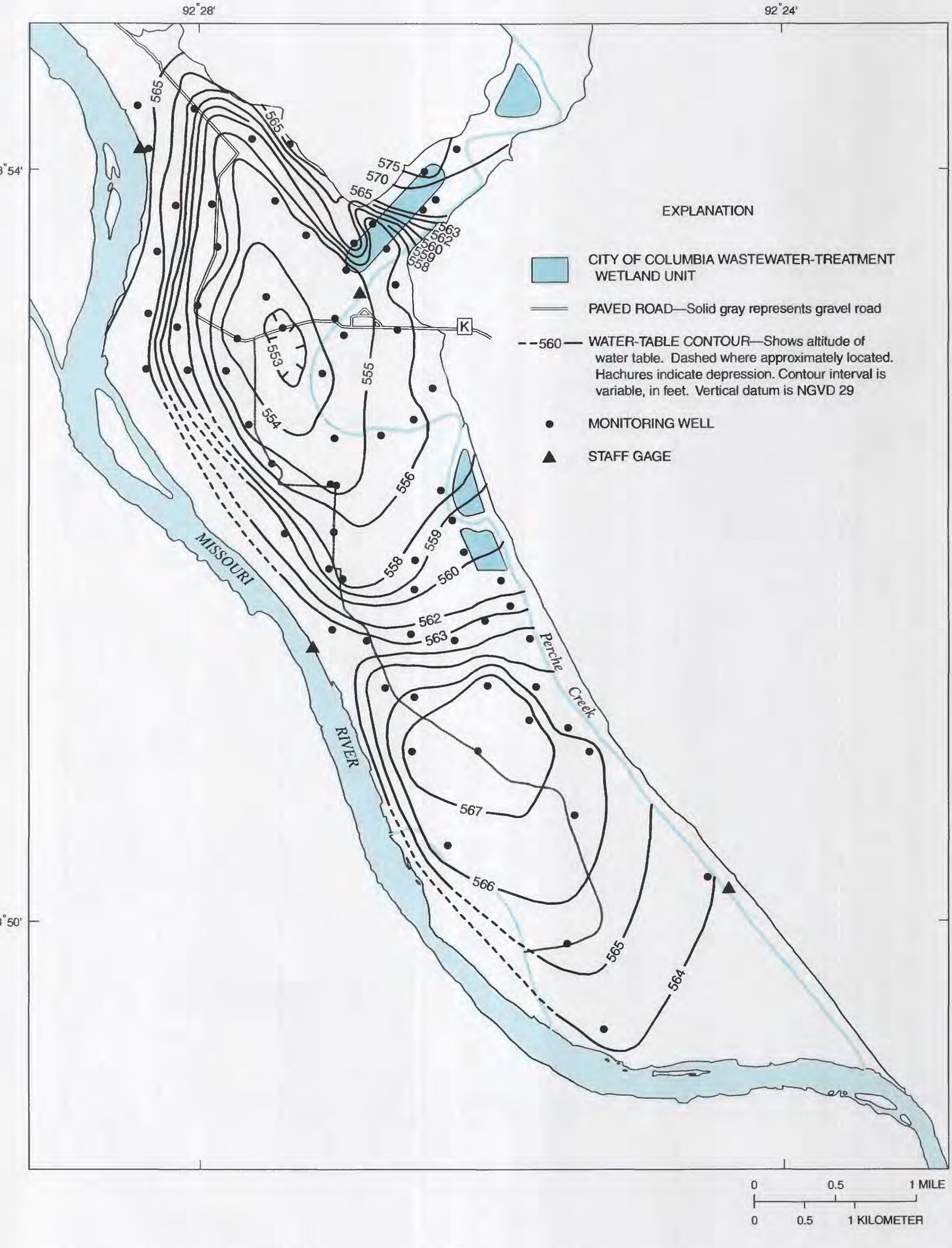

Figure 8. Altitude of the water table in the alluvial aquifer, March 19–20, 2001.

Table 8. Altitude of water levels in monitoring wells and staff gages, April 26–27, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	564.21	MW-125	560.08	MW-149	--	USGS-2S	566.77
MW-102	565.96	MW-126	556.76	MW-150	567.86	USGS-2D	566.16
MW-103	565.53	MW-127	558.31	MW-151	559.71	USGS-3S	563.71
MW-104	562.93	MW-128	558.46	MW-152	564.87	USGS-3D	563.46
MW-105	562.42	MW-129	557.28	MW-153	565.77	USGS-4	563.57
MW-106	563.39	MW-130	557.99	MW-154	556.70	USGS-5S	564.77
MW-107	563.73	MW-131	557.92	MW-155	556.86	USGS-5D	564.76
MW-108	565.69	MW-132	556.98	MW1-1A	569.38	USGS-6	560.92
MW-109	563.43	MW-133	556.22	MW1-1B	564.63	USGS-7	560.52
MW-110	561.97	MW-134	557.32	MW1-2A	557.15	USGS-8S	558.21
MW-111	558.94	MW-135	562.18	MW1-2B	557.12	USGS-8D	558.17
MW-112	561.69	MW-136	559.66	MW1-3A	554.03	USGS-9S	--
MW-113	561.49	MW-137	561.62	MW1-3B	553.92	USGS-9D	563.58
MW-114	564.41	MW-138	557.22	MW1-4A	572.21	SP11	562.93
MW-115	559.69	MW-139	556.76	MW1-4B	564.41	SP4	564.60
MW-116	560.80	MW-140	558.64	MW2-1A	559.33	MW13-67	558.14
MW-117	558.91	MW-141	556.89	MW2-1B	559.30	MW28-67	563.38
MW-118	560.40	MW-142	--	MW3-1A	561.11	River upper	566.70
MW-119	559.08	MW-143	569.02	MW3-1B	561.04	River lower	561.73
MW-120	557.30	MW-144	558.82	MW4-1A	563.10	Creek upper	557.64
MW-121	558.05	MW-145	562.50	MW4-1B	562.97	Creek lower	557.26
MW-122	557.29	MW-146	561.95	MW4-2A	564.66		
MW-123	556.91	MW-147	558.16	MW4-2B	564.63		
MW-124	558.14	MW-148	563.91	USGS-1	561.79		

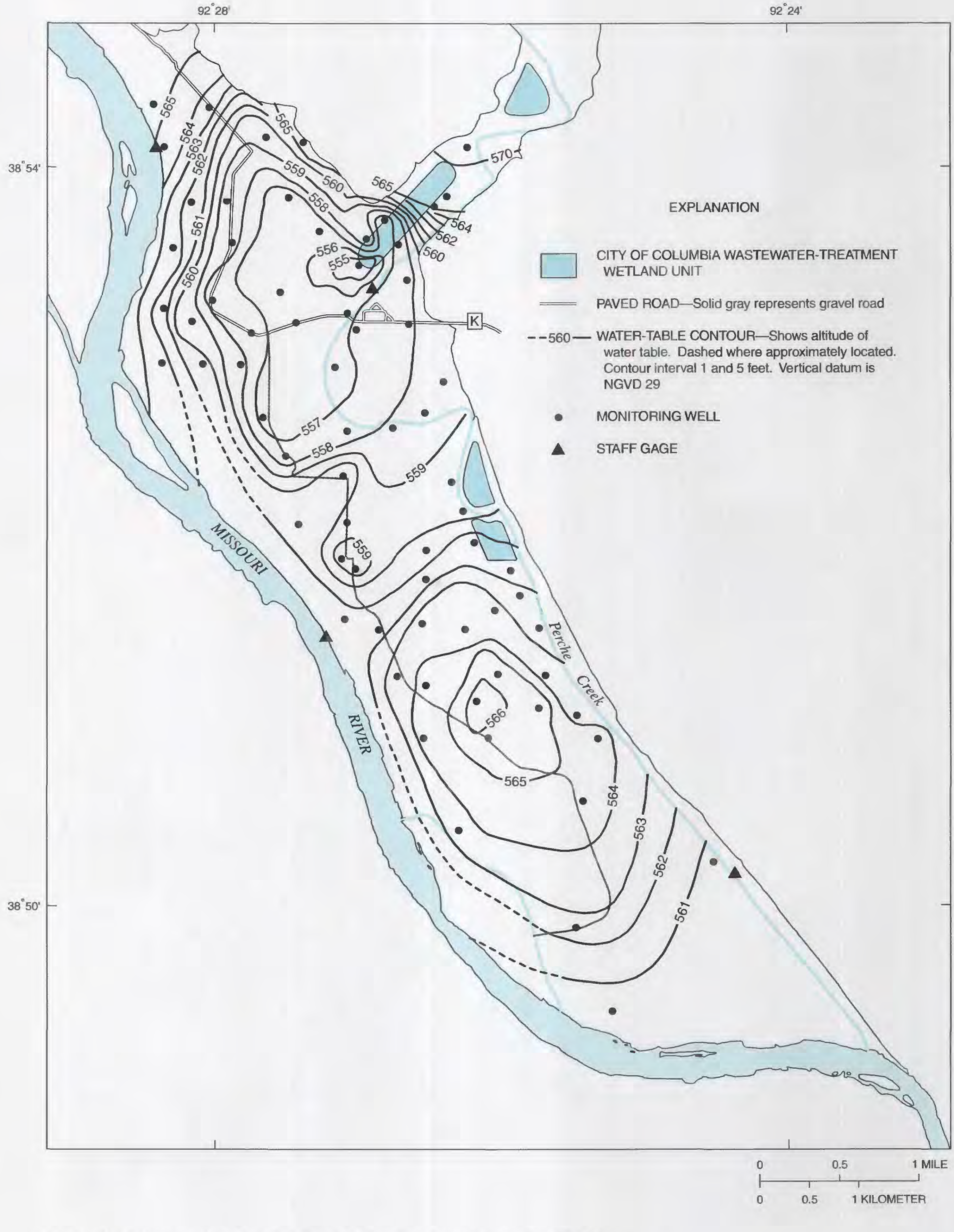

Figure 9. Altitude of the water table in the alluvial aquifer, April 26–27, 2001.

Table 9. Altitude of water levels in monitoring wells and staff gages, May 21–22, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	564.54	MW-125	561.17	MW-149	--	USGS-2S	566.55
MW-102	566.03	MW-126	558.50	MW-150	567.91	USGS-2D	566.54
MW-103	565.57	MW-127	560.45	MW-151	561.13	USGS-3S	564.14
MW-104	563.88	MW-128	560.90	MW-152	566.60	USGS-3D	563.89
MW-105	564.21	MW-129	559.13	MW-153	567.42	USGS-4	564.51
MW-106	564.72	MW-130	559.94	MW-154	558.21	USGS-5S	565.01
MW-107	564.96	MW-131	559.39	MW-155	558.64	USGS-5D	565.01
MW-108	565.90	MW-132	558.81	MW1-1A	569.82	USGS-6	562.15
MW-109	564.58	MW-133	557.14	MW1-1B	565.40	USGS-7	562.10
MW-110	563.75	MW-134	558.19	MW1-2A	558.96	USGS-8S	560.16
MW-111	561.83	MW-135	563.60	MW1-2B	558.96	USGS-8D	560.60
MW-112	563.47	MW-136	560.33	MW1-3A	558.62	USGS-9S	--
MW-113	563.44	MW-137	562.90	MW1-3B	558.54	USGS-9D	565.17
MW-114	565.26	MW-138	557.19	MW1-4A	572.38	SP11	564.04
MW-115	561.72	MW-139	557.87	MW1-4B	565.21	SP4	564.68
MW-116	563.76	MW-140	564.64	MW2-1A	561.23	MW13-67	560.58
MW-117	561.61	MW-141	558.81	MW2-1B	561.21	MW28-67	563.18
MW-118	562.39	MW-142	576.20	MW3-1A	562.94	River upper	570.40
MW-119	561.50	MW-143	569.26	MW3-1B	562.97	River lower	564.46
MW-120	559.35	MW-144	559.51	MW4-1A	564.46	Creek upper	560.49
MW-121	560.17	MW-145	563.89	MW4-1B	564.44	Creek lower	556.68
MW-122	559.57	MW-146	563.19	MW4-2A	565.36		
MW-123	559.05	MW-147	559.31	MW4-2B	565.34		
MW-124	559.14	MW-148	564.46	USGS-1	563.44		

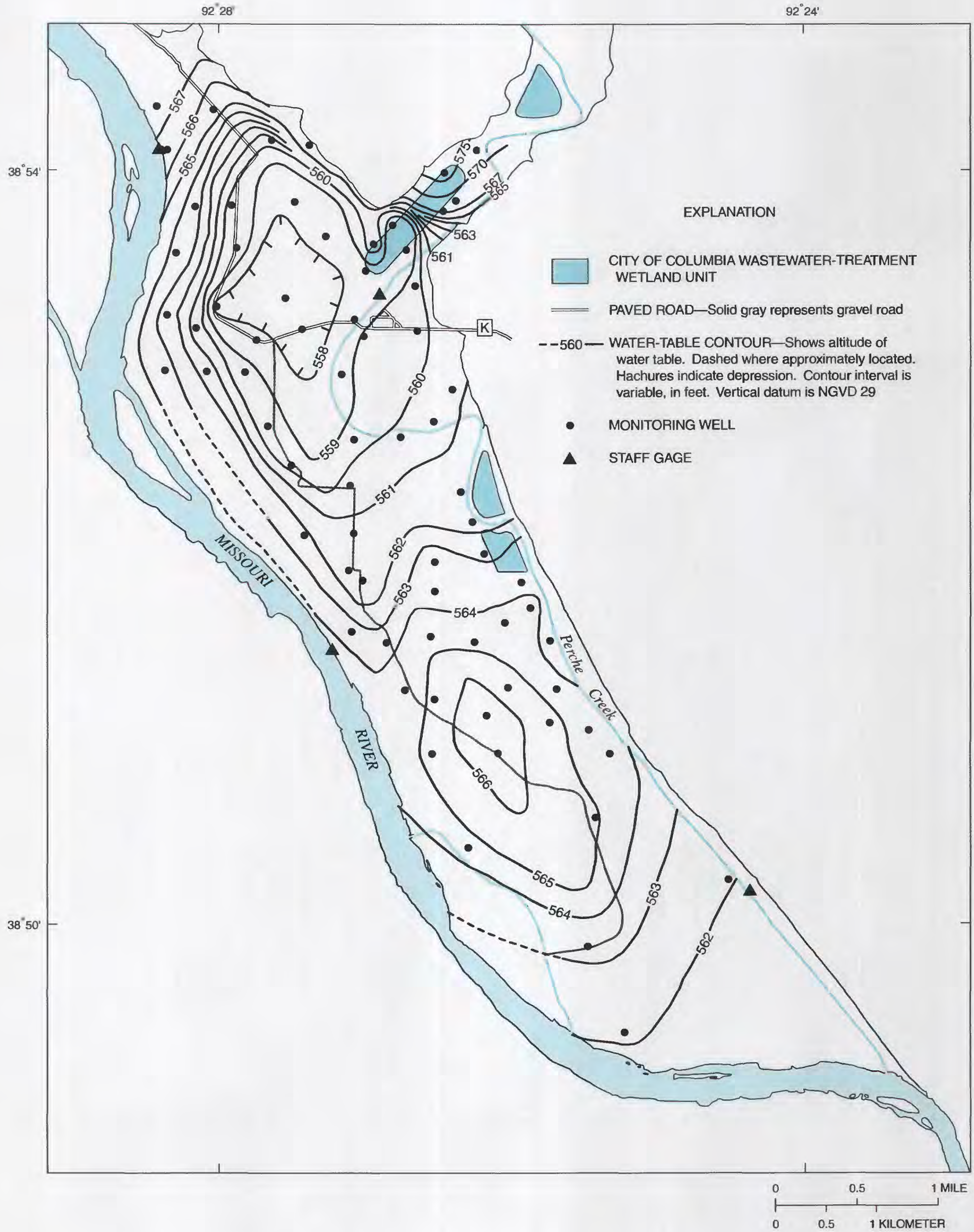

Figure 10. Altitude of the water table in the alluvial aquifer, May 21–22, 2001.

Table 10. Altitude of water levels in monitoring wells and staff gages, June 27–28, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	567.82	MW-125	569.13	MW-149	--	USGS-2S	568.04
MW-102	568.40	MW-126	564.40	MW-150	568.58	USGS-2D	568.05
MW-103	567.37	MW-127	565.06	MW-151	565.69	USGS-3S	566.10
MW-104	565.34	MW-128	564.96	MW-152	569.70	USGS-3D	565.91
MW-105	565.53	MW-129	564.50	MW-153	570.11	USGS-4	567.47
MW-106	566.44	MW-130	564.80	MW-154	563.34	USGS-5S	568.21
MW-107	566.91	MW-131	564.31	MW-155	563.71	USGS-5D	568.23
MW-108	567.32	MW-132	563.86	MW1-1A	570.67	USGS-6	563.60
MW-109	567.06	MW-133	563.83	MW1-1B	567.48	USGS-7	565.40
MW-110	567.06	MW-134	565.21	MW1-2A	563.48	USGS-8S	564.91
MW-111	567.05	MW-135	569.35	MW1-2B	563.49	USGS-8D	564.24
MW-112	566.92	MW-136	567.15	MW1-3A	563.54	USGS-9S	--
MW-113	567.60	MW-137	567.88	MW1-3B	563.44	USGS-9D	569.13
MW-114	567.29	MW-138	562.63	MW1-4A	572.44	SP11	569.24
MW-115	564.27	MW-139	563.78	MW1-4B	567.33	SP4	--
MW-116	566.31	MW-140	565.30	MW2-1A	564.41	MW13-67	563.24
MW-117	567.23	MW-141	563.46	MW2-1B	564.39	MW28-67	567.87
MW-118	--	MW-142	575.65	MW3-1A	565.54	River upper	570.20
MW-119	566.65	MW-143	570.23	MW3-1B	565.48	River lower	565.78
MW-120	566.87	MW-144	564.49	MW4-1A	567.45	Creek upper	560.84
MW-121	564.87	MW-145	567.29	MW4-1B	567.44	Creek lower	560.64
MW-122	565.09	MW-146	566.86	MW4-2A	567.35		
MW-123	567.66	MW-147	563.36	MW4-2B	567.37		
MW-124	567.37	MW-148	566.05	USGS-1	565.12		

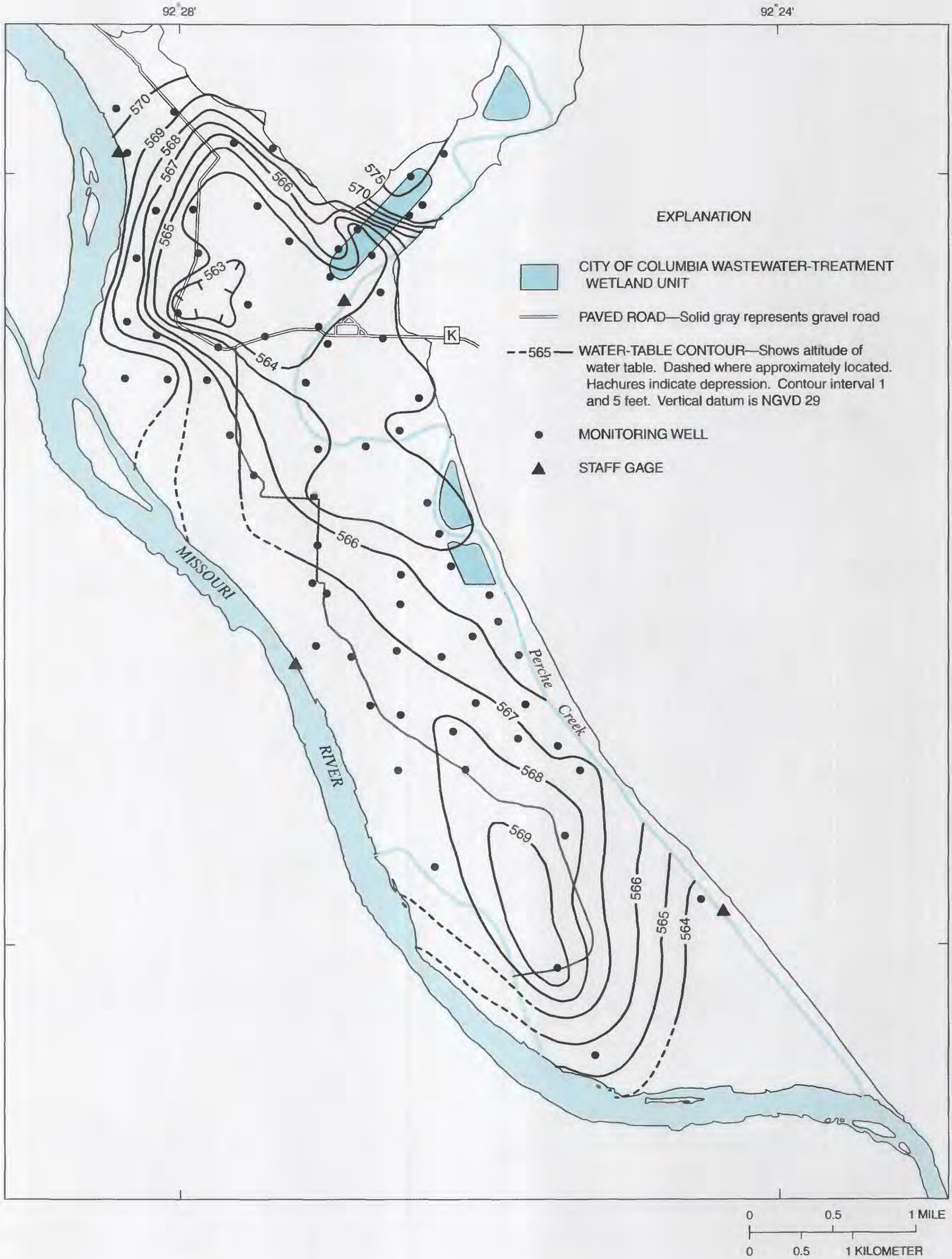

Figure 11. Altitude of the water table in the alluvial aquifer, June 27–28, 2001.

Table 11. Altitude of water levels in monitoring wells and staff gages, July 16–19, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	564.68	MW-125	563.20	MW-149	--	USGS-2S	564.01
MW-102	564.98	MW-126	559.49	MW-150	567.98	USGS-2D	564.02
MW-103	563.90	MW-127	559.45	MW-151	563.89	USGS-3S	563.11
MW-104	562.38	MW-128	559.74	MW-152	564.36	USGS-3D	562.80
MW-105	562.10	MW-129	560.35	MW-153	565.05	USGS-4	562.27
MW-106	562.83	MW-130	561.20	MW-154	561.95	USGS-5S	565.15
MW-107	562.91	MW-131	562.07	MW-155	561.58	USGS-5D	565.14
MW-108	563.66	MW-132	560.99	MW1-1A	569.79	USGS-6	560.42
MW-109	561.97	MW-133	561.86	MW1-1B	564.48	USGS-7	559.33
MW-110	561.58	MW-134	562.16	MW1-2A	561.55	USGS-8S	560.08
MW-111	561.65	MW-135	563.35	MW1-2B	561.57	USGS-8D	559.38
MW-112	562.44	MW-136	562.23	MW1-3A	561.90	USGS-9S	565.37
MW-113	560.85	MW-137	562.91	MW1-3B	561.77	USGS-9D	565.39
MW-114	562.76	MW-138	559.89	MW1-4A	572.03	SP11	565.76
MW-115	559.31	MW-139	562.12	MW1-4B	563.53	SP4	570.78
MW-116	561.83	MW-140	563.27	MW2-1A	559.50	MW13-67	558.44
MW-117	561.38	MW-141	562.04	MW2-1B	559.47	MW28-67	562.99
MW-118	562.44	MW-142	575.28	MW3-1A	561.33	River upper	563.80
MW-119	561.27	MW-143	569.11	MW3-1B	561.25	River lower	560.43
MW-120	560.76	MW-144	561.13	MW4-1A	562.99	Creek upper	556.64
MW-121	559.95	MW-145	562.92	MW4-1B	562.83	Creek lower	556.75
MW-122	560.20	MW-146	562.35	MW4-2A	562.83		
MW-123	561.17	MW-147	559.45	MW4-2B	562.80		
MW-124	562.86	MW-148	562.60	USGS-1	561.27		

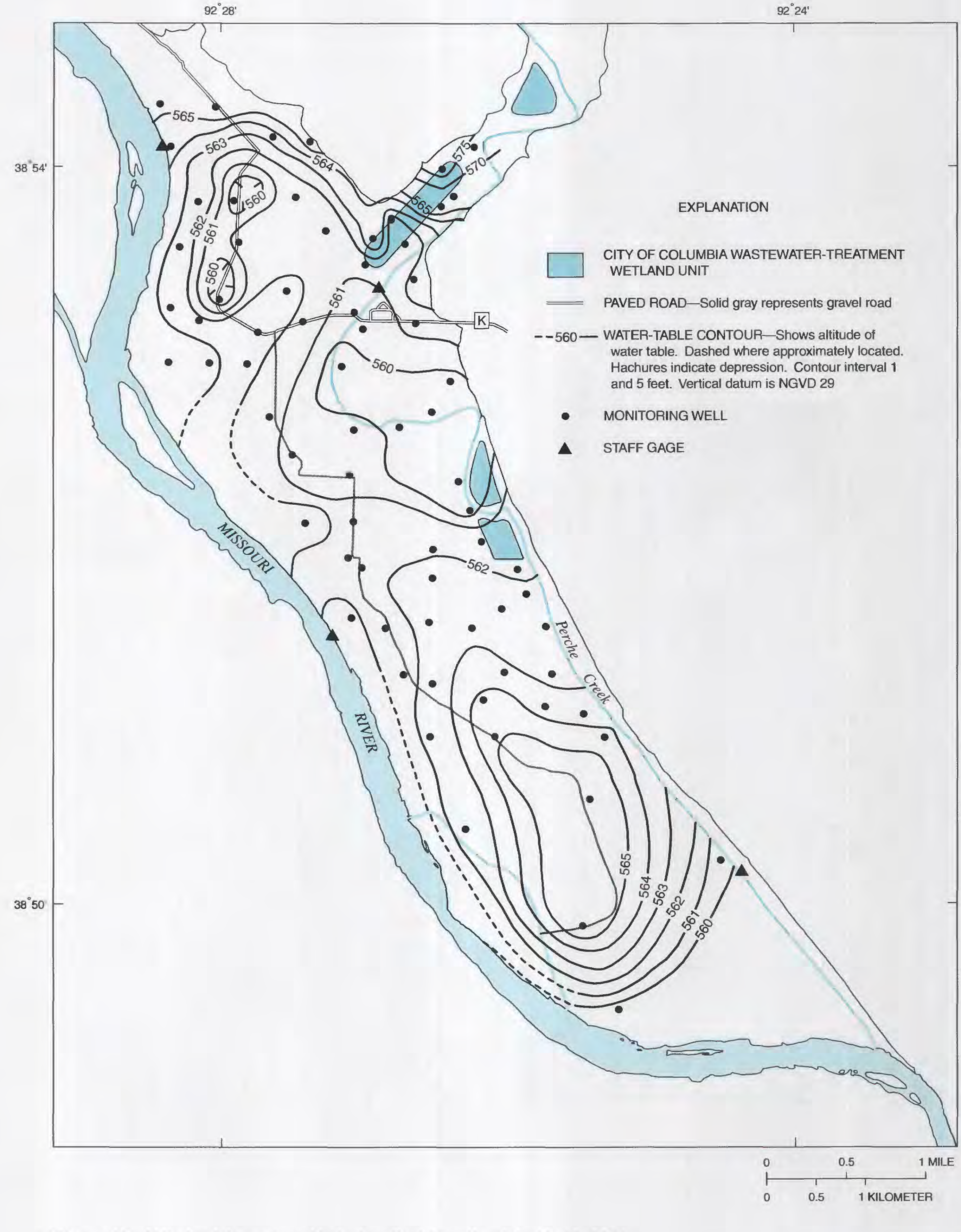

Figure 12. Altitude of the water table in the alluvial aquifer, July 16–19, 2001.

Table 12. Altitude of water levels in monitoring wells and staff gages, August 27–29, 2001

[Altitudes are in feet above NGVD 29; ft, feet]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	--	MW-125	557.83	MW-149	--	USGS-2S	--
MW-102	562.42	MW-126	555.73	MW-150	567.05	USGS-2D	--
MW-103	561.60	MW-127	555.79	MW-151	560.56	USGS-3S	559.96
MW-104	559.77	MW-128	556.24	MW-152	561.01	USGS-3D	559.74
MW-105	558.41	MW-129	556.86	MW-153	561.37	USGS-4	559.55
MW-106	559.80	MW-130	557.79	MW-154	558.76	USGS-5S	561.12
MW-107	560.12	MW-131	558.80	MW-155	558.70	USGS-5D	561.12
MW-108	563.30	MW-132	557.22	MW1-1A	569.05	USGS-6	557.20
MW-109	559.44	MW-133	556.67	MW1-1B	562.85	USGS-7	556.60
MW-110	558.08	MW-134	556.86	MW1-2A	558.95	USGS-8S	554.32
MW-111	555.58	MW-135	558.98	MW1-2B	558.97	USGS-8D	553.80
MW-112	557.70	MW-136	557.41	MW1-3A	558.65	USGS-9S	561.28
MW-113	557.59	MW-137	559.20	MW1-3B	558.52	USGS-9D	561.29
MW-114	560.53	MW-138	556.25	MW1-4A	571.63	SP11	560.51
MW-115	556.19	MW-139	557.57	MW1-4B	561.84	SP4	564.94
MW-116	556.92	MW-140	560.75	MW2-1A	555.97	MW13-67	553.01
MW-117	555.57	MW-141	559.26	MW2-1B	555.96	MW28-67	559.69
MW-118	556.93	MW-142	574.87	MW3-1A	557.25	River upper	562.45
MW-119	555.73	MW-143	568.20	MW3-1B	557.19	River lower	558.72
MW-120	555.32	MW-144	557.72	MW4-1A	559.06	Creek upper	555.58
MW-121	555.40	MW-145	559.34	MW4-1B	558.83	Creek lower	551.59
MW-122	554.93	MW-146	559.06	MW4-2A	561.14		
MW-123	555.51	MW-147	556.21	MW4-2B	561.11		
MW-124	557.09	MW-148	560.55	USGS-1	557.87		

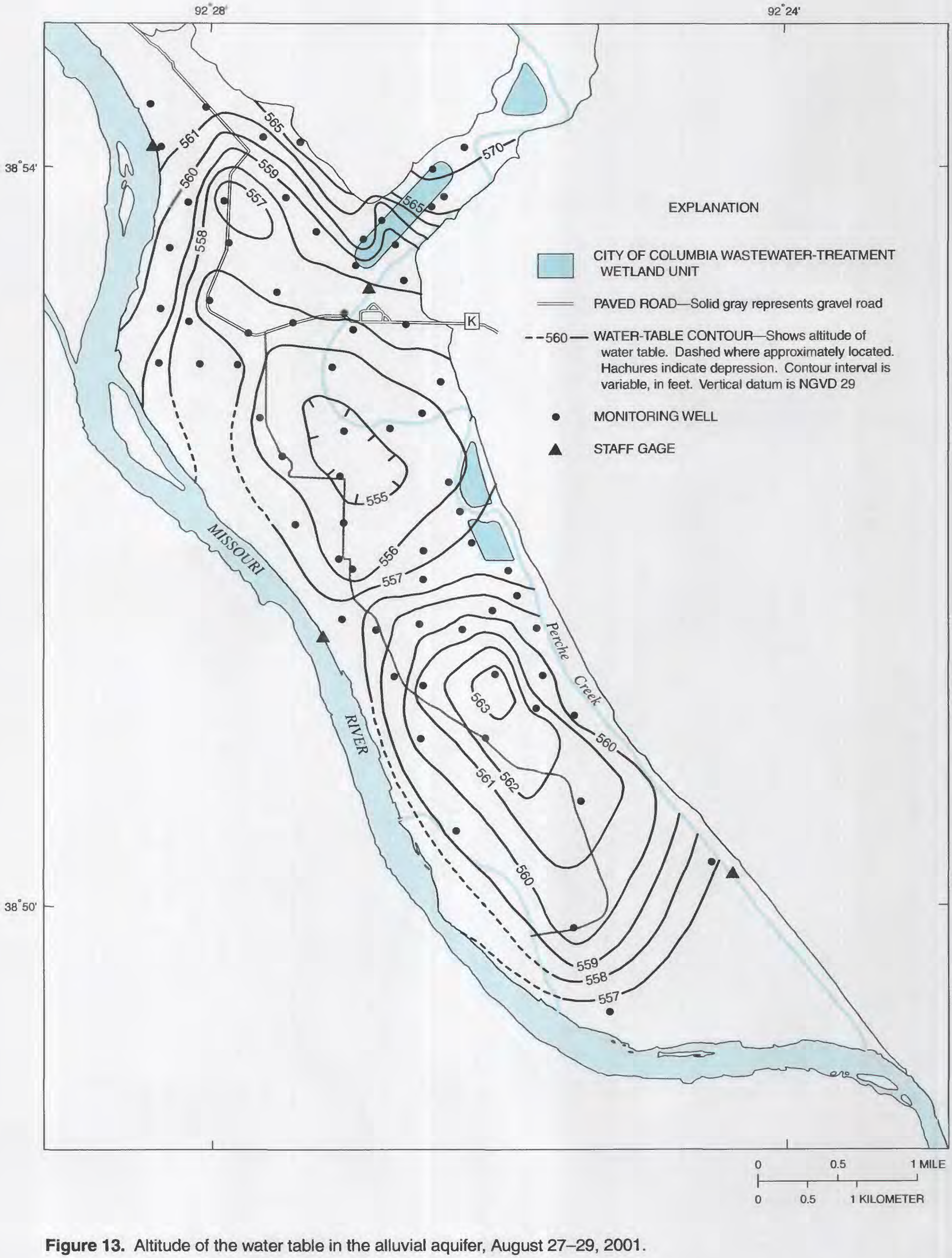

Figure 13. Altitude of the water table in the alluvial aquifer, August 27–29, 2001.

Table 13. Altitude of water levels in monitoring wells and staff gages, September 25–26, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	562.14	MW-125	557.40	MW-149	--	USGS-2S	564.97
MW-102	563.63	MW-126	554.79	MW-150	566.14	USGS-2D	564.92
MW-103	564.59	MW-127	555.28	MW-151	558.87	USGS-3S	562.98
MW-104	563.53	MW-128	555.45	MW-152	561.69	USGS-3D	562.71
MW-105	562.11	MW-129	555.88	MW-153	562.07	USGS-4	559.90
MW-106	562.00	MW-130	556.71	MW-154	557.21	USGS-5S	560.00
MW-107	561.76	MW-131	557.78	MW-155	557.23	USGS-5D	560.00
MW-108	564.99	MW-132	556.15	MW1-1A	568.52	USGS-6	556.71
MW-109	560.73	MW-133	555.88	MW1-1B	562.25	USGS-7	557.15
MW-110	559.22	MW-134	555.92	MW1-2A	557.84	USGS-8S	553.19
MW-111	556.36	MW-135	559.19	MW1-2B	557.86	USGS-8D	552.46
MW-112	558.50	MW-136	556.73	MW1-3A	557.30	USGS-9S	560.52
MW-113	558.70	MW-137	558.82	MW1-3B	557.26	USGS-9D	560.57
MW-114	561.90	MW-138	554.45	MW1-4A	571.23	SP11	559.36
MW-115	556.44	MW-139	556.23	MW1-4B	561.19	SP4	564.69
MW-116	557.45	MW-140	559.43	MW2-1A	555.89	MW13-67	551.58
MW-117	556.46	MW-141	558.02	MW2-1B	555.88	MW28-67	558.05
MW-118	557.01	MW-142	574.28	MW3-1A	557.89	River upper	--
MW-119	555.82	MW-143	567.85	MW3-1B	557.83	River lower	--
MW-120	554.58	MW-144	556.60	MW4-1A	560.10	Creek upper	--
MW-121	554.82	MW-145	559.54	MW4-1B	560.09	Creek lower	--
MW-122	553.95	MW-146	558.96	MW4-2A	562.24		
MW-123	555.34	MW-147	555.44	MW4-2B	562.26		
MW-124	556.17	MW-148	563.77	USGS-1	559.29		

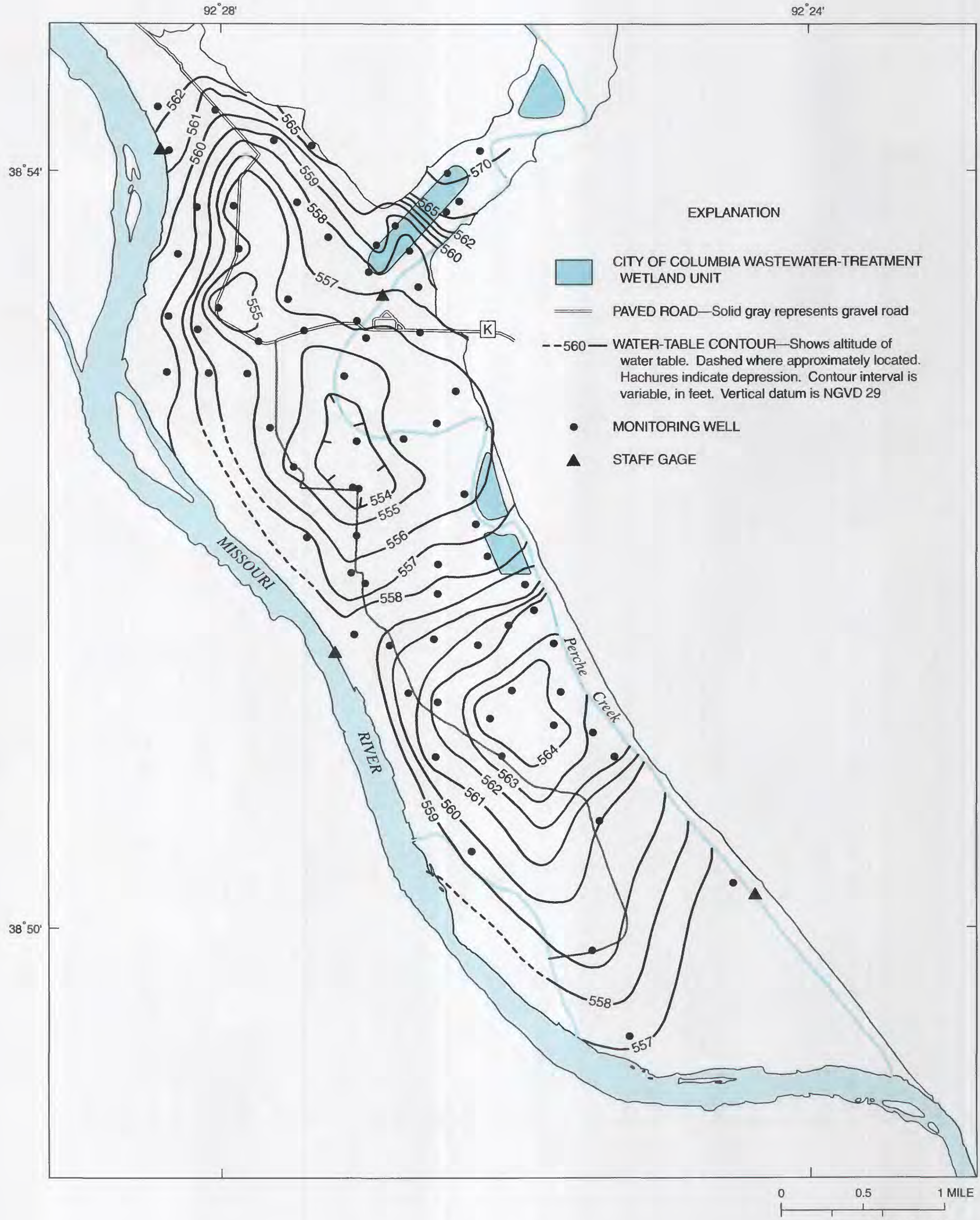

Figure 14. Altitude of the water table in the alluvial aquifer, September 25–26, 2001.

Table 14. Altitude of water levels in monitoring wells and staff gages, October 16–17, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	565.50	MW-125	556.42	MW-149	--	USGS-2S	564.48
MW-102	565.03	MW-126	554.29	MW-150	566.23	USGS-2D	564.48
MW-103	564.66	MW-127	554.39	MW-151	558.51	USGS-3S	563.10
MW-104	561.46	MW-128	554.91	MW-152	559.47	USGS-3D	562.87
MW-105	559.75	MW-129	555.44	MW-153	559.93	USGS-4	559.72
MW-106	560.63	MW-130	551.58	MW-154	556.81	USGS-5S	564.67
MW-107	561.09	MW-131	562.44	MW-155	556.88	USGS-5D	564.76
MW-108	564.03	MW-132	555.77	MW1-1A	568.93	USGS-6	557.12
MW-109	--	MW-133	555.79	MW1-1B	562.09	USGS-7	555.40
MW-110	560.03	MW-134	555.69	MW1-2A	557.30	USGS-8S	553.02
MW-111	555.31	MW-135	557.40	MW1-2B	557.31	USGS-8D	552.46
MW-112	557.77	MW-136	555.64	MW1-3A	556.90	USGS-9S	--
MW-113	557.86	MW-137	556.84	MW1-3B	556.78	USGS-9D	559.93
MW-114	562.21	MW-138	554.28	MW1-4A	571.51	SP11	558.91
MW-115	555.10	MW-139	556.10	MW1-4B	561.00	SP4	564.65
MW-116	556.61	MW-140	561.76	MW2-1A	554.73	MW13-67	551.57
MW-117	555.29	MW-141	557.52	MW2-1B	554.72	MW28-67	559.00
MW-118	555.47	MW-142	574.99	MW3-1A	556.84	River upper	560.15
MW-119	554.92	MW-143	568.13	MW3-1B	556.76	River lower	556.59
MW-120	553.55	MW-144	556.16	MW4-1A	559.71	Creek upper	553.74
MW-121	554.13	MW-145	557.81	MW4-1B	559.73	Creek lower	552.36
MW-122	553.64	MW-146	557.66	MW4-2A	562.58		
MW-123	554.58	MW-147	554.51	MW4-2B	562.61		
MW-124	555.75	MW-148	562.19	USGS-1	558.04		

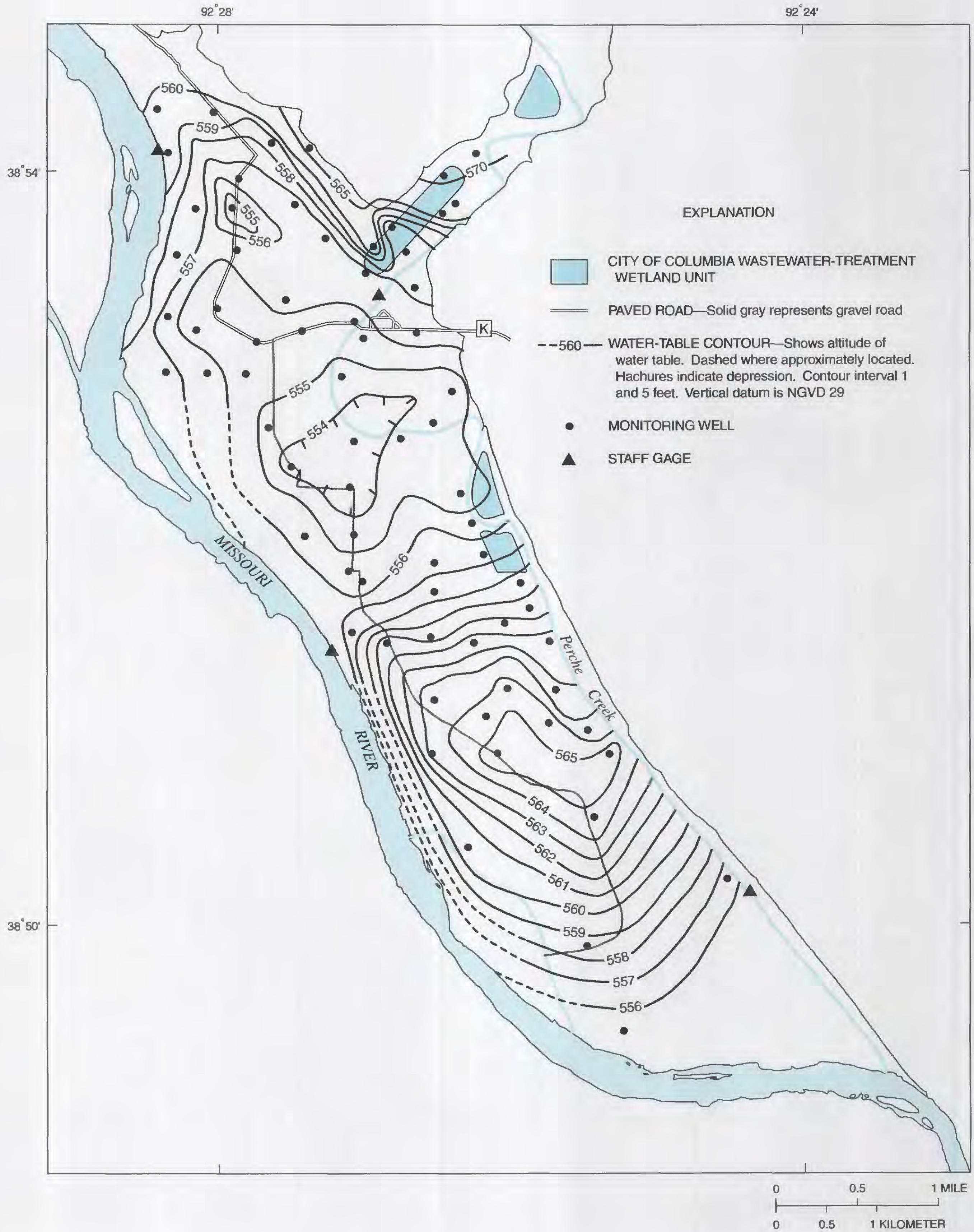

Figure 15. Altitude of the water table in the alluvial aquifer, October 16–17, 2001.

Table 15. Altitude of water levels in monitoring wells and staff gages, November 5–6, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	567.28	MW-125	555.80	MW-149	--	USGS-2S	564.54
MW-102	566.68	MW-126	553.90	MW-150	566.31	USGS-2D	565.54
MW-103	566.06	MW-127	554.13	MW-151	558.06	USGS-3S	564.61
MW-104	561.62	MW-128	554.57	MW-152	558.61	USGS-3D	564.32
MW-105	559.14	MW-129	554.99	MW-153	559.08	USGS-4	562.01
MW-106	561.03	MW-130	556.16	MW-154	556.43	USGS-5S	567.68
MW-107	561.72	MW-131	557.20	MW-155	556.56	USGS-5D	567.71
MW-108	564.87	MW-132	555.30	MW1-1A	568.73	USGS-6	559.62
MW-109	562.48	MW-133	555.41	MW1-1B	561.74	USGS-7	557.00
MW-110	560.54	MW-134	555.23	MW1-2A	556.78	USGS-8S	552.86
MW-111	555.86	MW-135	556.67	MW1-2B	556.79	USGS-8D	552.26
MW-112	558.37	MW-136	555.05	MW1-3A	556.46	USGS-9S	559.21
MW-113	558.53	MW-137	556.31	MW1-3B	556.35	USGS-9D	559.23
MW-114	562.89	MW-138	553.10	MW1-4A	571.47	SP11	560.05
MW-115	554.82	MW-139	555.73	MW1-4B	560.59	SP4	564.75
MW-116	556.98	MW-140	559.28	MW2-1A	554.47	MW13-67	551.38
MW-117	555.18	MW-141	557.05	MW2-1B	554.46	MW28-67	563.23
MW-118	555.04	MW-142	574.65	MW3-1A	556.93	River upper	559.30
MW-119	554.66	MW-143	567.96	MW3-1B	556.86	River lower	555.35
MW-120	552.94	MW-144	555.42	MW4-1A	560.73	Creek upper	551.84
MW-121	553.91	MW-145	557.07	MW4-1B	560.71	Creek lower	551.24
MW-122	553.46	MW-146	556.99	MW4-2A	563.31		
MW-123	553.72	MW-147	554.80	MW4-2B	563.33		
MW-124	555.21	MW-148	563.50	USGS-1	557.98		

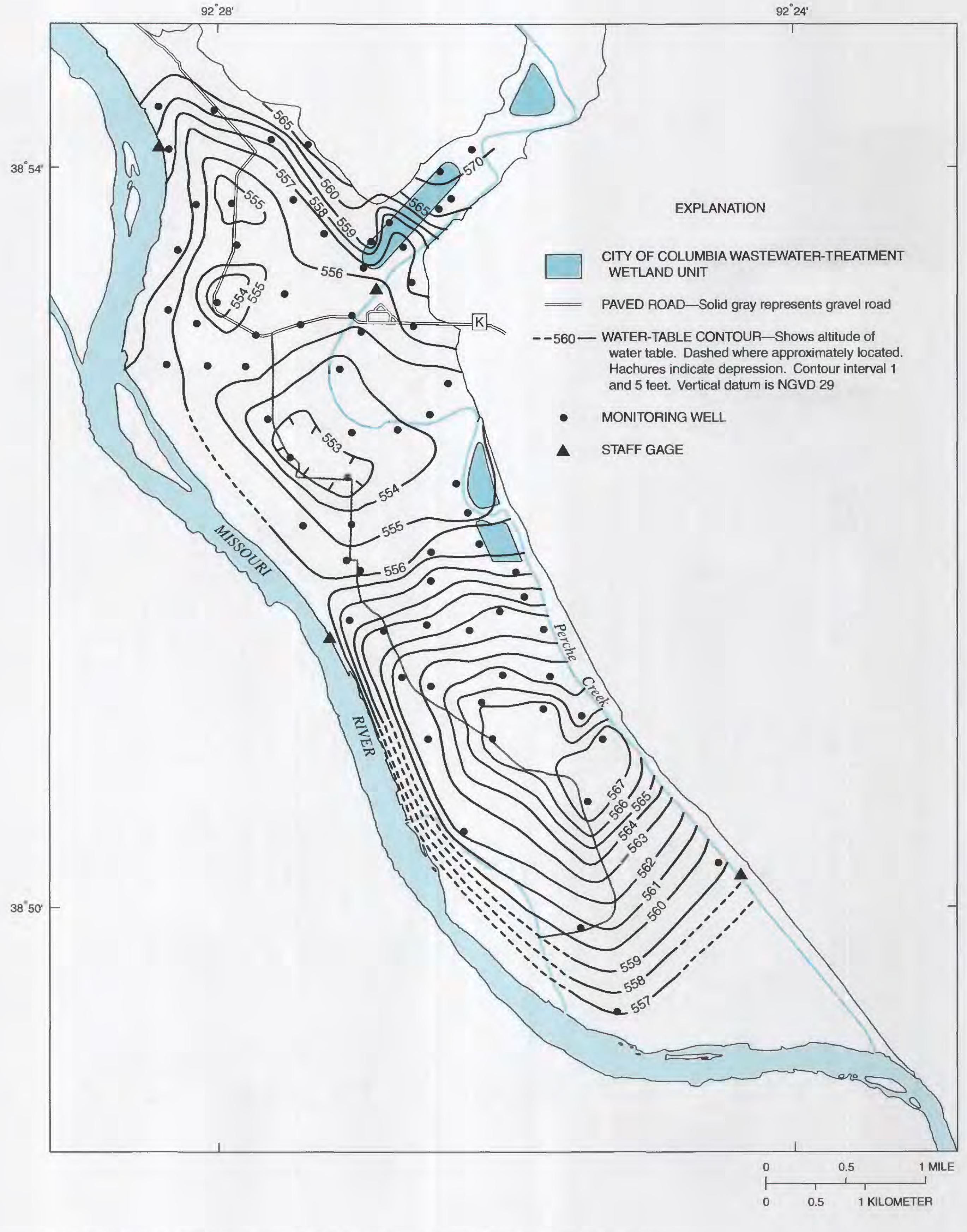

Figure 16. Altitude of the water table in the alluvial aquifer, November 5–6, 2001.

Table 16. Altitude of water levels in monitoring wells and staff gages, December 3–4, 2001

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	567.77	MW-125	554.57	MW-149	--	USGS-2S	565.88
MW-102	567.06	MW-126	553.33	MW-150	566.39	USGS-2D	566.07
MW-103	566.69	MW-127	553.77	MW-151	557.66	USGS-3S	565.15
MW-104	561.87	MW-128	554.04	MW-152	558.50	USGS-3D	564.87
MW-105	559.62	MW-129	554.38	MW-153	558.86	USGS-4	562.57
MW-106	561.74	MW-130	555.26	MW-154	555.97	USGS-5S	568.04
MW-107	562.46	MW-131	556.13	MW-155	556.28	USGS-5D	568.05
MW-108	565.63	MW-132	554.72	MW1-1A	568.64	USGS-6	560.16
MW-109	563.90	MW-133	554.83	MW1-1B	561.56	USGS-7	558.34
MW-110	561.77	MW-134	554.69	MW1-2A	556.22	USGS-8S	553.05
MW-111	555.78	MW-135	556.21	MW1-2B	556.23	USGS-8D	552.83
MW-112	558.97	MW-136	555.29	MW1-3A	--	USGS-9S	558.57
MW-113	558.73	MW-137	556.37	MW1-3B	555.73	USGS-9D	558.58
MW-114	563.29	MW-138	554.53	MW1-4A	571.47	SP11	561.63
MW-115	555.06	MW-139	555.22	MW1-4B	560.43	SP4	565.00
MW-116	557.38	MW-140	558.72	MW2-1A	554.65	MW13-67	552.78
MW-117	555.39	MW-141	556.52	MW2-1B	554.64	MW28-67	564.47
MW-118	555.11	MW-142	574.73	MW3-1A	557.37	River upper	559.25
MW-119	554.90	MW-143	567.96	MW3-1B	557.29	River lower	555.30
MW-120	553.87	MW-144	555.17	MW4-1A	561.75	Creek upper	551.40
MW-121	553.48	MW-145	556.99	MW4-1B	561.61	Creek lower	551.18
MW-122	552.72	MW-146	556.81	MW4-2A	563.85		
MW-123	553.85	MW-147	554.96	MW4-2B	563.86		
MW-124	554.17	MW-148	564.23	USGS-1	558.38		

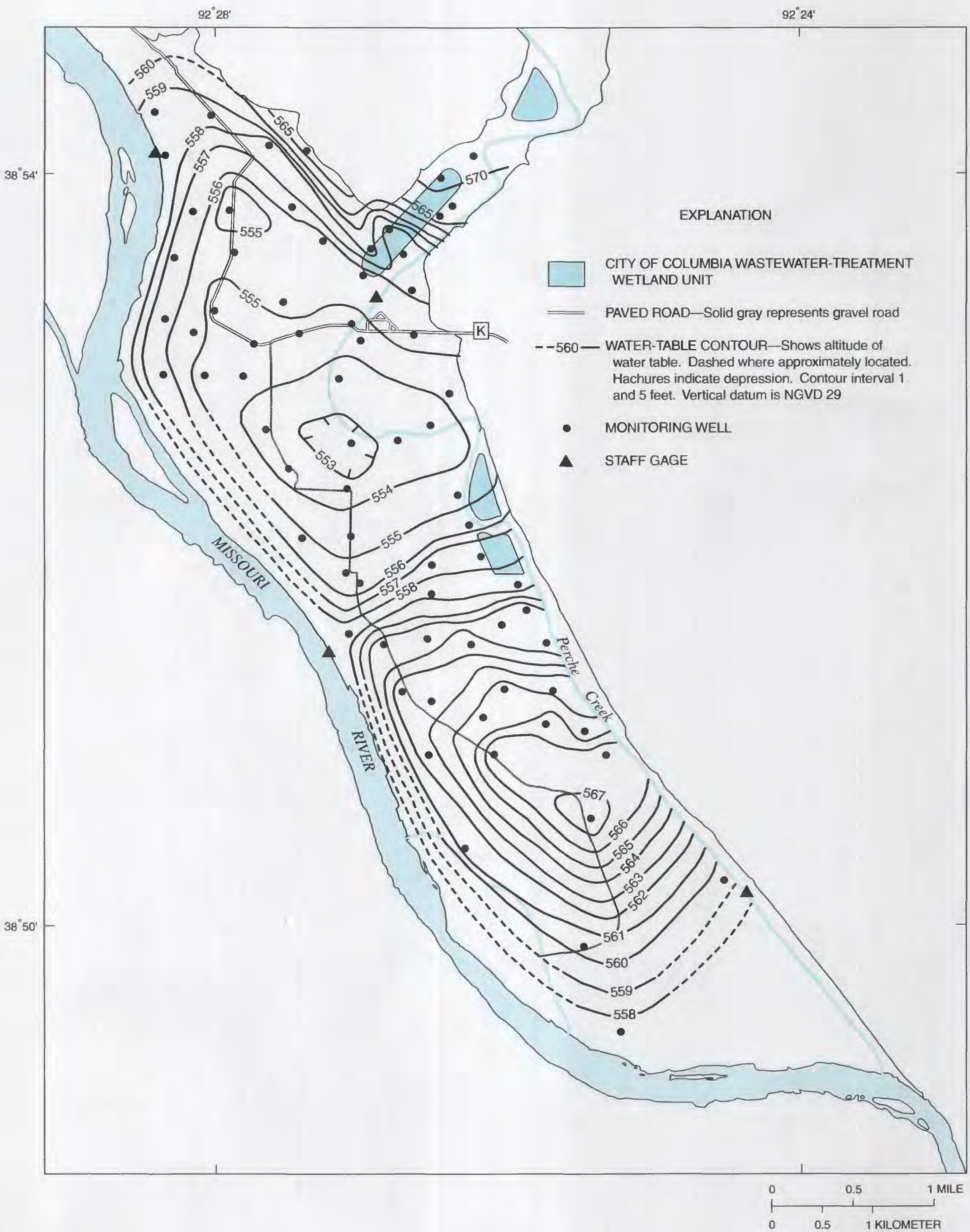

Figure 17. Altitude of the water table in the alluvial aquifer, December 3–4, 2001.

Table 17. Altitude of water levels in monitoring wells and staff gages, January 28–29, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	559.18	MW-125	553.06	MW-149	--	USGS-2S	559.00
MW-102	560.26	MW-126	--	MW-150	567.68	USGS-2D	559.00
MW-103	559.22	MW-127	560.51	MW-151	555.74	USGS-3S	557.85
MW-104	556.32	MW-128	--	MW-152	555.58	USGS-3D	557.63
MW-105	555.40	MW-129	553.31	MW-153	555.92	USGS-4	556.39
MW-106	556.41	MW-130	554.16	MW-154	554.51	USGS-5S	560.07
MW-107	556.52	MW-131	554.91	MW-155	554.89	USGS-5D	560.06
MW-108	558.35	MW-132	553.57	MW1-1A	568.23	USGS-6	554.36
MW-109	555.40	MW-133	553.38	MW1-1B	561.00	USGS-7	552.52
MW-110	554.34	MW-134	552.81	MW1-2A	555.10	USGS-8S	551.18
MW-111	552.54	MW-135	553.76	MW1-2B	555.10	USGS-8D	550.89
MW-112	554.60	MW-136	552.26	MW1-3A	554.64	USGS-9S	556.07
MW-113	553.31	MW-137	553.52	MW1-3B	554.51	USGS-9D	556.09
MW-114	557.39	MW-138	550.94	MW1-4A	571.24	SP11	561.18
MW-115	552.38	MW-139	--	MW1-4B	559.92	SP4	564.94
MW-116	553.90	MW-140	557.96	MW2-1A	552.59	MW13-67	--
MW-117	552.14	MW-141	555.33	MW2-1B	552.58	MW28-67	556.97
MW-118	552.43	MW-142	574.48	MW3-1A	554.01	River upper	560.01
MW-119	552.18	MW-143	567.55	MW3-1B	553.93	River lower	552.40
MW-120	550.57	MW-144	552.87	MW4-1A	555.54	Creek upper	552.04
MW-121	552.22	MW-145	554.19	MW4-1B	555.42	Creek lower	548.62
MW-122	551.32	MW-146	554.12	MW4-2A	556.91		
MW-123	551.35	MW-147	552.14	MW4-2B	556.92		
MW-124	552.64	MW-148	557.35	USGS-1	554.67		

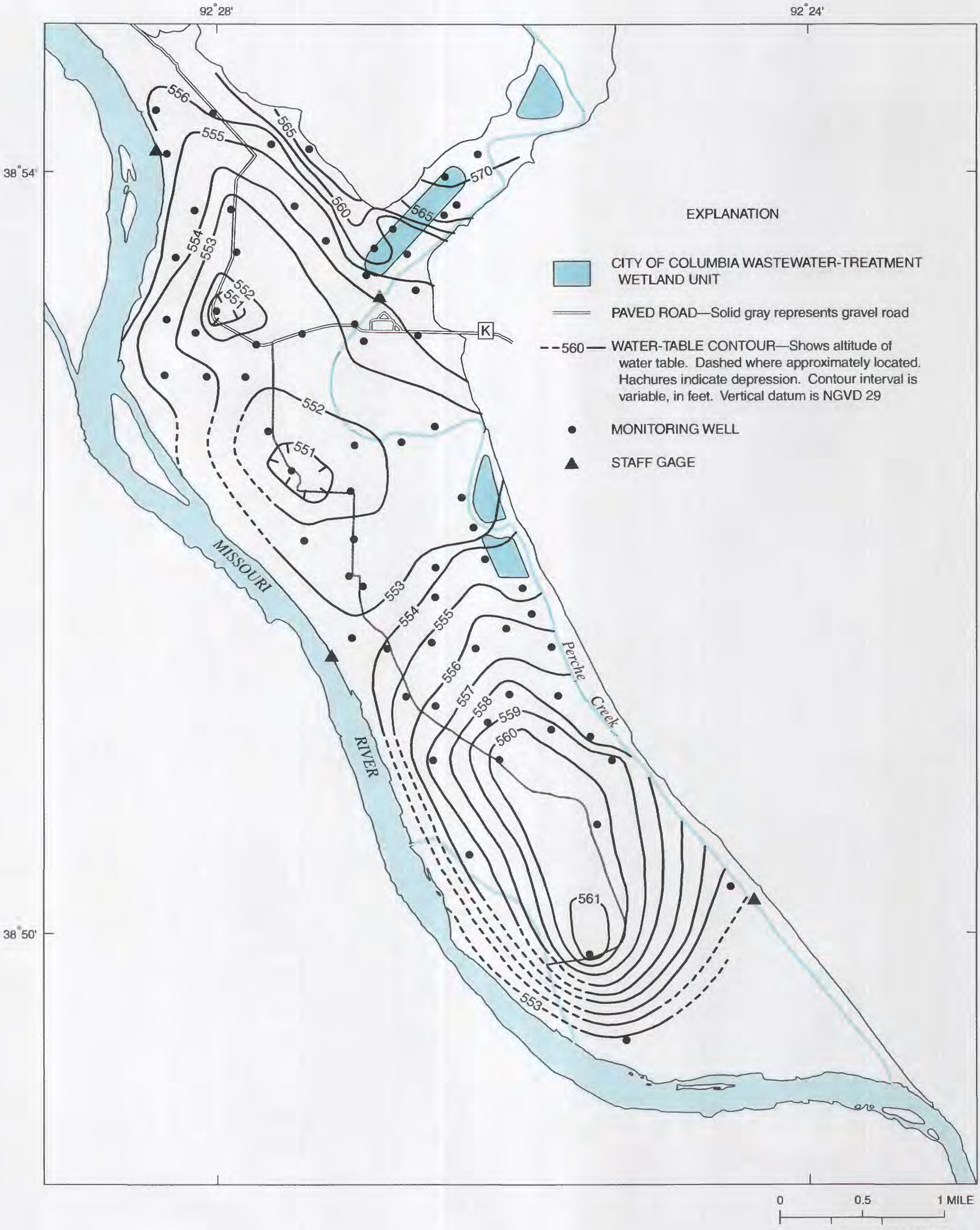

Figure 18. Altitude of the water table in the alluvial aquifer, January 28–29, 2002.

Table 18. Altitude of water levels in monitoring wells and staff gages, February 12–13, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	560.06	MW-125	552.87	MW-149	--	USGS-2S	559.79
MW-102	560.95	MW-126	552.07	MW-150	567.47	USGS-2D	559.77
MW-103	560.24	MW-127	552.51	MW-151	555.31	USGS-3S	558.69
MW-104	557.09	MW-128	553.33	MW-152	555.58	USGS-3D	558.49
MW-105	555.88	MW-129	554.26	MW-153	555.95	USGS-4	557.04
MW-106	556.92	MW-130	554.27	MW-154	554.12	USGS-5S	561.37
MW-107	556.99	MW-131	554.92	MW-155	554.44	USGS-5D	561.36
MW-108	559.24	MW-132	553.53	MW1-1A	568.83	USGS-6	555.15
MW-109	555.75	MW-133	553.06	MW1-1B	561.90	USGS-7	552.96
MW-110	554.48	MW-134	552.47	MW1-2A	555.13	USGS-8S	551.09
MW-111	552.45	MW-135	553.74	MW1-2B	555.12	USGS-8D	550.83
MW-112	554.60	MW-136	551.95	MW1-3A	554.51	USGS-9S	556.00
MW-113	553.45	MW-137	553.31	MW1-3B	554.39	USGS-9D	556.03
MW-114	557.87	MW-138	550.05	MW1-4A	571.83	SP11	560.61
MW-115	552.54	MW-139	553.15	MW1-4B	561.02	SP4	564.78
MW-116	553.83	MW-140	560.88	MW2-1A	552.65	MW13-67	550.82
MW-117	552.09	MW-141	555.25	MW2-1B	552.62	MW28-67	557.66
MW-118	552.50	MW-142	575.60	MW3-1A	554.05	River upper	556.57
MW-119	552.10	MW-143	568.09	MW3-1B	553.99	River lower	553.04
MW-120	550.65	MW-144	552.48	MW4-1A	555.73	Creek upper	552.67
MW-121	552.17	MW-145	553.97	MW4-1B	555.62	Creek lower	551.49
MW-122	551.31	MW-146	553.90	MW4-2A	557.35		
MW-123	551.49	MW-147	551.86	MW4-2B	557.38		
MW-124	552.43	MW-148	558.30	USGS-1	554.95		

Figure 19. Altitude of the water table in the alluvial aquifer, February 12–13, 2002.

Table 19. Altitude of water levels in monitoring wells and staff gages, March 21–22, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	557.49	MW-125	550.75	MW-149	--	USGS-2S	557.78
MW-102	558.74	MW-126	551.58	MW-150	567.71	USGS-2D	557.81
MW-103	557.35	MW-127	552.46	MW-151	554.69	USGS-3S	556.63
MW-104	555.70	MW-128	552.89	MW-152	556.61	USGS-3D	556.41
MW-105	554.87	MW-129	552.68	MW-153	566.67	USGS-4	556.28
MW-106	555.61	MW-130	553.64	MW-154	553.30	USGS-5S	559.44
MW-107	555.82	MW-131	554.39	MW-155	553.75	USGS-5D	559.45
MW-108	557.16	MW-132	552.78	MW1-1A	568.75	USGS-6	555.17
MW-109	555.56	MW-133	551.97	MW1-1B	561.84	USGS-7	553.44
MW-110	554.73	MW-134	551.10	MW1-2A	554.37	USGS-8S	552.18
MW-111	552.59	MW-135	553.09	MW1-2B	554.36	USGS-8D	552.18
MW-112	554.13	MW-136	551.01	MW1-3A	553.70	USGS-9S	555.65
MW-113	554.19	MW-137	553.37	MW1-3B	553.57	USGS-9D	555.68
MW-114	557.20	MW-138	549.26	MW1-4A	571.74	SP11	559.27
MW-115	552.62	MW-139	552.10	MW1-4B	560.95	SP4	564.40
MW-116	553.53	MW-140	558.66	MW2-1A	552.70	MW13-67	552.17
MW-117	552.29	MW-141	554.48	MW2-1B	552.69	MW28-67	557.29
MW-118	552.99	MW-142	575.33	MW3-1A	553.67	River upper	561.50
MW-119	552.41	MW-143	568.12	MW3-1B	553.62	River lower	554.70
MW-120	550.70	MW-144	551.87	MW4-1A	555.12	Creek upper	552.74
MW-121	552.41	MW-145	554.33	MW4-1B	555.10	Creek lower	550.66
MW-122	551.94	MW-146	554.04	MW4-2A	556.60		
MW-123	550.40	MW-147	551.49	MW4-2B	556.60		
MW-124	550.65	MW-148	556.17	USGS-1	554.25		

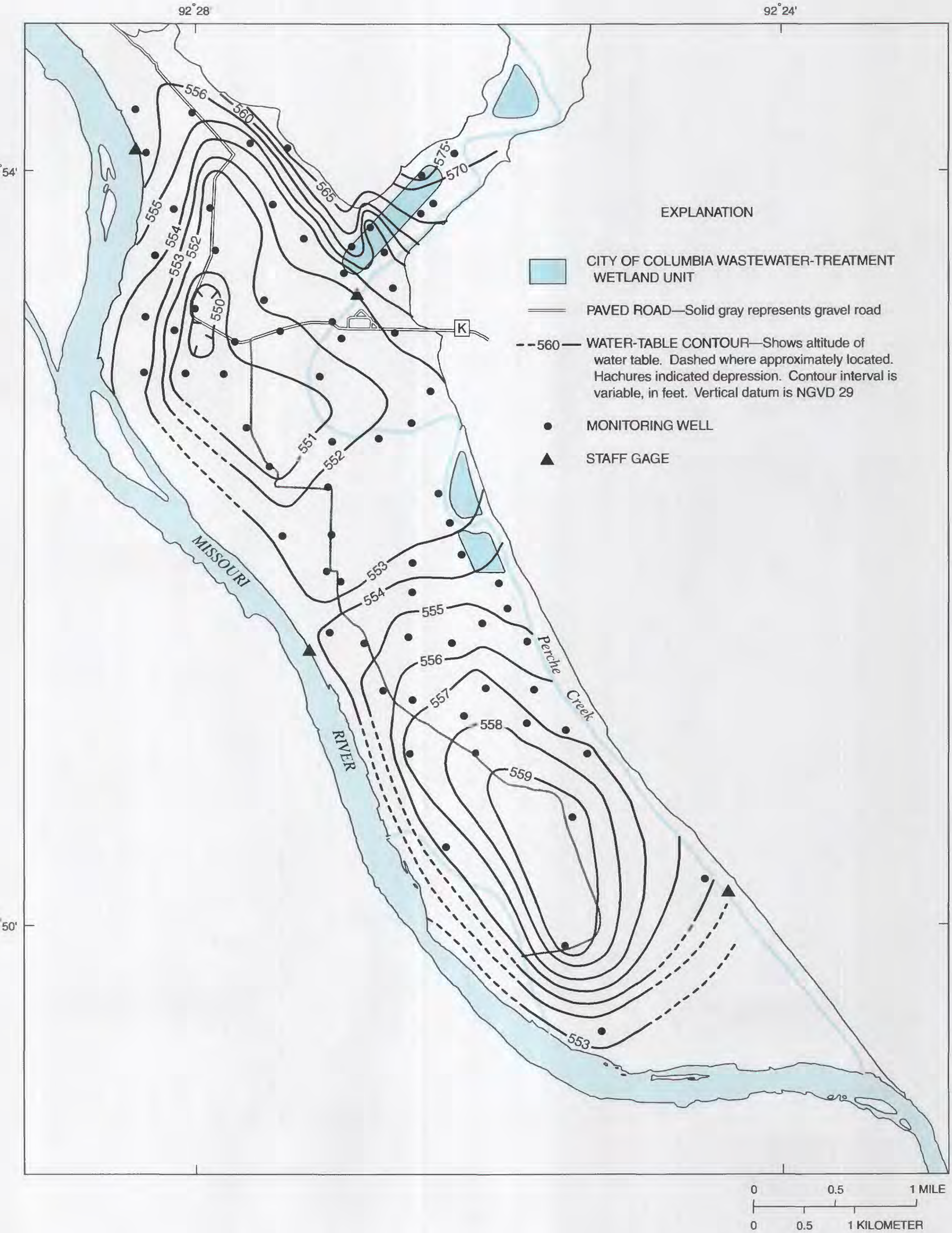

Figure 20. Altitude of the water table in the alluvial aquifer, March 21–22, 2002.

Table 20. Altitude of water levels in monitoring wells and staff gages, April 29–30, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	560.31	MW-125	551.42	MW-149	--	USGS-2S	--
MW-102	562.19	MW-126	551.86	MW-150	567.20	USGS-2D	--
MW-103	560.94	MW-127	553.52	MW-151	554.90	USGS-3S	560.59
MW-104	559.72	MW-128	554.44	MW-152	562.62	USGS-3D	560.37
MW-105	557.98	MW-129	553.00	MW-153	561.49	USGS-4	561.09
MW-106	558.31	MW-130	554.10	MW-154	552.96	USGS-5S	561.59
MW-107	558.88	MW-131	554.72	MW-155	553.40	USGS-5D	561.60
MW-108	56.65	MW-132	553.05	MW1-1A	569.42	USGS-6	560.04
MW-109	560.49	MW-133	550.95	MW1-1B	563.56	USGS-7	--
MW-110	559.14	MW-134	550.95	MW1-2A	554.78	USGS-8S	552.30
MW-111	556.06	MW-135	557.14	MW1-2B	554.77	USGS-8D	552.13
MW-112	556.18	MW-136	553.70	MW1-3A	553.72	USGS-9S	557.32
MW-113	559.93	MW-137	558.04	MW1-3B	553.61	USGS-9D	557.39
MW-114	562.08	MW-138	552.23	MW1-4A	572.23	SP11	558.60
MW-115	555.71	MW-139	--	MW1-4B	563.35	SP4	563.75
MW-116	555.40	MW-140	561.71	MW2-1A	554.79	MW13-67	552.08
MW-117	556.11	MW-141	554.51	MW2-1B	554.78	MW28-67	560.91
MW-118	556.60	MW-142	576.42	MW3-1A	555.83	River upper	571.50
MW-119	554.59	MW-143	568.60	MW3-1B	555.81	River lower	564.50
MW-120	551.84	MW-144	553.42	MW4-1A	557.94	Creek upper	559.04
MW-121	--	MW-145	558.41	MW4-1B	558.15	Creek lower	558.42
MW-122	552.15	MW-146	557.30	MW4-2A	560.84		
MW-123	551.14	MW-147	553.80	MW4-2B	560.87		
MW-124	550.47	MW-148	560.33	USGS-1	556.75		

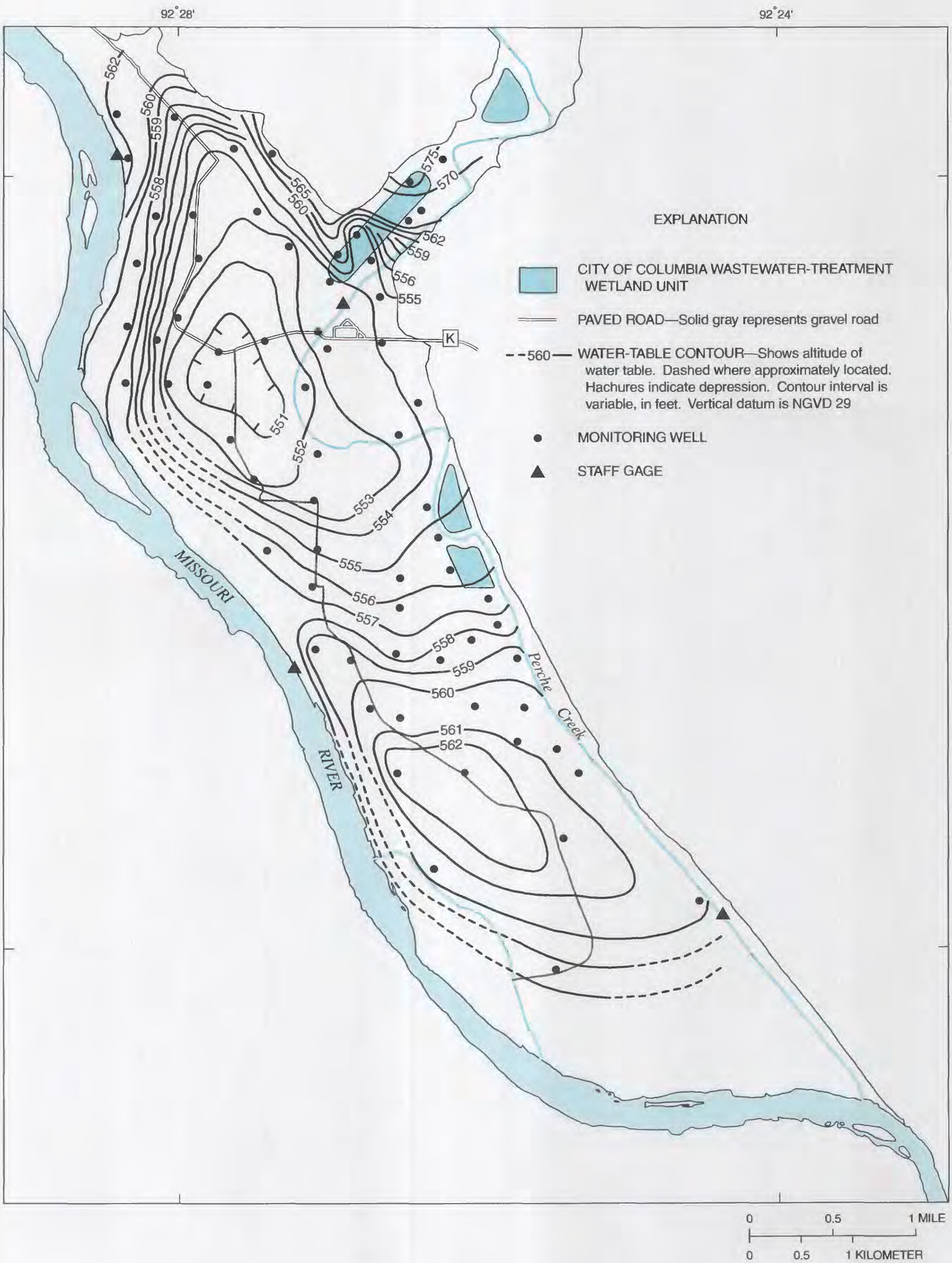

Figure 21. Altitude of the water table in the alluvial aquifer, April 29–30, 2002.

Table 21. Altitude of water levels in monitoring wells and staff gages, May 20–21, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	565.84	MW-125	563.20	MW-149	--	USGS-2S	566.50
MW-102	567.33	MW-126	556.83	MW-150	567.29	USGS-2D	566.50
MW-103	565.74	MW-127	559.28	MW-151	557.02	USGS-3S	564.51
MW-104	563.91	MW-128	560.26	MW-152	565.46	USGS-3D	564.26
MW-105	564.36	MW-129	556.79	MW-153	566.62	USGS-4	564.99
MW-106	565.05	MW-130	558.28	MW-154	554.84	USGS-5S	566.96
MW-107	565.43	MW-131	557.57	MW-155	554.97	USGS-5D	566.95
MW-108	565.94	MW-132	556.20	MW1-1A	570.87	USGS-6	562.52
MW-109	565.03	MW-133	554.29	MW1-1B	567.61	USGS-7	561.96
MW-110	565.19	MW-134	555.54	MW1-2A	557.09	USGS-8S	560.43
MW-111	565.86	MW-135	566.00	MW1-2B	557.10	USGS-8D	560.42
MW-112	565.18	MW-136	562.80	MW1-3A	556.07	USGS-9S	562.68
MW-113	565.18	MW-137	564.31	MW1-3B	555.97	USGS-9D	562.78
MW-114	565.44	MW-138	557.87	MW1-4A	573.40	SP11	563.34
MW-115	560.53	MW-139	554.30	MW1-4B	568.52	SP4	566.70
MW-116	563.12	MW-140	563.62	MW2-1A	560.23	MW13-67	560.18
MW-117	565.30	MW-141	556.78	MW2-1B	560.19	MW28-67	565.26
MW-118	--	MW-142	577.46	MW3-1A	562.65	River upper	--
MW-119	563.43	MW-143	570.49	MW3-1B	562.57	River lower	561.64
MW-120	561.89	MW-144	557.52	MW4-1A	565.16	Creek upper	557.99
MW-121	558.73	MW-145	563.29	MW4-1B	565.07	Creek lower	552.59
MW-122	558.08	MW-146	561.92	MW4-2A	565.75		
MW-123	560.50	MW-147	556.92	MW4-2B	565.68		
MW-124	557.75	MW-148	564.18	USGS-1	563.41		

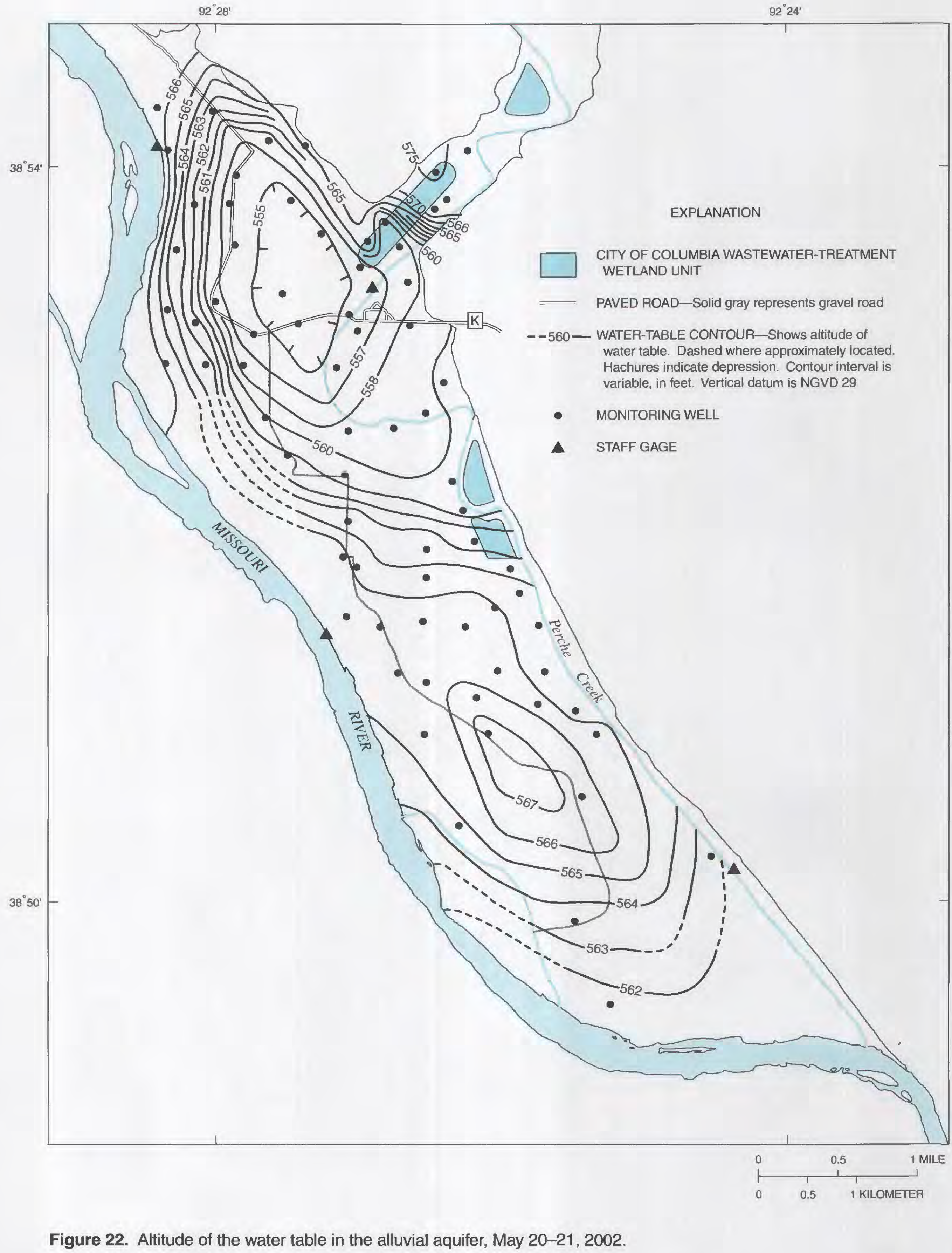

Figure 22. Altitude of the water table in the alluvial aquifer, May 20–21, 2002.

Table 22. Altitude of water levels in monitoring wells and staff gages, June 17–18, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	561.55	MW-125	557.77	MW-149	--	USGS-2S	562.65
MW-102	562.99	MW-126	557.39	MW-150	567.13	USGS-2D	562.66
MW-103	561.92	MW-127	558.39	MW-151	558.85	USGS-3S	561.08
MW-104	561.09	MW-128	558.76	MW-152	562.67	USGS-3D	560.82
MW-105	561.22	MW-129	557.96	MW-153	563.28	USGS-4	560.94
MW-106	561.77	MW-130	558.84	MW-154	557.08	USGS-5S	562.52
MW-107	561.92	MW-131	558.29	MW-155	556.43	USGS-5D	562.20
MW-108	562.49	MW-132	557.79	MW1-1A	569.79	USGS-6	559.29
MW-109	561.41	MW-133	557.16	MW1-1B	564.31	USGS-7	558.41
MW-110	560.96	MW-134	557.35	MW1-2A	557.95	USGS-8S	558.99
MW-111	559.89	MW-135	560.19	MW1-2B	557.97	USGS-8D	558.86
MW-112	560.72	MW-136	558.39	MW1-3A	557.70	USGS-9S	561.79
MW-113	560.47	MW-137	560.27	MW1-3B	557.60	USGS-9D	561.83
MW-114	561.47	MW-138	556.70	MW1-4A	572.58	SP11	562.97
MW-115	558.30	MW-139	557.37	MW1-4B	563.98	SP4	563.99
MW-116	560.11	MW-140	563.46	MW2-1A	558.48	MW13-67	558.85
MW-117	559.82	MW-141	557.86	MW2-1B	558.44	MW28-67	561.22
MW-118	560.04	MW-142	576.43	MW3-1A	559.89	River upper	563.50
MW-119	559.63	MW-143	569.22	MW3-1B	559.82	River lower	559.80
MW-120	557.35	MW-144	557.46	MW4-1A	--	Creek upper	556.24
MW-121	558.00	MW-145	560.62	MW4-1B	561.27	Creek lower	554.79
MW-122	557.93	MW-146	559.93	MW4-2A	561.96		
MW-123	556.61	MW-147	556.70	MW4-2B	561.92		
MW-124	557.17	MW-148	561.09	USGS-1	560.47		

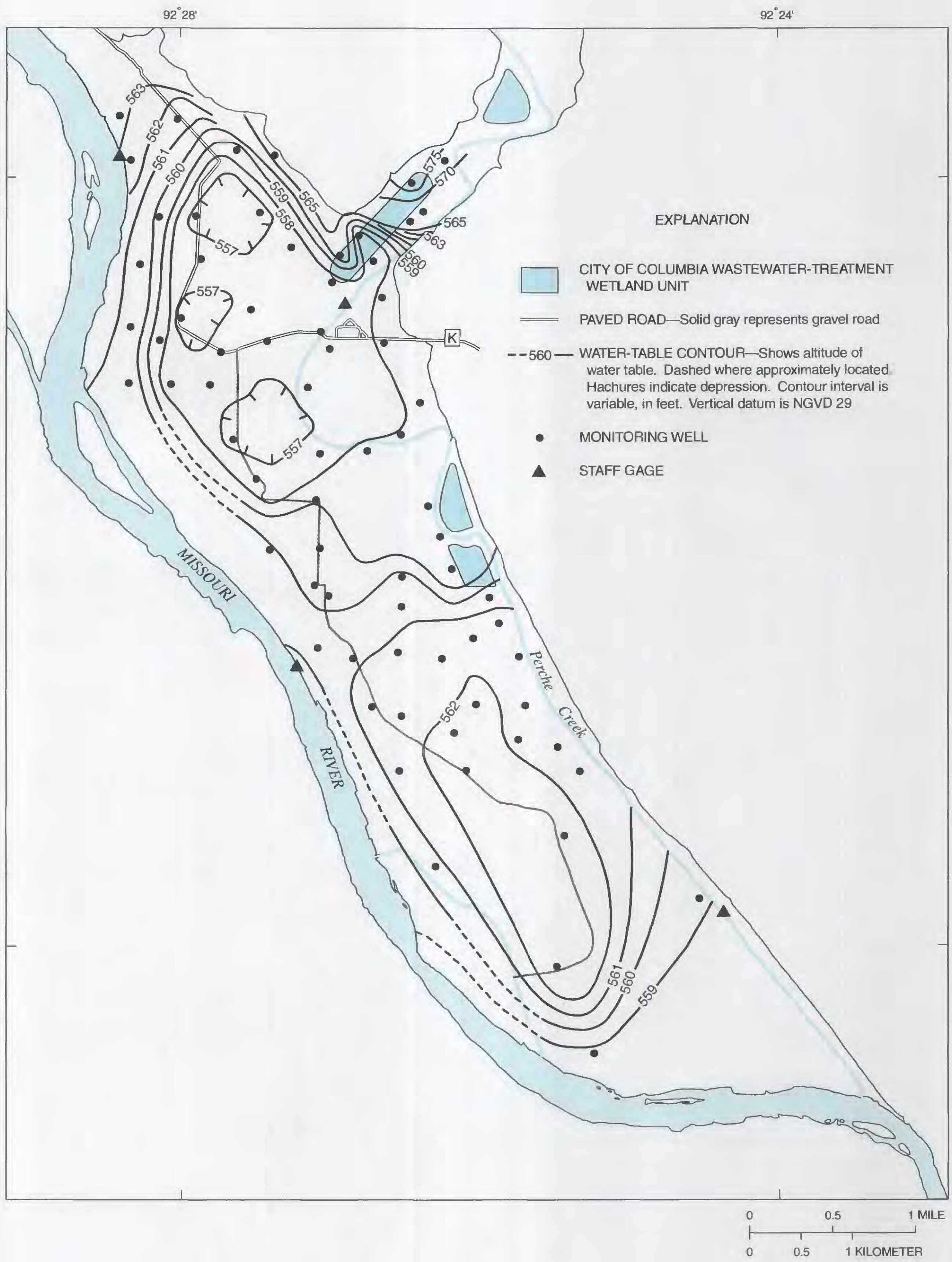

Figure 23. Altitude of the water table in the alluvial aquifer, June 17–18, 2002.

Table 23. Altitude of water levels in monitoring wells and staff gages, July 15–16, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	558.75	MW-125	554.39	MW-149	--	USGS-2S	560.48
MW-102	561.32	MW-126	554.48	MW-150	566.82	USGS-2D	560.46
MW-103	559.85	MW-127	554.78	MW-151	558.50	USGS-3S	558.49
MW-104	558.22	MW-128	554.41	MW-152	558.65	USGS-3D	558.26
MW-105	558.46	MW-129	555.60	MW-153	559.14	USGS-4	557.93
MW-106	558.46	MW-130	556.73	MW-154	556.71	USGS-5S	--
MW-107	558.56	MW-131	557.21	MW-155	556.84	USGS-5D	560.23
MW-108	559.83	MW-132	555.78	MW1-1A	568.75	USGS-6	555.91
MW-109	557.26	MW-133	555.65	MW1-1B	562.39	USGS-7	554.83
MW-110	556.27	MW-134	555.05	MW1-2A	556.95	USGS-8S	553.49
MW-111	555.56	MW-135	556.18	MW1-2B	556.98	USGS-8D	552.91
MW-112	556.70	MW-136	554.88	MW1-3A	556.75	USGS-9S	559.65
MW-113	555.45	MW-137	556.22	MW1-3B	556.62	USGS-9D	559.66
MW-114	559.32	MW-138	553.01	MW1-4A	562.51	SP11	560.85
MW-115	554.59	MW-139	556.00	MW1-4B	561.53	SP4	563.70
MW-116	556.10	MW-140	559.25	MW2-1A	554.69	MW13-67	552.04
MW-117	554.69	MW-141	557.18	MW2-1B	554.66	MW28-67	558.40
MW-118	555.22	MW-142	574.89	MW3-1A	556.12	River upper	558.90
MW-119	554.81	MW-143	568.09	MW3-1B	556.09	River lower	555.10
MW-120	554.13	MW-144	555.90	MW4-1A	557.55	Creek upper	552.34
MW-121	554.39	MW-145	557.12	MW4-1B	557.41	Creek lower	551.27
MW-122	554.12	MW-146	557.22	MW4-2A	558.93		
MW-123	553.34	MW-147	554.68	MW4-2B	558.94		
MW-124	554.36	MW-148	558.54	USGS-1	556.91		

Figure 24. Altitude of the water table in the alluvial aquifer, July 15–16, 2002.

Table 24. Altitude of water levels in monitoring wells and staff gages, August 12–13, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	556.81	MW-125	552.47	MW-149	--	USGS-2S	557.00
MW-102	557.68	MW-126	552.95	MW-150	566.69	USGS-2D	557.02
MW-103	556.64	MW-127	553.25	MW-151	556.99	USGS-3S	555.97
MW-104	555.43	MW-128	554.00	MW-152	556.92	USGS-3D	555.77
MW-105	555.13	MW-129	554.18	MW-153	557.31	USGS-4	555.86
MW-106	555.69	MW-130	555.31	MW-154	555.41	USGS-5S	558.41
MW-107	555.72	MW-131	556.21	MW-155	555.65	USGS-5D	558.42
MW-108	556.65	MW-132	554.41	MW1-1A	568.26	USGS-6	555.22
MW-109	555.11	MW-133	553.79	MW1-1B	561.51	USGS-7	553.22
MW-110	554.27	MW-134	553.05	MW1-2A	555.99	USGS-8S	552.08
MW-111	552.35	MW-135	554.38	MW1-2B	556.03	USGS-8D	552.12
MW-112	554.43	MW-136	552.93	MW1-3A	555.59	USGS-9S	557.70
MW-113	553.46	MW-137	554.44	MW1-3B	555.46	USGS-9D	557.76
MW-114	556.13	MW-138	551.76	MW1-4A	570.93	SP11	559.43
MW-115	552.90	MW-139	554.13	MW1-4B	560.51	SP4	563.46
MW-116	553.94	MW-140	558.25	MW2-1A	553.10	MW13-67	552.10
MW-117	552.35	MW-141	556.23	MW2-1B	553.10	MW28-67	556.43
MW-118	553.15	MW-142	574.23	MW3-1A	554.14	River upper	560.50
MW-119	552.72	MW-143	567.32	MW3-1B	554.08	River lower	553.90
MW-120	551.45	MW-144	553.95	MW4-1A	555.07	Creek upper	551.74
MW-121	552.80	MW-145	555.24	MW4-1B	554.97	Creek lower	550.18
MW-122	552.07	MW-146	555.17	MW4-2A	556.03		
MW-123	551.43	MW-147	552.51	MW4-2B	556.02		
MW-124	552.41	MW-148	555.70	USGS-1	554.75		

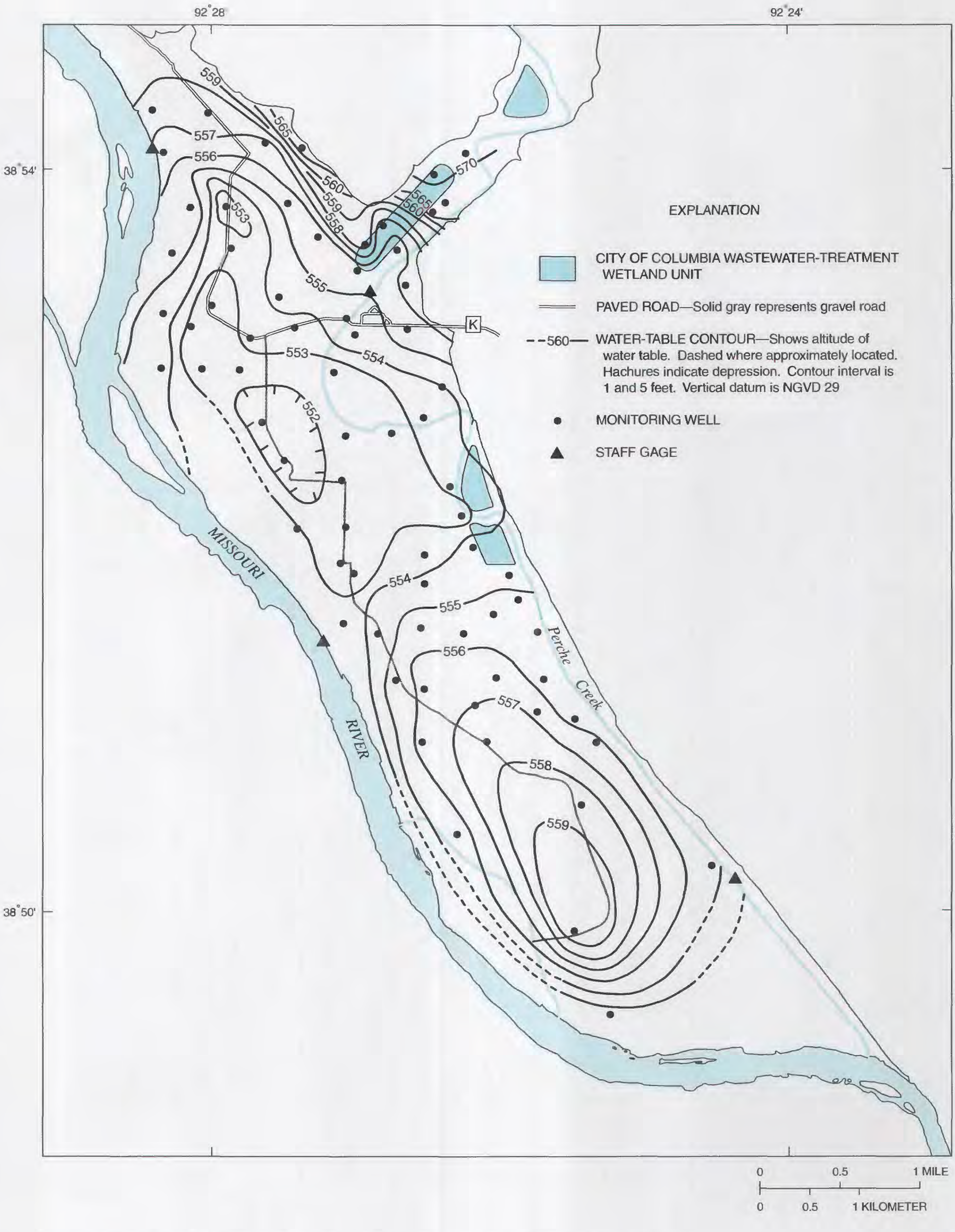

Figure 25. Altitude of the water table in the alluvial aquifer, August 12–13, 2002.

Table 25. Altitude of water levels in monitoring wells and staff gages, September 9–10, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	557.60	MW-125	551.84	MW-149	--	USGS-2S	558.36
MW-102	560.06	MW-126	552.34	MW-150	566.69	USGS-2D	558.38
MW-103	557.54	MW-127	553.18	MW-151	556.18	USGS-3S	566.74
MW-104	556.04	MW-128	553.79	MW-152	557.56	USGS-3D	556.54
MW-105	555.37	MW-129	553.59	MW-153	558.04	USGS-4	556.80
MW-106	556.08	MW-130	555.21	MW-154	554.64	USGS-5S	559.92
MW-107	556.33	MW-131	556.92	MW-155	554.94	USGS-5D	559.93
MW-108	557.39	MW-132	553.67	MW1-1A	568.44	USGS-6	556.40
MW-109	557.82	MW-133	552.21	MW1-1B	561.50	USGS-7	554.83
MW-110	556.08	MW-134	551.73	MW1-2A	555.69	USGS-8S	553.03
MW-111	552.64	MW-135	554.47	MW1-2B	555.69	USGS-8D	552.96
MW-112	554.84	MW-136	552.59	MW1-3A	554.99	USGS-9S	557.56
MW-113	555.10	MW-137	554.59	MW1-3B	554.86	USGS-9D	557.58
MW-114	557.00	MW-138	550.73	MW1-4A	571.16	SP11	558.49
MW-115	553.32	MW-139	552.99	MW1-4B	560.42	SP4	563.85
MW-116	554.27	MW-140	559.00	MW2-1A	553.39	MW13-67	552.96
MW-117	552.61	MW-141	555.83	MW2-1B	553.39	MW28-67	558.87
MW-118	553.80	MW-142	574.40	MW3-1A	554.36	River upper	558.30
MW-119	553.15	MW-143	567.78	MW3-1B	554.30	River lower	554.40
MW-120	551.16	MW-144	553.20	MW4-1A	555.89	Creek upper	551.50
MW-121	552.93	MW-145	555.56	MW4-1B	555.89	Creek lower	550.67
MW-122	552.57	MW-146	555.15	MW4-2A	557.55		
MW-123	550.50	MW-147	551.84	MW4-2B	557.59		
MW-124	551.31	MW-148	556.42	USGS-1	554.88		

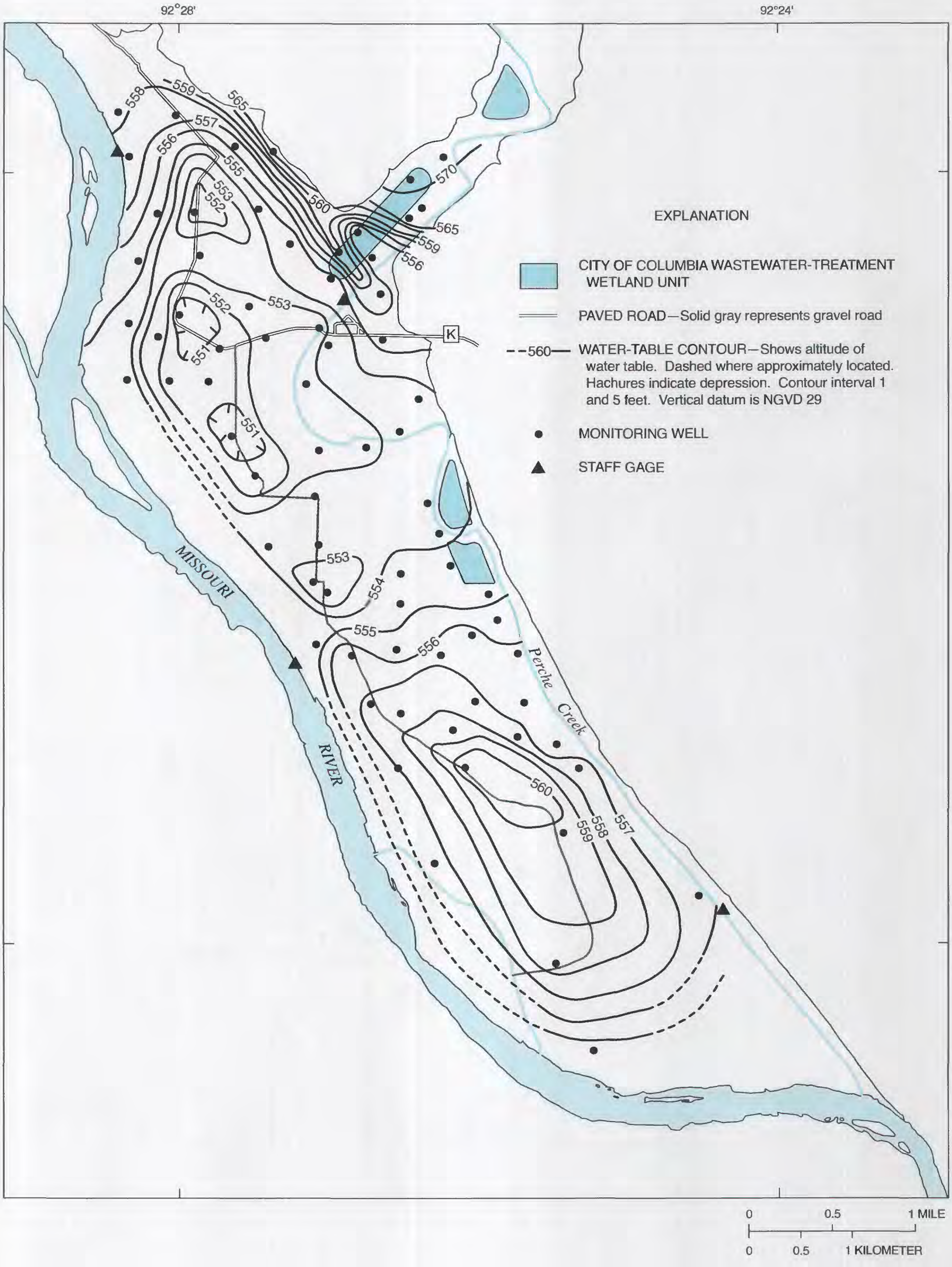

Figure 26. Altitude of the water table in the alluvial aquifer, September 9–10, 2002.

Table 26. Altitude of water levels in monitoring wells and staff gages, October 7–8, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	560.11	MW-125	551.34	MW-149	--	USGS-2S	--
MW-102	563.22	MW-126	551.70	MW-150	566.69	USGS-2D	--
MW-103	561.42	MW-127	552.74	MW-151	555.32	USGS-3S	559.76
MW-104	559.96	MW-128	553.19	MW-152	557.63	USGS-3D	559.51
MW-105	556.94	MW-129	552.98	MW-153	557.87	USGS-4	558.18
MW-106	558.20	MW-130	554.43	MW-154	553.75	USGS-5S	561.75
MW-107	558.60	MW-131	556.11	MW-155	554.01	USGS-5D	561.76
MW-108	561.06	MW-132	--	MW1-1A	568.13	USGS-6	556.71
MW-109	560.22	MW-133	552.32	MW1-1B	561.13	USGS-7	554.49
MW-110	557.33	MW-134	551.73	MW1-2A	555.00	USGS-8S	552.52
MW-111	553.31	MW-135	554.25	MW1-2B	555.00	USGS-8D	552.49
MW-112	555.61	MW-136	552.73	MW1-3A	554.23	USGS-9S	556.89
MW-113	556.16	MW-137	554.74	MW1-3B	554.10	USGS-9D	556.92
MW-114	560.37	MW-138	551.59	MW1-4A	571.00	SP11	558.83
MW-115	553.51	MW-139	552.59	MW1-4B	560.17	SP4	563.68
MW-116	554.61	MW-140	557.75	MW2-1A	553.27	MW13-67	552.51
MW-117	553.06	MW-141	555.06	MW2-1B	553.55	MW28-67	558.84
MW-118	553.66	MW-142	574.32	MW3-1A	554.80	River upper	559.20
MW-119	553.12	MW-143	567.59	MW3-1B	554.74	River lower	555.40
MW-120	550.51	MW-144	552.66	MW4-1A	557.46	Creek upper	552.14
MW-121	552.54	MW-145	555.43	MW4-1B	557.52	Creek lower	551.37
MW-122	551.95	MW-146	554.88	MW4-2A	560.33		
MW-123	549.79	MW-147	551.90	MW4-2B	560.36		
MW-124	550.85	MW-148	559.67	USGS-1	555.74		

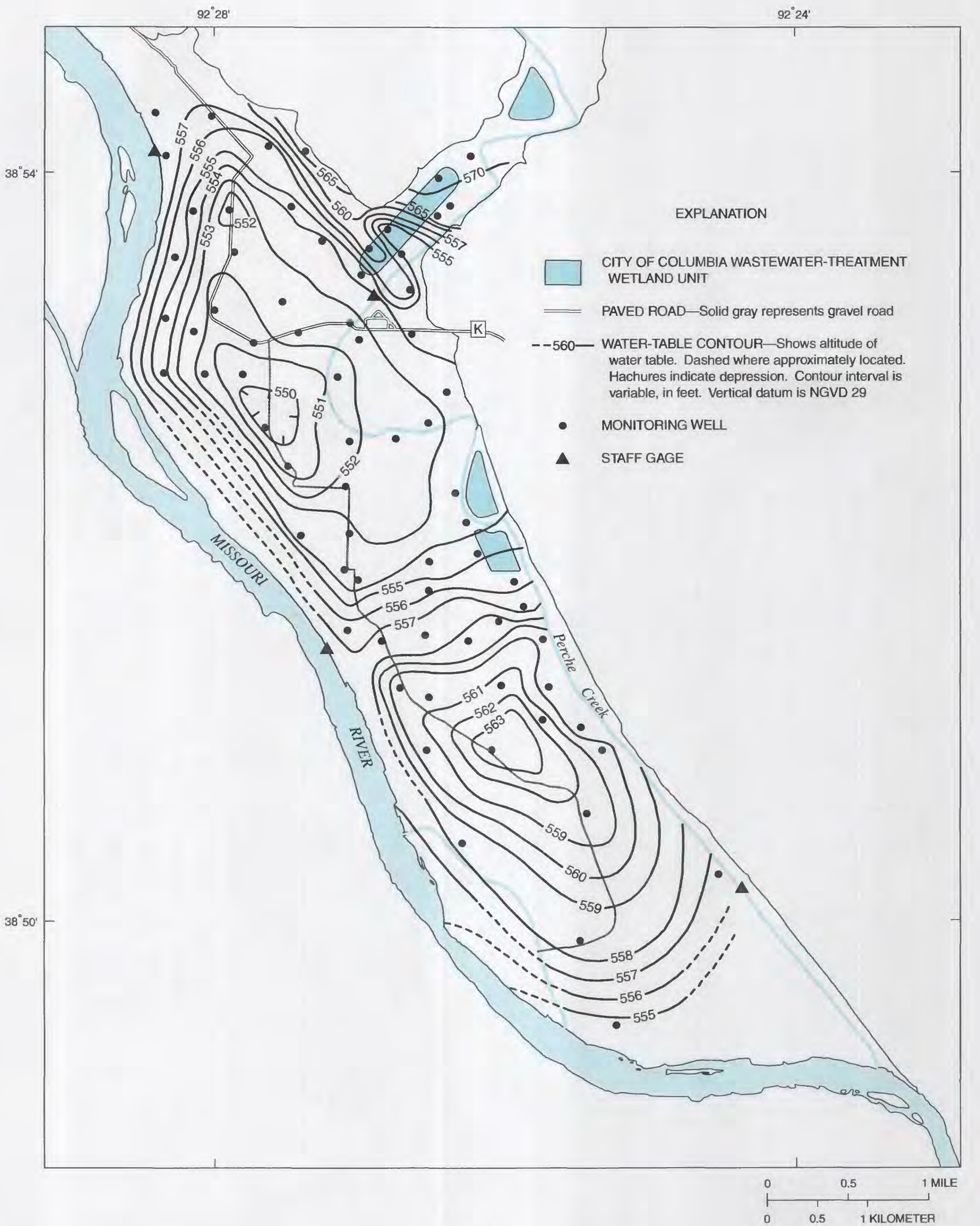

Figure 27. Altitude of the water table in the alluvial aquifer, October 7–8, 2002.

Table 27. Altitude of water levels in monitoring wells and staff gages, November 4, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	566.79	MW-125	551.42	MW-149	--	USGS-2S	565.22
MW-102	565.95	MW-126	551.50	MW-150	565.05	USGS-2D	565.22
MW-103	565.56	MW-127	552.43	MW-151	553.03	USGS-3S	563.90
MW-104	561.99	MW-128	552.76	MW-152	557.57	USGS-3D	563.68
MW-105	559.52	MW-129	552.78	MW-153	557.97	USGS-4	560.51
MW-106	560.54	MW-130	554.23	MW-154	551.52	USGS-5S	567.10
MW-107	560.97	MW-131	555.89	MW-155	551.60	USGS-5D	567.11
MW-108	564.91	MW-132	552.93	MW1-1A	568.42	USGS-6	558.95
MW-109	562.29	MW-133	552.24	MW1-1B	561.00	USGS-7	556.82
MW-110	559.20	MW-134	549.88	MW1-2A	554.60	USGS-8S	552.27
MW-111	554.61	MW-135	554.26	MW1-2B	554.61	USGS-8D	552.28
MW-112	557.15	MW-136	552.84	MW1-3A	552.00	USGS-9S	554.90
MW-113	557.29	MW-137	554.71	MW1-3B	551.86	USGS-9D	554.94
MW-114	562.08	MW-138	549.63	MW1-4A	571.19	SP11	559.25
MW-115	553.95	MW-139	552.52	MW1-4B	559.96	SP4	563.88
MW-116	555.96	MW-140	557.83	MW2-1A	553.29	MW13-67	552.26
MW-117	554.00	MW-141	554.62	MW2-1B	553.59	MW28-67	562.05
MW-118	553.94	MW-142	574.55	MW3-1A	555.54	River upper	558.70
MW-119	553.55	MW-143	567.77	MW3-1B	555.77	River lower	554.80
MW-120	550.85	MW-144	550.73	MW4-1A	559.49	Creek upper	551.79
MW-121	551.99	MW-145	555.48	MW4-1B	559.50	Creek lower	551.03
MW-122	551.69	MW-146	554.86	MW4-2A	562.50		
MW-123	550.18	MW-147	549.22	MW4-2B	562.51		
MW-124	550.91	MW-148	563.38	USGS-1	556.97		

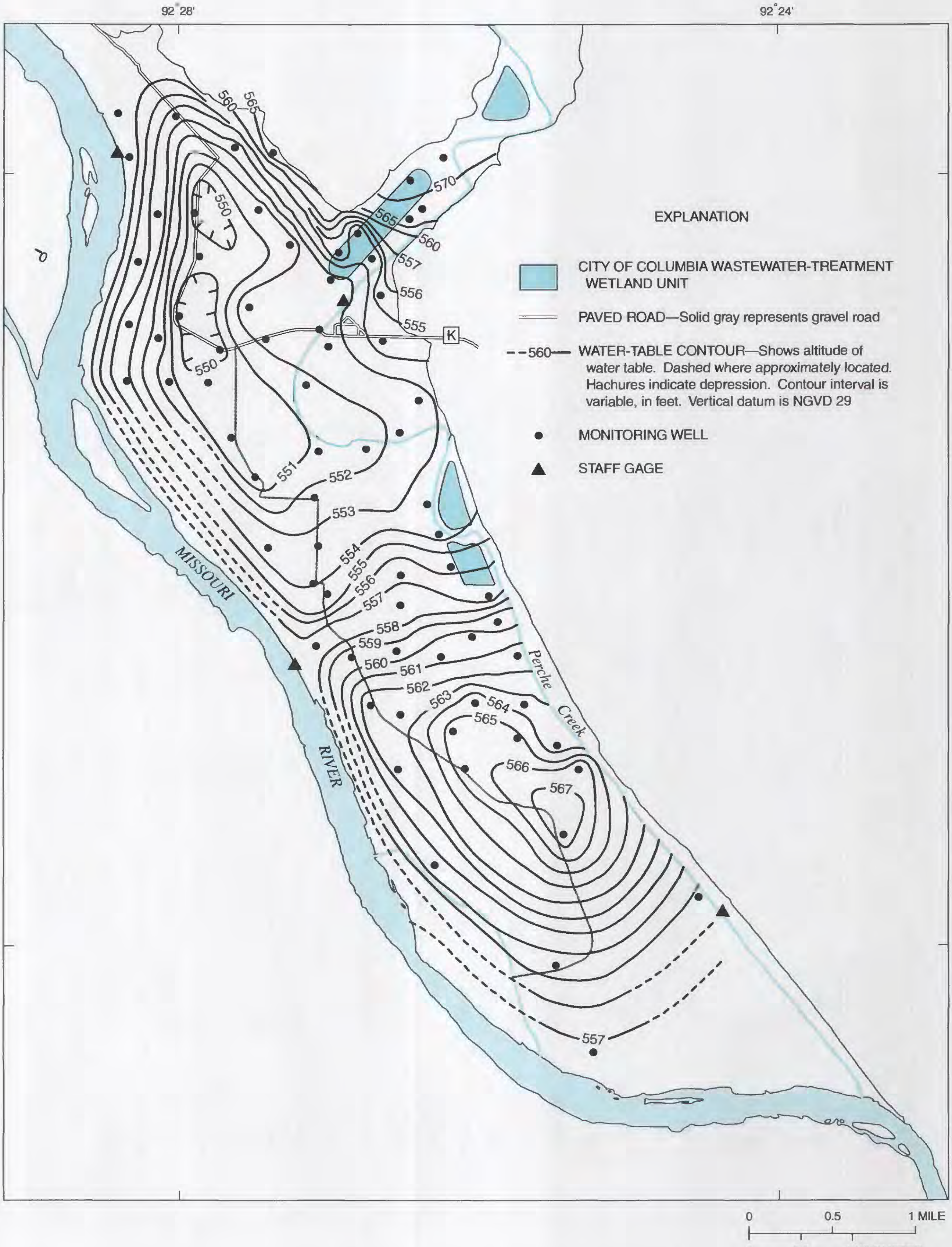

Figure 28. Altitude of the water table in the alluvial aquifer, November 4, 2002.

Table 28. Altitude of water levels in monitoring wells and staff gages, December 12, 2002

[Altitudes are in feet above NGVD 29; ft, feet; --, no data]

Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)	Site (fig. 2)	Altitude (ft)
MW-101	566.07	MW-125	550.43	MW-149	--	USGS-2S	564.02
MW-102	562.83	MW-126	551.36	MW-150	565.34	USGS-2D	564.01
MW-103	564.16	MW-127	552.29	MW-151	552.61	USGS-3S	562.67
MW-104	560.76	MW-128	552.67	MW-152	554.62	USGS-3D	562.40
MW-105	557.65	MW-129	552.39	MW-153	555.36	USGS-4	558.50
MW-106	559.78	MW-130	553.40	MW-154	551.01	USGS-5S	566.65
MW-107	560.21	MW-131	554.16	MW-155	551.16	USGS-5D	566.67
MW-108	563.82	MW-132	550.60	MW1-1A	566.12	USGS-6	556.90
MW-109	559.84	MW-133	549.93	MW1-1B	558.59	USGS-7	553.09
MW-110	557.65	MW-134	549.09	MW1-2A	551.96	USGS-8S	549.74
MW-111	553.99	MW-135	552.54	MW1-2B	551.96	USGS-8D	549.70
MW-112	556.77	MW-136	551.03	MW1-3A	551.40	USGS-9S	554.00
MW-113	554.83	MW-137	552.42	MW1-3B	551.26	USGS-9D	554.01
MW-114	558.18	MW-138	548.10	MW1-4A	569.13	SP11	560.06
MW-115	553.05	MW-139	552.08	MW1-4B	557.70	SP4	565.65
MW-116	555.70	MW-140	555.14	MW2-1A	552.88	MW13-67	549.77
MW-117	551.39	MW-141	553.86	MW2-1B	--	MW28-67	559.71
MW-118	552.66	MW-142	572.46	MW3-1A	555.42	River upper	555.30
MW-119	551.18	MW-143	567.37	MW3-1B	555.33	River lower	551.00
MW-120	549.22	MW-144	549.86	MW4-1A	558.69	Creek upper	551.56
MW-121	551.62	MW-145	553.28	MW4-1B	558.63	Creek lower	546.97
MW-122	551.68	MW-146	553.15	MW4-2A	560.94		
MW-123	547.66	MW-147	549.04	MW4-2B	560.94		
MW-124	550.26	MW-148	561.75	USGS-1	556.13		

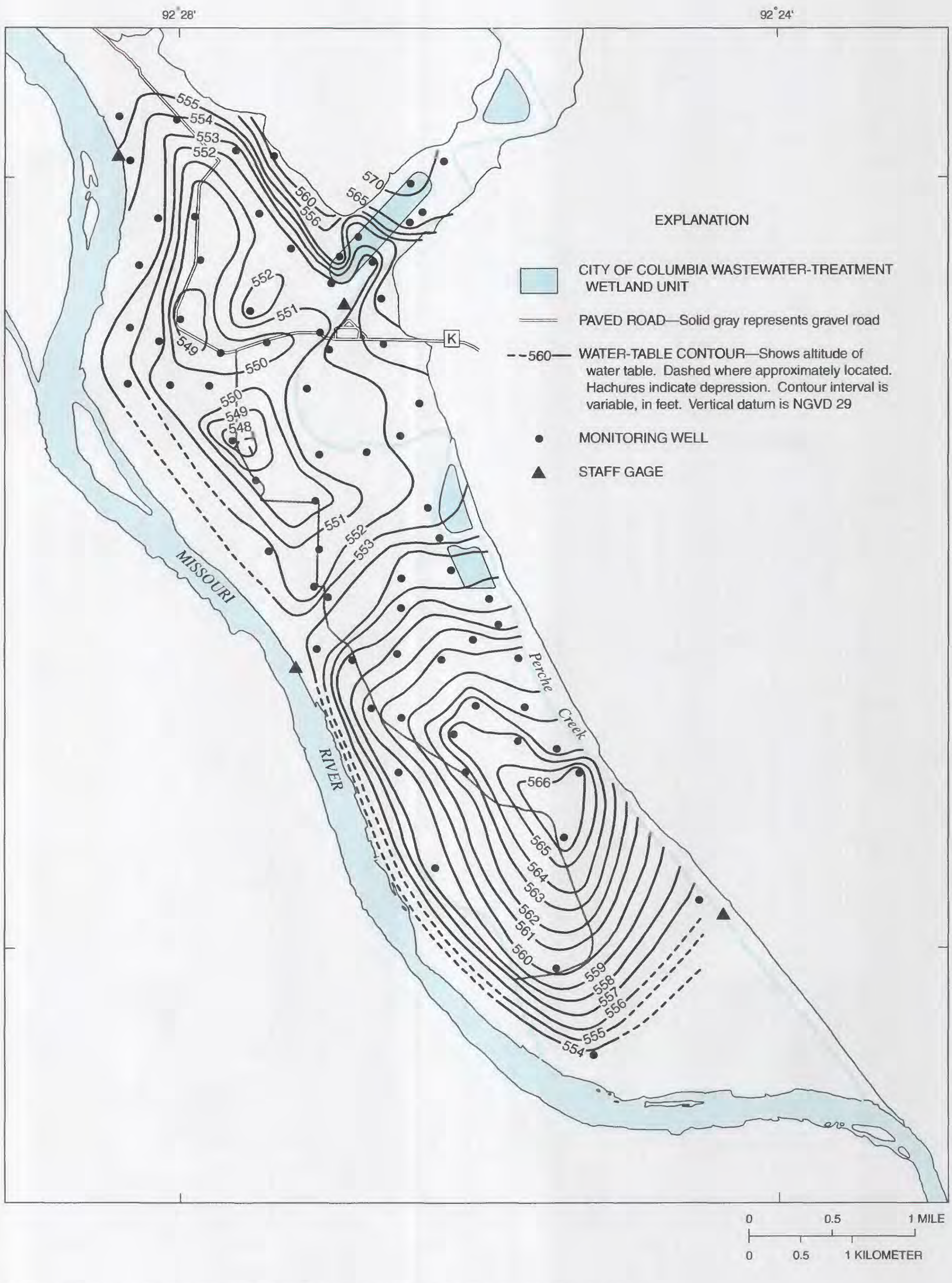

Figure 29. Altitude of the water table in the alluvial aquifer, December 12, 2002.

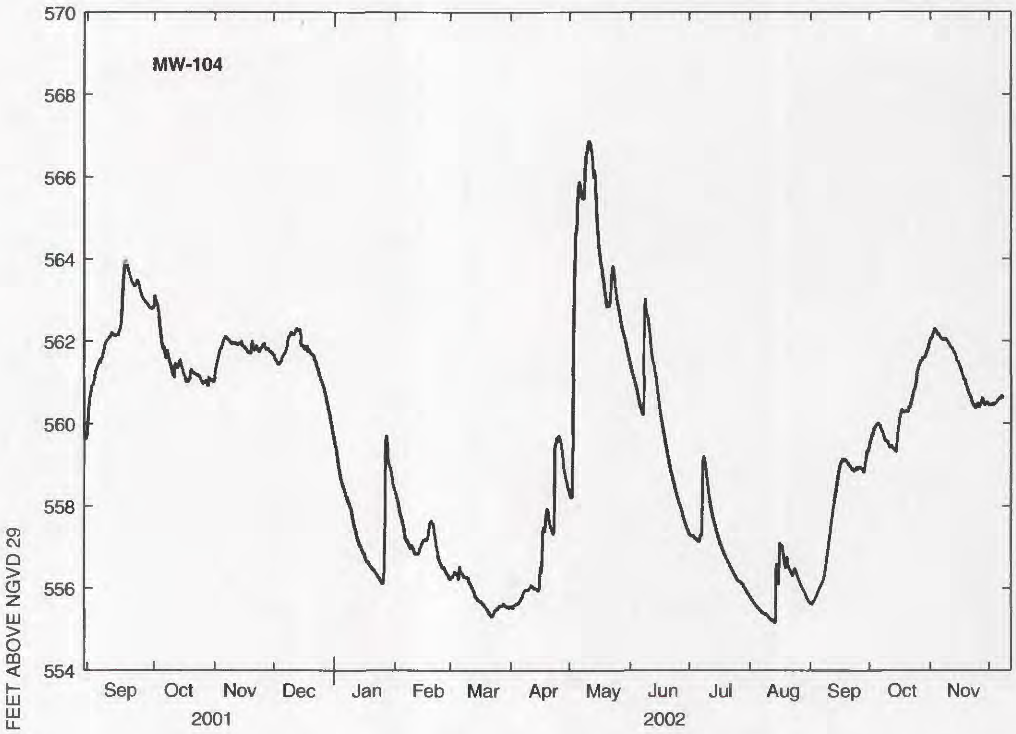

Figure 34. Daily mean water-level altitude in monitoring well MW-104, August 31, 2001, through December 11, 2002.

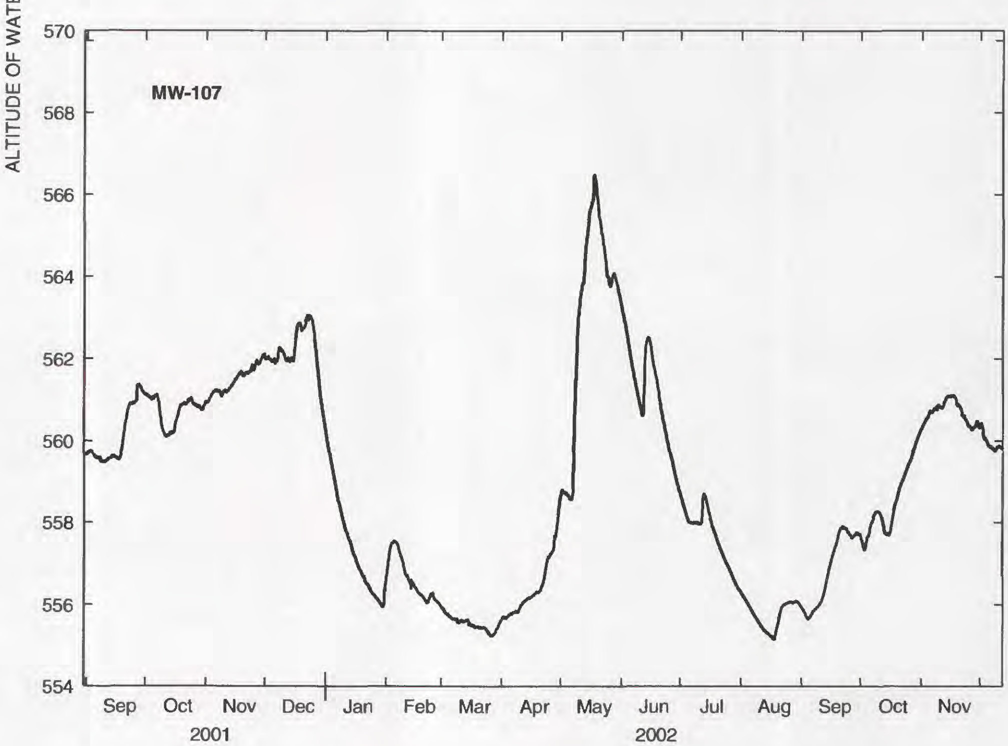

Figure 35. Daily mean water-level altitude in monitoring well MW-107, August 31, 2001, through December 11, 2002.

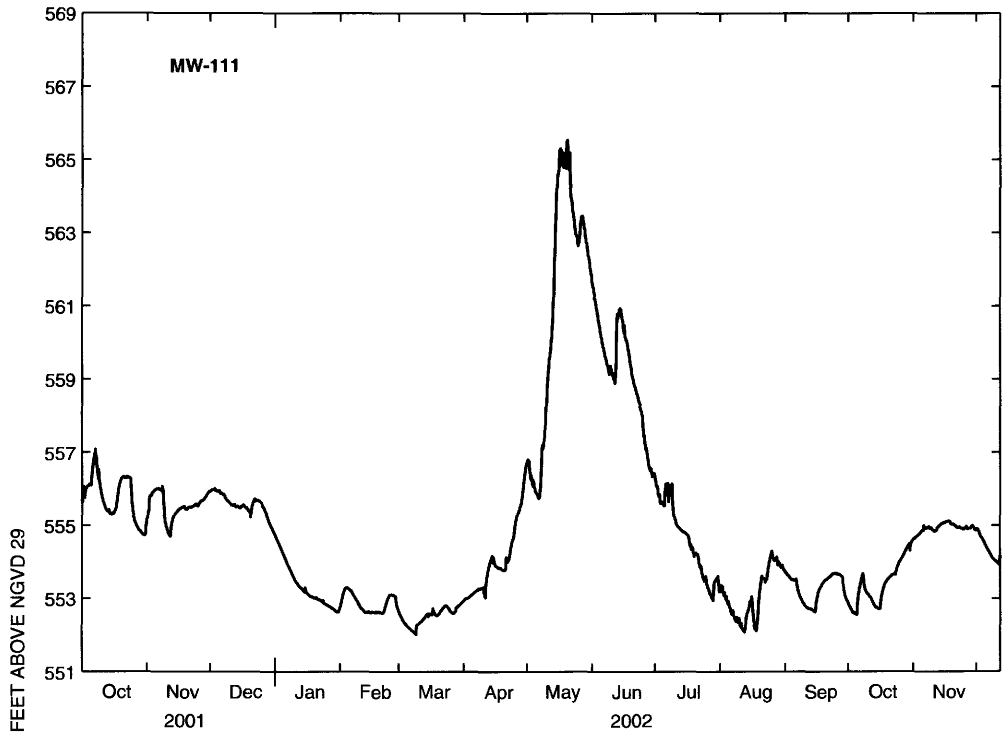

Figure 36. Daily mean water-level altitude in monitoring well MW-111, August 31, 2001, through December 11, 2002.

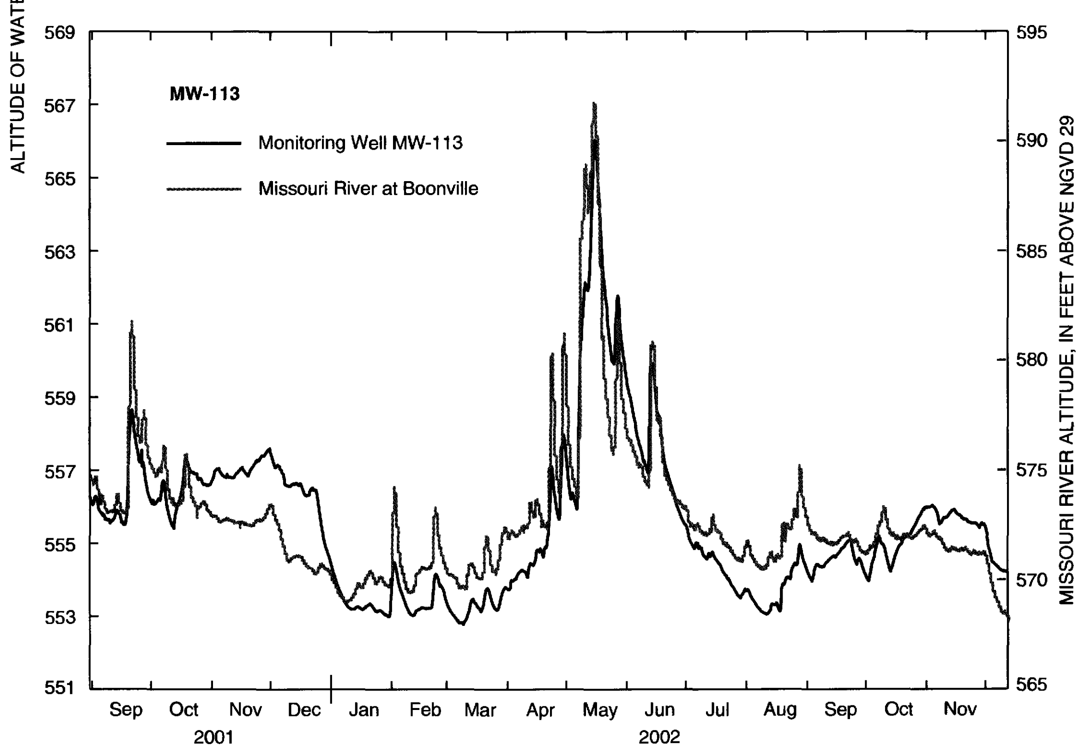

Figure 37. Daily mean water-level altitude in monitoring well MW-113, August 31, 2001, through December 11, 2002.

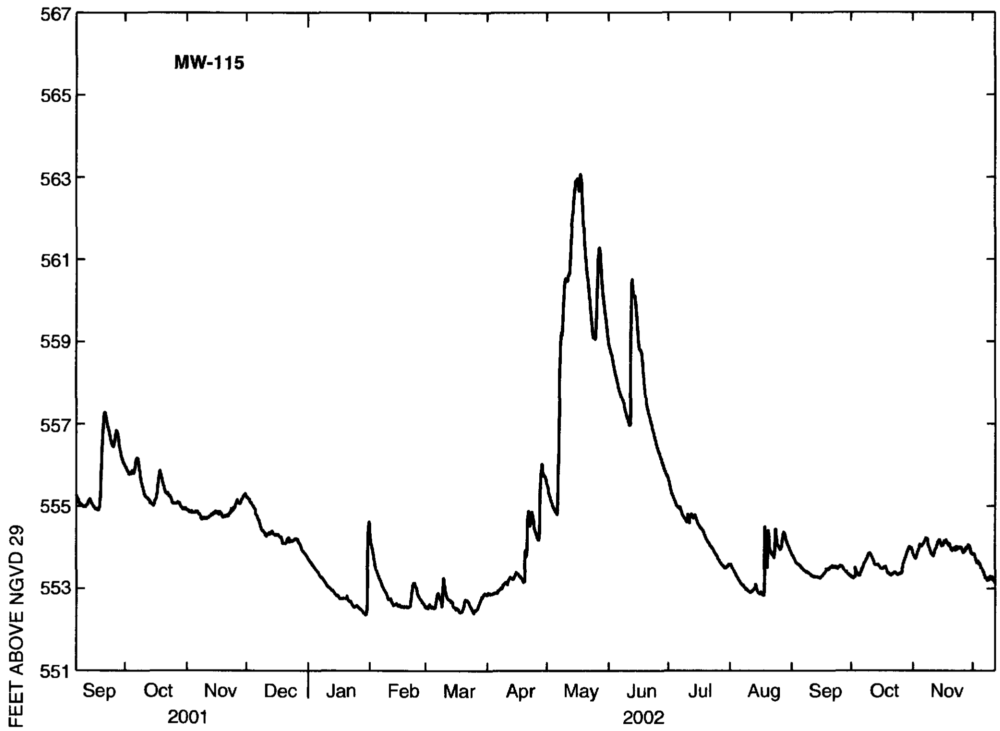

Figure 38. Daily mean water-level altitude in monitoring well MW-115, September 7, 2001, through December 11, 2002.

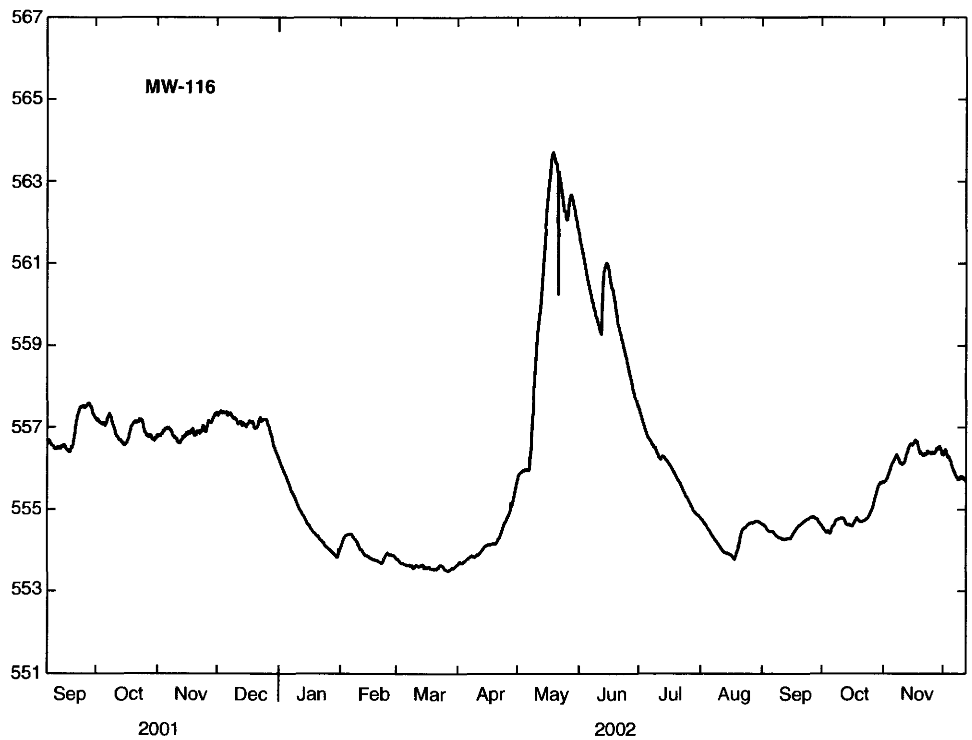

Figure 39. Daily mean water-level altitude in monitoring well MW-116, September 7, 2001, through December 11, 2002.

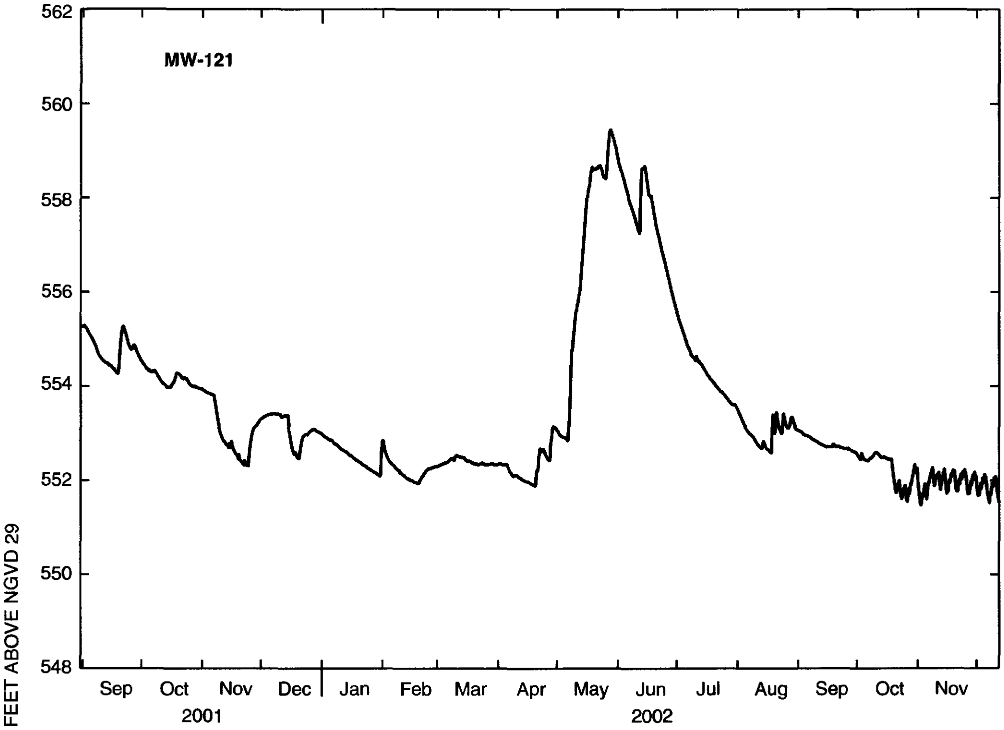

Figure 40. Daily mean water-level altitude in monitoring well MW-121, August 31, 2001, through December 11, 2002.

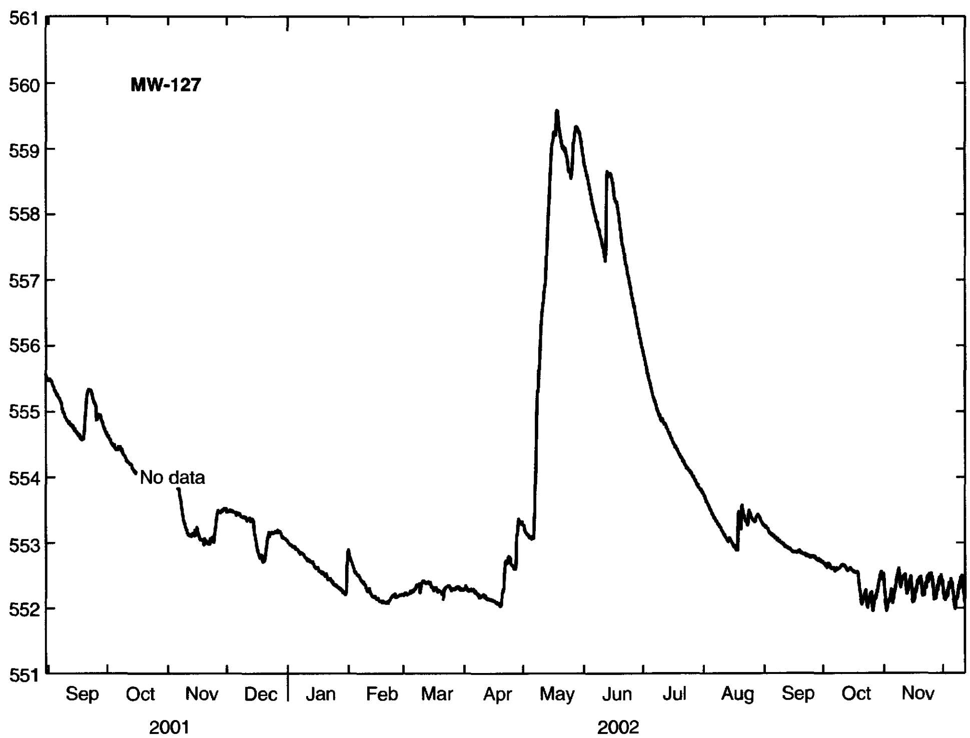

Figure 41. Daily mean water-level altitude in monitoring well MW-127, August 31, 2001, through December 11, 2002.

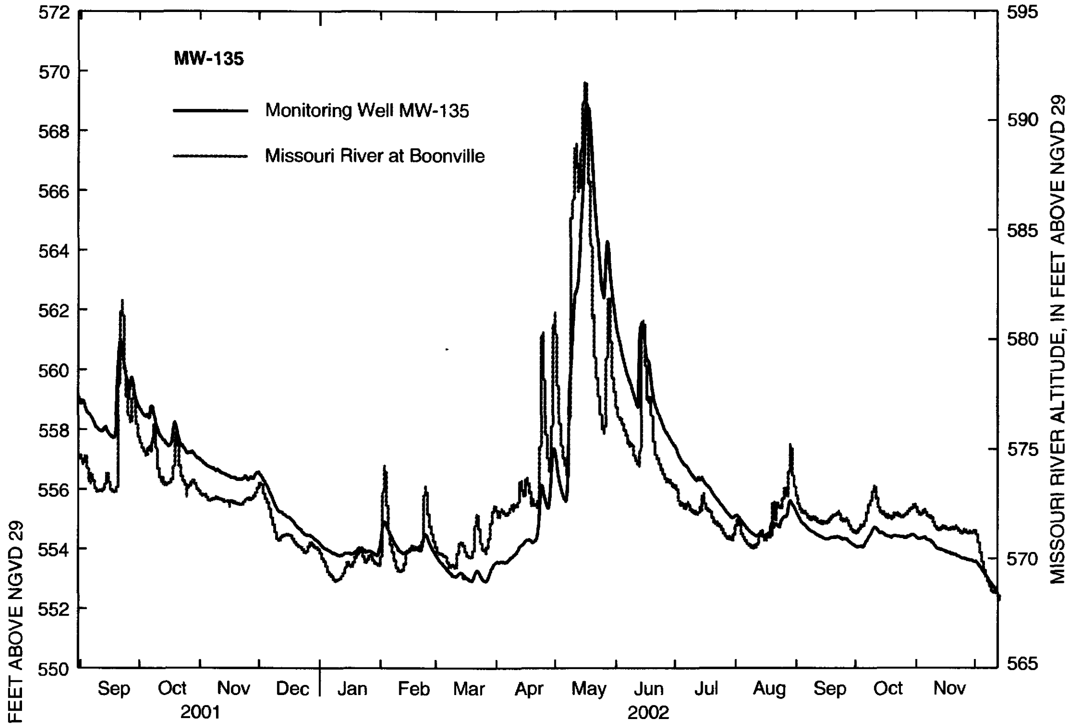

Figure 42. Daily mean water-level altitude in monitoring well MW-135, August 31, 2001, through December 11, 2002.

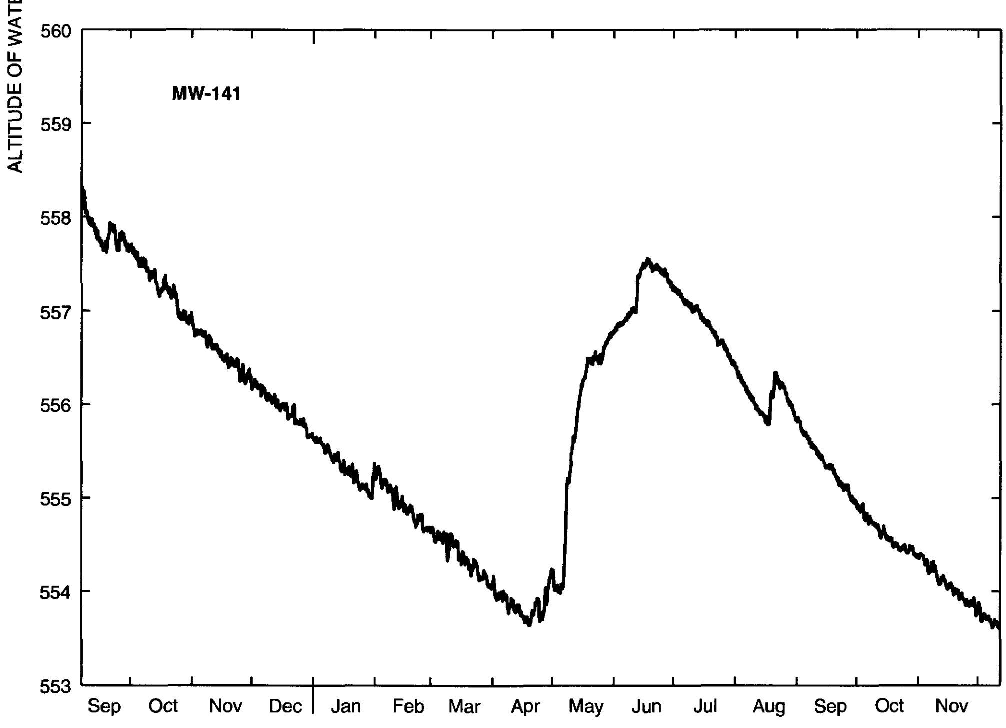

Figure 43. Daily mean water-level altitude in monitoring well MW-141, September 7, 2001, through December 11, 2002.

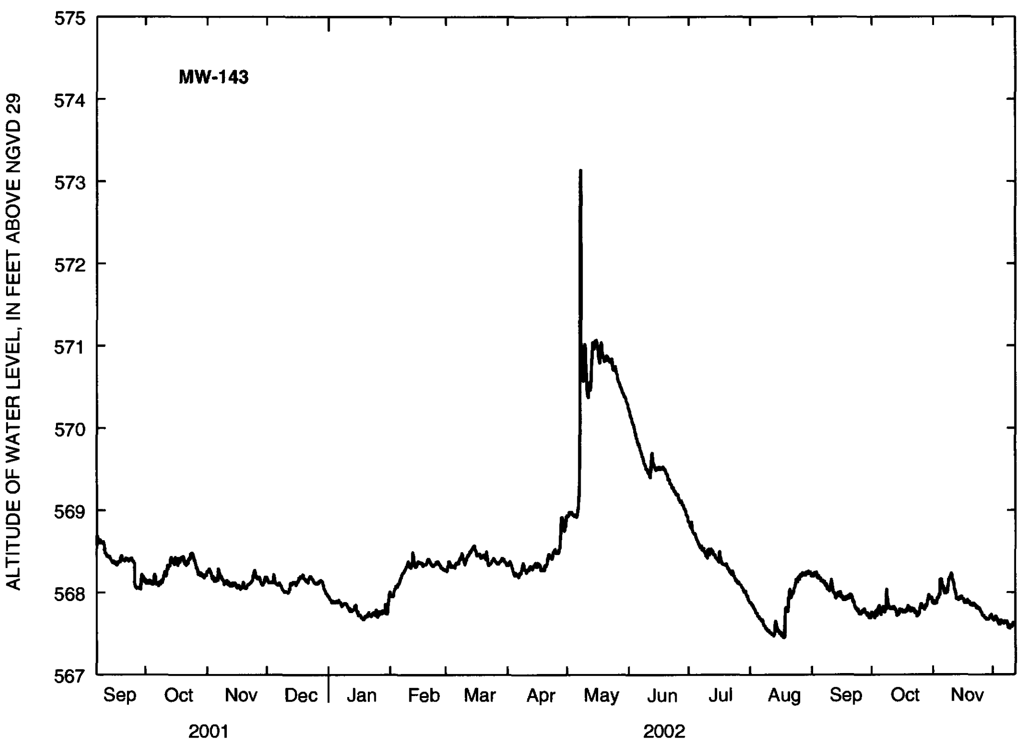

Figure 44. Daily mean water-level altitude in monitoring well MW-143, September 7, 2001, through December 11, 2002.

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