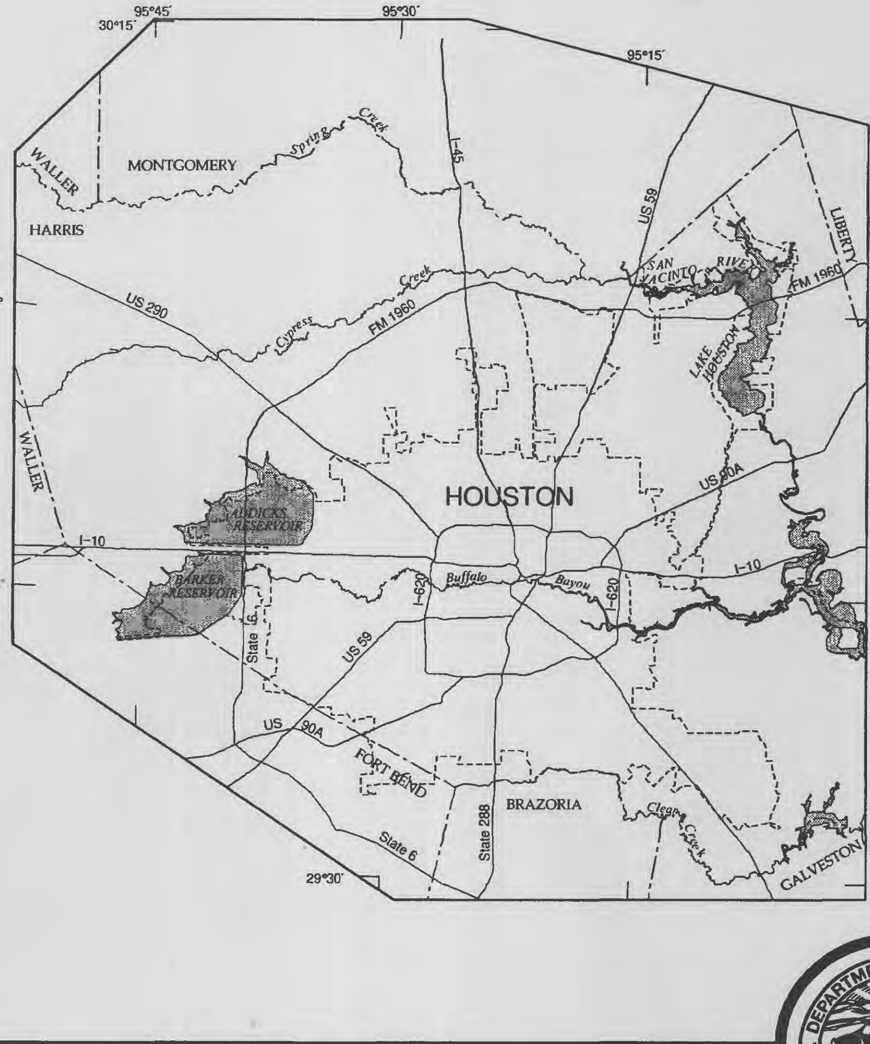
SUMMARY OF SURFACE-WATER HYDROLOGIC DATA FOR THE HOUSTON METROPOLITAN AREA, TEXAS, WATER YEARS 1964–89

U.S. GEOLOGICAL SURVEY
Open-File Report 96–250



Prepared in cooperation with the
CITY OF HOUSTON *and*
HARRIS COUNTY FLOOD CONTROL DISTRICT

U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

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Austin, Texas
1997

U.S. DEPARTMENT OF THE INTERIOR

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VERTICAL DATUM

Sea Level: In this report. "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Summary of Surface-Water Hydrologic Data for the Houston Metropolitan Area, Texas, Water Years 1964–89

By Fred Liscum, D.W. Brown, *and* Mark C. Kasmarek

Abstract

The study area, a metropolitan area in southeast Texas about 45 miles north of the Gulf of Mexico, has been undergoing extensive urban development since the 1950s. The Houston Urban Runoff Program was begun by the U.S. Geological Survey in water year 1964 to define the magnitude and frequency of flood peaks, to determine the impact of continuing urban development on surface-water hydrologic responses, and to determine variations in stream water quality for different flow conditions, seasons, and urban development. An extensive data base has been developed.

During water years 1964–89, the Houston Urban Runoff Program collected information from a total of 54 U.S. Geological Survey streamflow-gaging stations, 30 U.S. Geological Survey water-quality sampling sites, and 102 rain gages (operated by the U.S. Geological Survey, the National Weather Service, and local agencies). In addition, basin characteristics were developed to aid in understanding the effects of urban development on surface-water hydrologic responses.

Surface-water hydrologic data on diskettes describe the 54 U.S. Geological Survey streamflow-gaging stations, list annual peaks (and where available, peaks above an arbitrary base) for 50 streamflow sites, tabulate 1,125 storm hydrographs from 43 sites, and document 102 water-quality parameters determined from 3,242 available samples.

INTRODUCTION

Background

The U.S. Geological Survey (USGS) began hydrologic investigations of urban watersheds in Texas in 1954. Studies have been done in most of the major metropolitan areas, including Houston, Dallas, San Antonio, and Austin. This report summarizes data collected for the Houston metropolitan area during water years[1] 1964–89.

The USGS, in cooperation with the City of Houston, began studies of streamflow in the Houston metropolitan area in water year 1964. The program, known as the Houston Urban Runoff Program (HURP), was expanded in water year 1968 to include collection of water-quality data. The objectives of the continuing Houston urban-hydrology study are

1. To determine, on the basis of historical data and hydrologic analyses of data collected, the magnitude and frequency of flood peaks;
2. To determine the effects of continuing urban development on flood peaks, flood volumes, and the timing characteristics of flood runoff; and
3. To determine variations in stream water quality for different flow conditions, different seasons, and varying patterns of urban development.

The study has produced an extensive data base and several interpretive reports. An interpretative report by Johnson and Sayre (1973) used records collected during water years 1965–69 to study the effects of urbanization on floods in the Houston area. That report also presented various basin characteristics (descriptors of drainage basins). A report by Waddell and others (1979) presented data on runoff from the Houston area and computed concentrations and loads of selected water-quality constituents discharged to Galveston Bay. The study used a variation of the "STORM" model developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 1976). A report by Liscum and Massey

[1]A water year is the 12-month period October 1 through September 30, designated by the calendar year in which it ends.

(1980) presented a technique for estimating the magnitude and frequency of floods in the Houston area from selected basin characteristics, drainage area, bankfull channel conveyance, and percentage of urban development.

The USGS gratefully acknowledges the support of the various agencies who participated in this study. Principal among these are the City of Houston and the Harris County Flood Control District (HCFCD). The U.S. Army Corps of Engineers also has provided support for parts of the study.

Purpose and Scope

This report presents a summary of selected hydrologic data collected in the Houston metropolitan area during water years 1964–89. The USGS primarily has concentrated on the collection of surface-water hydrologic data during this study (streamflow and samples to determine water quality). However, to build a data base that would be available (in a readily accessible form) for "cause and effect" studies of the rainfall-runoff process in an urban environment, two other types of data have been obtained: Selected basin characteristics were determined during the study (Johnson and Sayre, 1973; Liscum and Massey, 1980; and Sauer and others, 1983); and precipitation data were collected by the USGS and compiled from other agencies, notably the National Weather Service (NWS). A series of annual reports, published for water years 1965–84, present the data obtained during those years. This report summarizes those data and contains the complete data base for water years 1964–89 on computer diskettes.

Location and Description of the Study Area

The study area (fig. 1), the Houston metropolitan area in southeast Texas about 45 miles (mi) north of the Gulf of Mexico, is on an almost level plain. The land-surface altitude increases from about 35 feet (ft) above sea level in the southeast to about 135 ft in the northwest. Soils in the area predominantly are clay, clay loams, and fine sandy loams of low permeability.

Records show that the entire Houston metropolitan area developed rapidly during 1964–89. Population, in millions, grew from 1.24 in 1960 to 3.30 in 1990 with intervening censuses of 1.90 in 1970 and 2.74 in 1980 (A.H. Belo Corp., 1991).

The major stream draining the area is Buffalo Bayou (fig. 1), a tributary of the San Jacinto River. Buffalo Bayou is regulated by the Barker and the Addicks flood-detention reservoirs in the western part of the area. From these reservoirs, Buffalo Bayou meanders east, is fed by four major tributaries (Whiteoak, Brays, Sims, and Greens Bayous), and enters the Houston Ship Channel and then Galveston Bay on the Gulf of Mexico. The drainage area of Buffalo Bayou, excluding the area above the flood-detention reservoirs, is about 810 square miles (mi^2).

The climate of the Houston metropolitan area is characterized by short, mild winters, long, hot summers, high relative humidity, and prevailing southeasterly winds. The average annual temperature (1941–70) is 68.9 °F (20.5 °C). The average annual rainfall (1941–70) for Houston is 48.19 inches (in.), which is distributed uniformly throughout the year.

DATA COLLECTION

History of Data Collection

To collect the data required for the HURP, the USGS began installing and maintaining stream-gaging devices on most major drainage basins in the metropolitan area (Buffalo, Whiteoak, Brays, Sims, and Greens Bayous) and on many minor ones, including Keegans, Little Whiteoak, Berry, Vince, Hunting, and Halls Bayous. This activity started in water year 1964. Within 2 years, the HURP data network consisted of 27 rain gages and 33 streamflow-gaging stations (19 continuous; 14 flood hydrograph) maintained by the USGS. The maximum number of instrumented streamflow sites (39 locations) occurred in water years 1971, 1972 and 1982, which included 25 USGS-maintained rain gages (water years 1970–72 and 1980–82). Water-quality sampling began at 1 site in water year 1968 and increased to 13 sites in water year 1969. The water-quality network had a maximum of 15 sites in water year 1972 and 14 sites during water years 1974–75 and 1980–81. A total of 54 stations and 102 rain gages were monitored during water years 1964–89.

The data network has undergone two major modifications. In water year 1978, the water-quality sampling procedures were changed considerably due to a recommendation by Waddell and others (1979) that water-quality data should be collected during a storm. Thus, sample collection procedures were changed to allow the inclusion of samples taken at discrete times during a storm using either manual collection techniques or automatic samplers. Because of financial constraints, most of the rain gages in the network

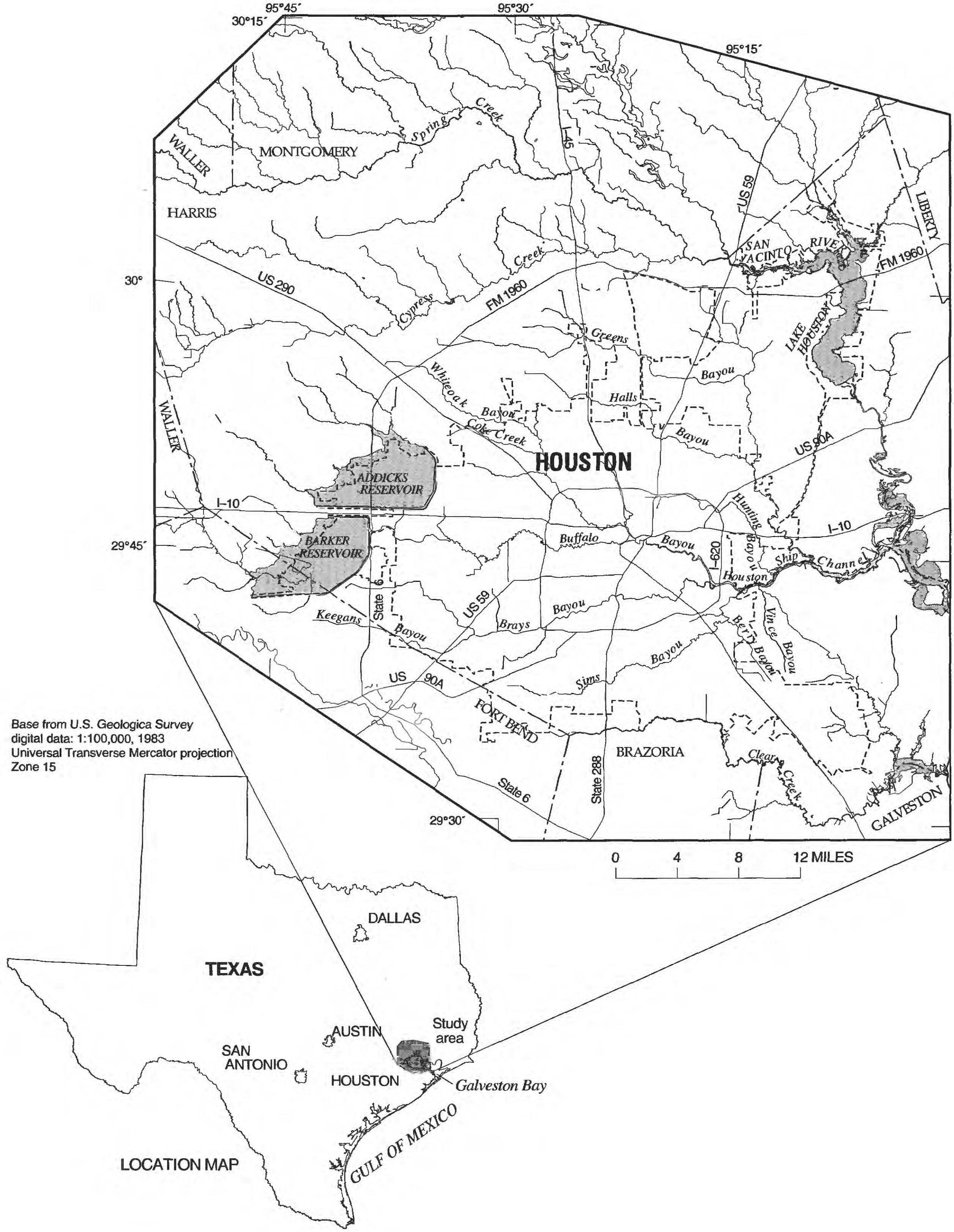


Figure 1. Location of the study area including major streams.

(maintained by the USGS), which were used to define storm rainfall over the various drainage basins in the study area, were dismantled in water year 1984. Thus, storm-related data for water years 1985–89 are based on a less-dense network of USGS and NWS rain gages and on some available data obtained from the HCFCD flood-warning system (ALERT) located at USGS gaging stations.

Data collected in this study have been published in 21 urban hydrologic data reports featuring data collected beginning in water year 1964 and ending in water year 1984 (Smith and Johnson, 1965; Johnson and Smith, 1965; Johnson, 1966–68, 1971; Ferguson, 1972–74; Fisher and King, 1975; Ranzau, 1976–77; Hutchison, 1978–79; Hutchison and Weigel, 1980; Liscum and others, 1982–83, 1985, 1987; and Liscum, 1985–86). Before this report, the storm data published in the listed reports had not been archived to computer-compatible media. The daily data collected at the sites of this study have been published in the annual series, Water Resources Data, for Texas (volume 2) for water years 1964–89.

Description of Data Network

The USGS data collection network consists of several types of gaging stations. These are described below and are used in table 1 (at end of this report) to classify the various sites by type of data collected at each station. The types of gaging stations are

(1) Continuous-record streamflow—the gage consists of a water-stage sensor and a recording device that records water stage from base (or zero) flow to flood stage. Discharge measurements are made at the site to define a stage-discharge relation. Data computed are flood discharges, flood stages, daily average flows, and flood-runoff hydrographs.

(2) Flood hydrograph—the gage consists of a water-stage sensor and a recording device that records water stage from an arbitrary minimum stage to flood stage. Discharge measurements are made at the site to define a stage-discharge relation. Data computed are flood discharges, flood stages, and flood-runoff hydrographs.

(3) Flood hydrograph, stage only—the gage consists of a water-stage sensor and a recording device that records water stage from some arbitrary minimum stage to flood stage. Data computed are annual maximum stage. Flood-stage hydrographs also are available.

(4) Reservoir contents—the gage consists of a water-stage sensor and a recording device that records water stage, from an arbitrary datum, within the reservoir. Surveying techniques are used to relate the water stage to the actual volume of water (contents of the reservoir) in acre-feet.

(5) Partial-record low flow—no gage is present. A reference measuring point is established to determine water stage to an arbitrary datum. Discharge measurements are obtained to define low flow.

(6) Discharge measurements only—no gage is present. A reference measuring point is established to determine water stage to an arbitrary datum. Discharge measurements are obtained at various water stages.

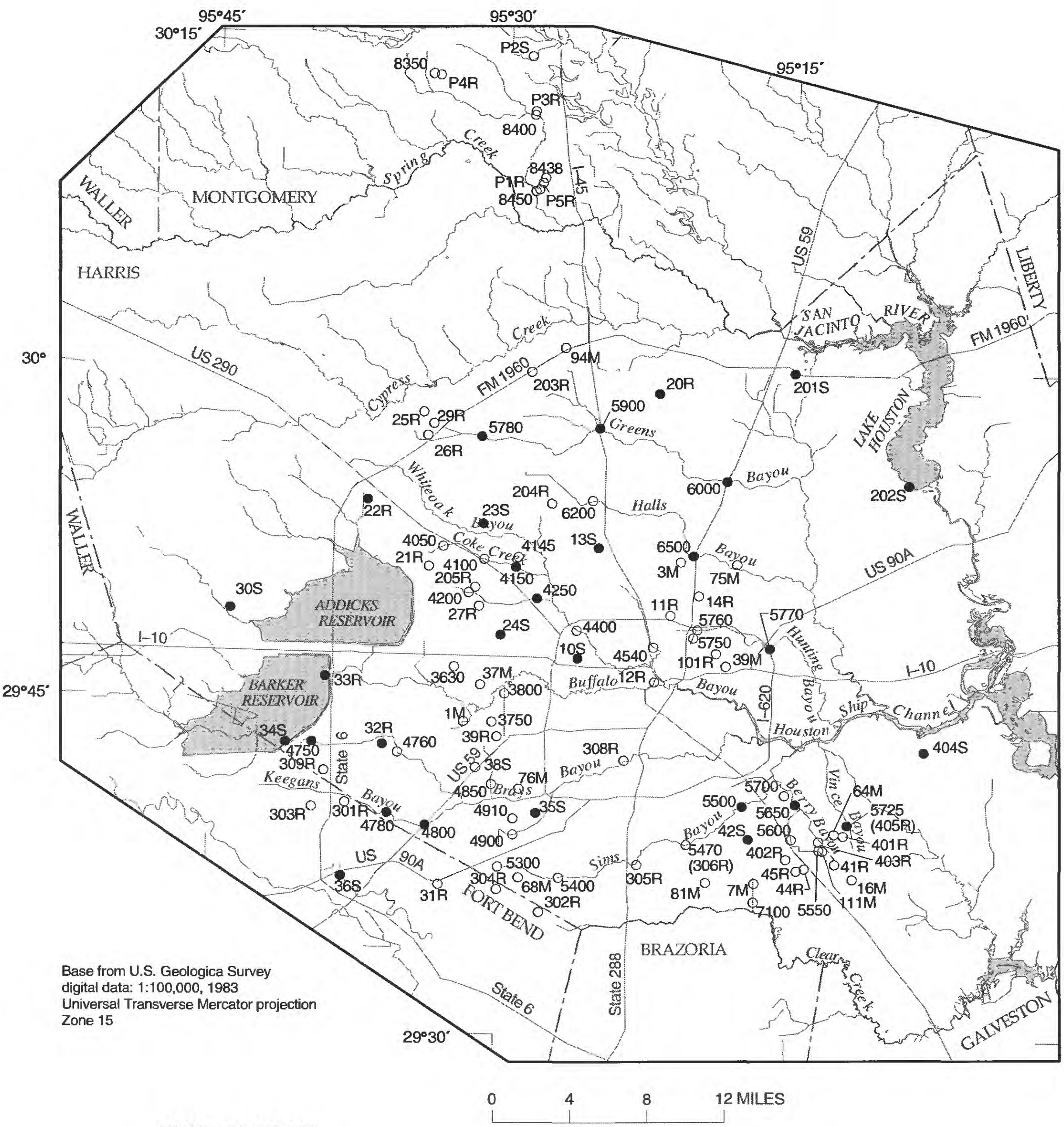
(7) Water quality—the gage consists of a site where water-quality samples are collected either manually or automatically (using a sampler that, when activated by rising water, collects a sample at discrete times).

(8) Precipitation (rainfall)—the gage consists of a rainfall collecting device that requires either a tipping bucket, a float, or a weighing device to determine accumulated rainfall. Data computed are daily total rainfall and incremental amounts for given time intervals. Rain gages used in this study were maintained by the USGS, the NWS, and local agencies: Harris County Mosquito Control District (HCMCD), Rice University, City of Houston, and HCFCD.

The locations of all data collection sites, which include hydrologic-instrument installations and water-quality sampling sites, used in the study are shown in figures 2a–c for the entire period covered by this report. Plot symbols emphasize which sites were in operation, or active, as of September 30, 1989. Table 1 summarizes the period of record and the type of data collected for each USGS site active during the study. A station manuscript for each surface-water site, which contains the station location and other pertinent information, is on the diskettes furnished with this report.

BASIN CHARACTERISTICS

To understand the changes in hydrologic responses due to urban development, various basin characteristics have been defined. These basin characteristics enable the hydrologic data collected from the HURP network to be subjected to various forms of analysis, including the development of statistical models, to estimate the effect of urban development on surface-water hydrologic responses. The basin characteristics

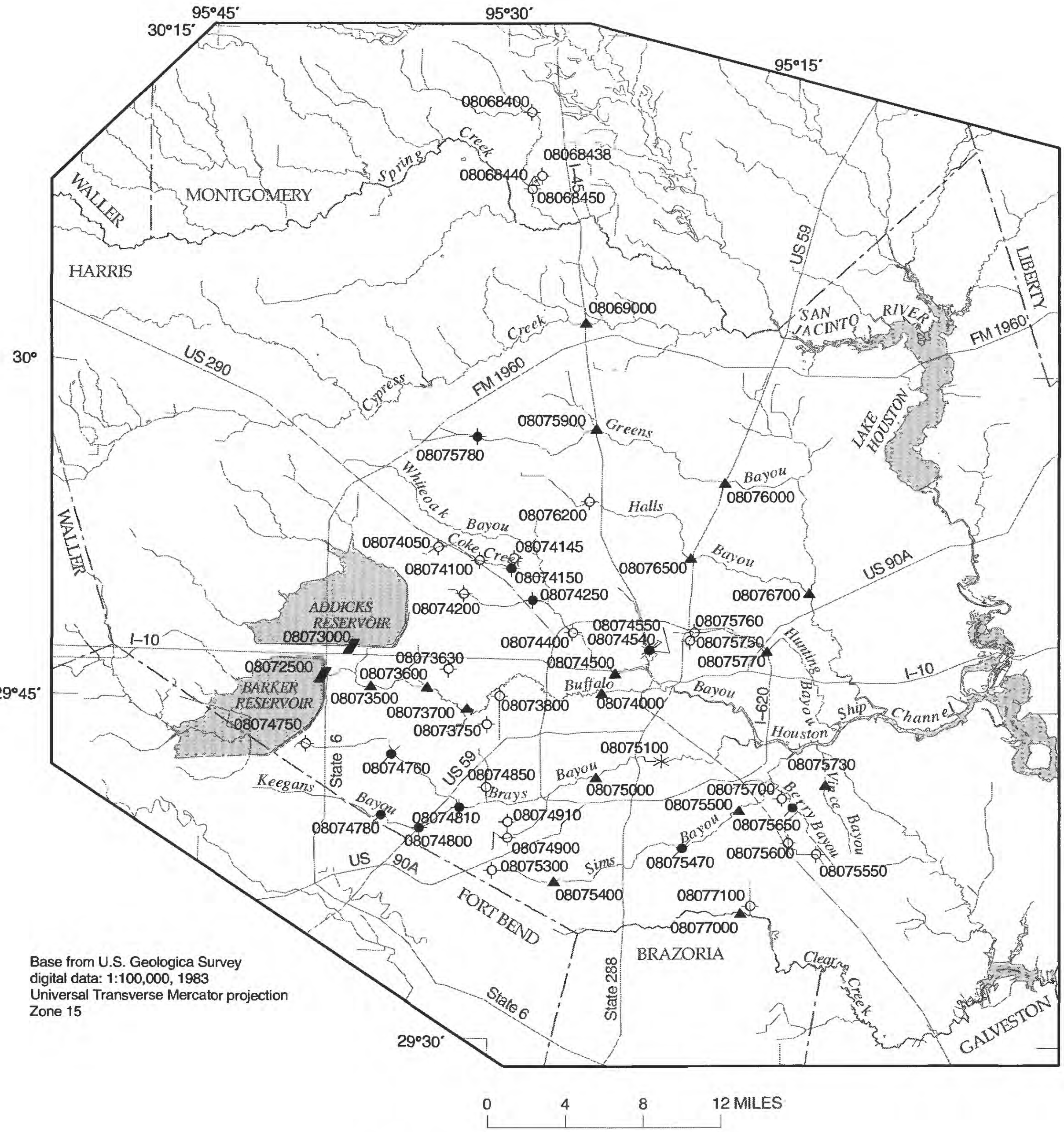


EXPLANATION

30S ● **Rain gage and number (active in 1989)**

5760 ○ **Rain gage and number (inactive in 1989)**

Figure 2a. Location of the data-collection sites for rainfall.



EXPLANATION

- ▲ Continuous-record station (active in 1989)
- △ Continuous-record station (inactive in 1989)
- Flood-hydrograph station (active in 1989)
- Flood-hydrograph station (inactive in 1989)
- Flood-hydrograph stage-only station (active in 1989)
- Flood-hydrograph stage-only station (inactive in 1989)
- Reservoir-contents station (active in 1989)
- ✳ Partial-record low-flow station (inactive in 1989)
- 08077000 Station number

Figure 2b. Location of the data-collection sites for streamflow.

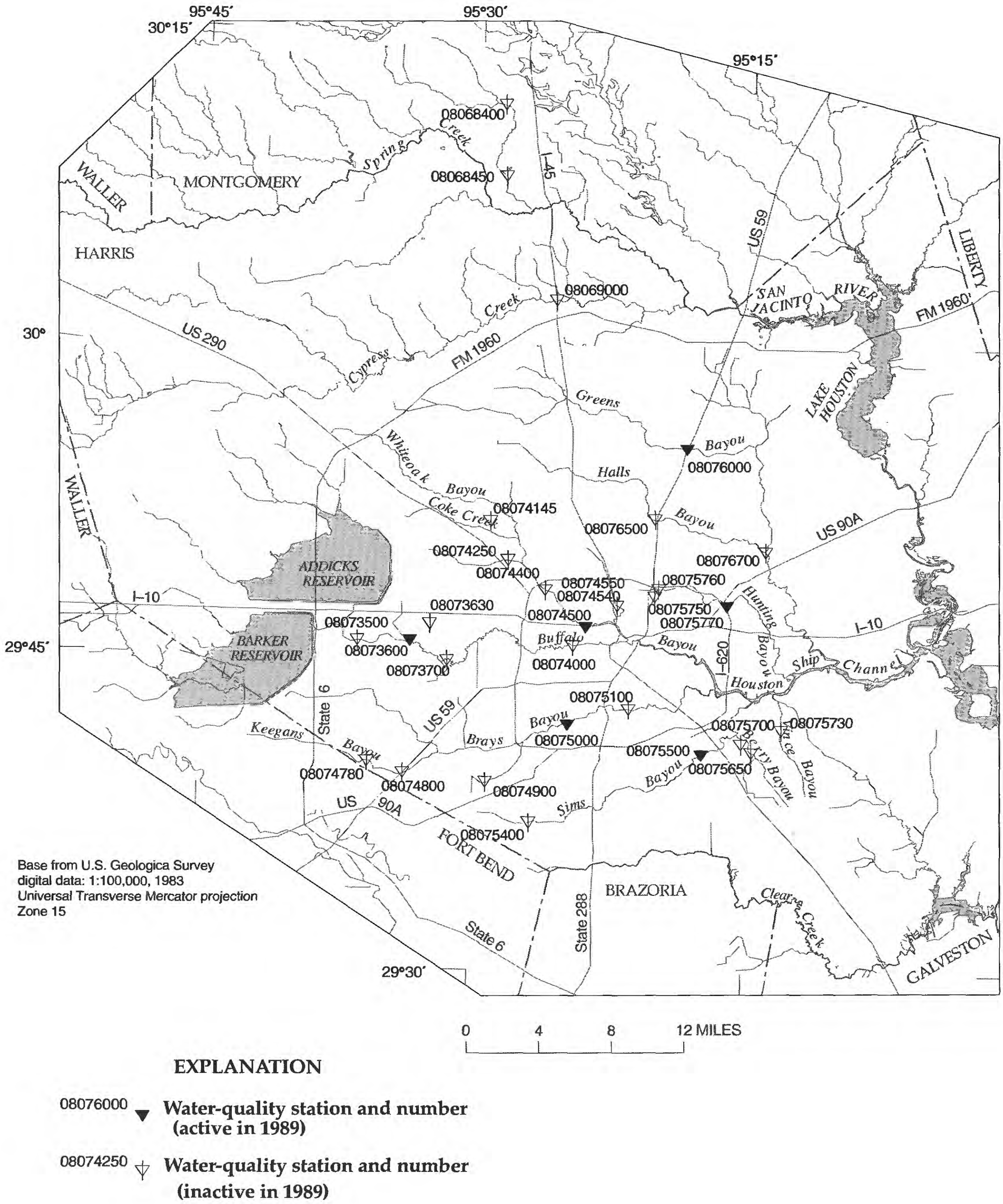


Figure 2c. Location of the data-collection sites for water quality.

developed during this study fall into two general categories: The first category comprises basin characteristics that represent the topography of the basin; all are essentially time invariant or were computed only once during the study. The second category comprises basin characteristics that reflect changes in urban development; they vary with time and were computed for 3 water years.

Descriptors of Basin Topography

Eleven basin characteristics (drainage area, channel slope, channel rise, shape factor, basin length, drainage density, soil index, impervious area, storm-sewered area, urban-location ratio, and bank-full channel conveyance) were computed for two studies done in the HURP program. Most of these basin characteristics were computed for 29 sites (table 2 at the end of this report). Except for bank-full channel conveyance, the basin characteristics were computed by Johnson and Sayre (1973). Bank-full channel conveyance was computed by Liscum and Massey (1980). Following is the definition of each characteristic with a brief summary of the values determined:

Drainage area (*A*)—Drainage area is the contributing drainage area, in square miles, upstream of the location of the streamflow-gaging station. Areas range from 0.50 to 182.0 mi^2; 12 are greater than 10.00 mi^2, 3 are less than 2.00 mi^2, and 14 range from 2.05 to 9.28 mi^2.

Channel slope (*Sc*)—Channel slope is the slope, in feet per mile, between the points at 10 percent and 85 percent of the length along the main channel from the gaging station to the edge of the basin. Slopes range from 2.50 to 8.80 feet per mile (ft/mi); 4 slopes are greater than 6.00 ft/mi, 10 are less than 4.00 ft/mi, and 12 range from 4.40 to 60.0 ft/mi.

Channel rise (*H*)—Channel rise is the difference in altitude, in feet, between the 10-percent and 85-percent points of the length along the main channel from the gaging station to the edge of the basin. Rises range from 1.80 to 79.0 ft; 18 rises are greater than 10.00 ft, 2 are less than 5.00 ft, and 6 range from 7.00 to 9.00 ft.

Shape factor (*Sf*)—Shape factor is the ratio of the drainage area (*A*) divided by the square of the distance along the main channel from the gaging station to a point on the channel nearest the centroid of the basin. Shape factors range from 0.70 to 4.10; 9 are greater than 2.00, 5 are less than 1.00, and 12 range from 1.00 to 2.00.

Basin length (*Lb*)—Basin length is the distance, in miles, along the channel from the gaging station to the head of the basin. Basin lengths range from 0.80 to 20.0 mi; 4 lengths are greater than 10.00 mi, 4 are less than 2.00 mi, and 18 range from 2.00 to 9.90 mi.

Drainage density (*Dd*)—Drainage density is the total length of storm sewers and drainage channels (including the main channel) divided by the drainage area, in miles per square mile. To simplify the computation, only storm sewers with diameters 36 in. or greater were used. Generally, all ditches and channels shown on USGS 7–1/2 minute quadrangle maps and those maintained by HCFCD were used in the calculation of lengths. Densities range from 0.51 to 3.24 mi/mi^2; 6 densities are greater than 2.00 mi/mi^2, 6 are less than 1.00 mi/mi^2, and 14 range from 1.07 to 1.99 mi/mi^2.

Soil index (*Si*)—Soil index is the maximum permeability of the natural soil, in inches, based on U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) soil survey maps. Indexes are either 0.20 in. or 2.00 in., except for one site with an index of 1.30 in. In general, soils north of Buffalo Bayou are more permeable than those south of Buffalo Bayou.

The following topographic descriptors can change with time but were computed only once during the study:

Impervious area (*Ai*)—Impervious area is the total area, in square miles, covered by impervious surfaces such as houses, buildings, streets, and parking lots. Areas range from 0.07 to 13.30 mi^2, which represents a range in impervious area of 1.9 to 34.9 percent.

Storm-sewered area (*As*)—Storm-sewered area is the total area, in square miles, in the basin served by storm sewers. It includes all area within 200 ft of a storm sewer, or a street or parking lot drained by a storm sewer. Areas range from 0.02 to 28.70 mi^2. This measure of urbanization, like impervious area, is difficult to compute without detailed maps.

Urban-location ratio (*U*)—Urban location ratio is the distance along the main channel from the gaging station to the point on the channel nearest the centroid of the basin divided by the distance from the gaging station to the centroid of the urban area. Ratios range from 0.80 to 3.30; 4 ratios are greater than 2.00, 1 is less than 1.00, and 21 range from 1.00 to 1.90.

Bank-full channel conveyance (*K*)—Bank-full channel conveyance is the conveyance, in cubic feet per second, at the controlling section of the stream, when the stage is equal to that of the lower bank, as computed from Manning's equation for open-channel flow:

$$K = \frac{1.49}{n} Ax R^{\frac{2}{3}} ,$$

where

Ax = bank-full cross-sectional area, in square feet;
R = bank-full hydraulic radius, in feet; and
n = Manning's roughness coefficient.

Conveyances range from 12,000 to 2,800,000 cubic feet per second (ft^3/s); 2 conveyances are greater than 1,000,000 ft^3/s, 10 are less than 100,000 ft^3/s, and 10 range from 100,000 to 930,000 ft^3/s.

Descriptors of Urban Development

Four basin characteristics, percentage of urban development (*PAd*), degree of development (*DegD*), type of development (*TypeD*), and basin development factor (*BDF*) represent how a basin changes over time. Change with time is determined by computing each descriptor at different times and assuming a linear relation between the computed values. Each descriptor was computed from map data for water years 1966, 1976, and 1984. Variation in measures of urban development ranges from little or no change for urban basins with older development, such as Hunting Bayou (fig. 3) near downtown Houston, to rather sharp changes for suburban basins with newer development, such as Greens Bayou in north Harris County. Basin characteristics, computed for 29 sites in the data network (table 3 at the end of this report), are discussed below:

(1) *PAd* is the percentage of the total contributing drainage area upstream of a gage within 200 ft of streets, roads, parking lots, and industrial sites that is drained by open street ditches or storm sewers. This area also includes roads in rural areas. *PAd* as used by Johnson and Sayre (1973) is highly correlated with the percentage of impervious area (Southard, 1986). For this reason, and the fact that it is easier to determine accurately from aerial photographs, Liscum and Massey (1980) used *PAd* rather than impervious area in their study. *PAd* ranges from 15.3 to 100 percent for 1966–84. In 1966, the contributing drainage areas upstream of 9 sites had *PAds* less than 30 percent. By 1984, no site had a *Pad* less than 30 percent.

(2) *DegD* is represented by integers that indicate ranges of percentage of urban development, *PAd*. For 1984, *DegD* equaled 1 for no sites, 2 for 7 sites, and 3 for 22 sites.

(3) *TypeD* is represented by integers that indicate the predominant land use for contributing drainage areas above gages. In 1966 rural use was predominant in the contributing drainage areas upstream of 12 sites. By 1984, rural use was not predominant in any of the drainage areas.

(4) *BDF* is an index of the prevalence of drainage-enhancing features in a basin—channel improvements (*BDF–CI*), impervious channel linings (*BDF–CL*), storm sewers (*BDF–SS*), and curb and gutters (*BDF–CAG*). A *BDF* of zero indicates that the drainage-enhancing features are not prevalent but does not necessarily mean that the basin is not urbanized. A *BDF* of 12.0 (each of the 4 features has a maximum of 3.0) indicates full development of the drainage-enhancing features throughout the basin (Sauer and others, 1983). In 1966, the contributing drainage areas upstream of 9 sites had *BDFs* less than 3.0. By 1984, no site had a *BDF* less than 3.0.

SUMMARY OF PRECIPITATION DATA

All precipitation data measured in the study area are rainfall. Rain gages were distributed throughout the drainage basins to measure total rainfall and to define rainfall incremental amounts. A total of 102 rain gages (fig. 2a) were used during this study; 76 rain gages were used to define storm rainfall (incremental rainfall amounts) (table 4 at the end of this report). Thirty-eight

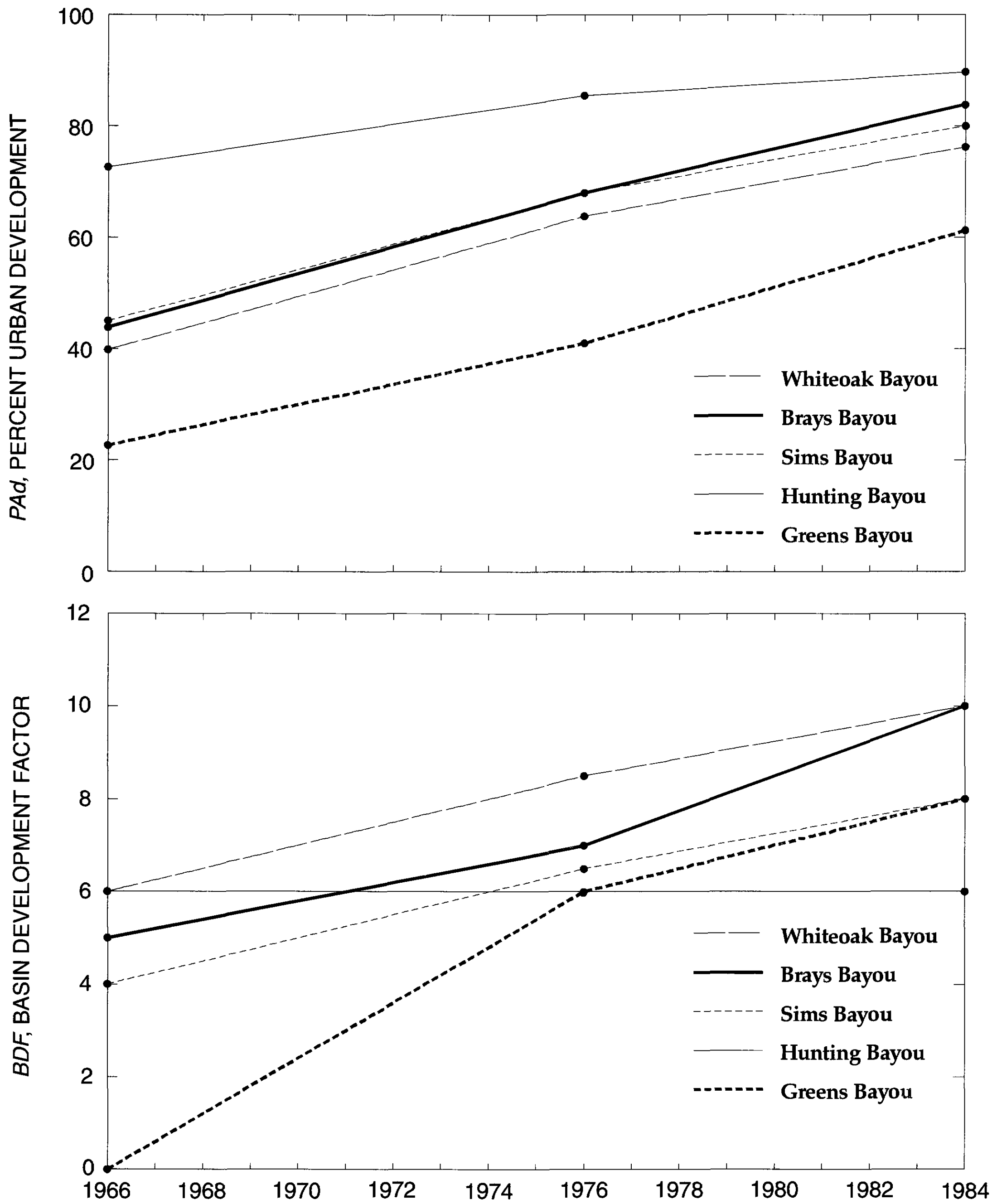


Figure 3. Variation in selected basin characteristics for selected basins, water years 1966–84.

of the rain gages were located at USGS streamflow sites; other rain gages not located at USGS streamflow sites were operated either by the USGS at remote sites or by other agencies (NWS, HCMCD, Rice University, City of Houston, or HCFCD). The data network begun in water year 1964 consisted of 45 rain gages. By water year 1970, the rainfall network had 54 rain gages. In water year 1984, the USGS operated 37 rain gages (27 at streamflow sites and 10 at other sites), and the network total was 58 rain gages. At the end of water year 1984, the rain gage network was reduced. The network for water years 1984–89 consisted of 35 rain gages (14 operated by the USGS and 21 operated by NWS). HCFCD began installing radio telemetry for rain gages in 1983, and, as of water year 1989, had installed them at 18 USGS streamflow sites. General locations and period of record for the rain gages in the network are listed in table 4.

Rainfall data for five basins (Whiteoak, Brays, Sims, Hunting, and Greens Bayous) collected during water years 1965–89 compared to NWS rainfall data collected before the study (water years 1950–64) show that the mean monthly rainfall did not vary appreciably between the two time periods (fig. 4). Water year total rainfall varied from a maximum of 88.81 in. at NWS rain gage 404S[2] in Deer Park for 1979 to a minimum of 22.62 in. for water year 1984 at the rain gage in Greens Bayou at USGS streamflow station 08076000[3]. These annual totals compare closely to annual totals recorded during the 15 years before the study, water years 1950–64 (maximum, 79.15 in. at 13S in water year 1961; minimum, 19.89 in. at 404S in water year 1956).

Rainfall was recorded at 5-, 15-, 30-, and 60-minute increments during the study. These data are the basis for defining storm rainfall for the various storm hydrographs presented in this report. From the total of 76 rain gages used during the study to define storm rainfall, the maximum recorded incremental rainfall observed for 15, 30, and 60 minutes can be compared to data from the NWS for the 25-year recurrence interval and for the 50-year recurrence interval (Hershfield, 1961; Frederick and others, 1977):

Time increment (minutes)	25-year recurrence total (inches)	50-year recurrence total (inches)	Maximum for this study (inches)
15	1.7	1.9	2.25
30	3.1	3.4	3.00
60	3.8	4.2	4.90

Rainfall recorded at a rain gage is assumed to be representative of the area surrounding the rain gage. Several methods can be used to distribute point rainfall over an area. The method chosen for the HURP study is that using weighted-mean precipitation factors for a drainage basin. Weighted-mean precipitation factors for drainage basins in the Houston area are included with the storm hydrograph data on the diskettes. Weighted-mean precipitation for a study area is determined by the Thiessen method described by Linsley and others (1982). Because the number of rain gages in the HURP network was reduced from 58 to 35 after water year 1984, it is assumed that less accurate basin total rainfall amounts were computed after 1984.

[2]Rain gage ID number 404S indicates a rain gage not located at a USGS streamflow station. These 3-digit numbers (followed by either "R" or "S" were arbitrarily assigned for use in the study (Smith and Johnson, 1965). The letter "S" indicates a daily non-recording gage and "R" indicates a recording gage.

[3]The last 4 digits of the USGS station number (6000) indicate the rain gage ID number.

SUMMARY OF SURFACE-WATER HYDROLOGIC DATA

Two general types of surface-water hydrologic data for water years 1964–89 are provided: (1) water-quantity data that indicate the hydrologic response on the land surface to precipitation (for example, surface runoff for the selected streamflow sites) and (2) water-quality data. All of the data summarized in this section, with the exception of daily mean flows, are on the computer diskettes, the formats for which are in a later section of this report.

Water-Quantity Data

The objectives of HURP required that several measures of surface runoff be determined for the sites selected for this study. Runoff data are based on discharge measurements and stage records that were collected during the study at a total of 54 stations (fig. 2b; table 1). The number of continuous-record streamflow-gaging stations was 16 in water year 1964 and also 16 in water year 1989; a maximum of 22 sites were monitored in water years 1975 and 1976. The number of flood-hydrograph stations operated was 13 in water year 1964 and 10 in water year 1989; a maximum of 23 sites were monitored in water year 1982.

The type of runoff data computed comprise the following:

(1) Flood peaks—Annual flood peaks, defined as the maximum discharge, in cubic feet per second, that occurred during the water year, were determined for each site. At selected sites, peaks above a base discharge, defined by selecting a discharge that, on average, was exceeded about three times per year, were determined. The analysis of flood peaks provides information for planners, engineers and others to develop methods to understand, prevent, and (or) reduce damage from floods. Thirty-five of the sites used for the study had 10 or more years of record. Nine of these stations (08069000, 08073500, 08074000, 08074500, 08075000, 08075500, 08076000, 08076500, 08077000) have periods of record longer than the study period. The recorded annual peaks show that at five of these long-term sites (08074500, 08075000, 08075500, 08076000, 08076500), the peak for period of record

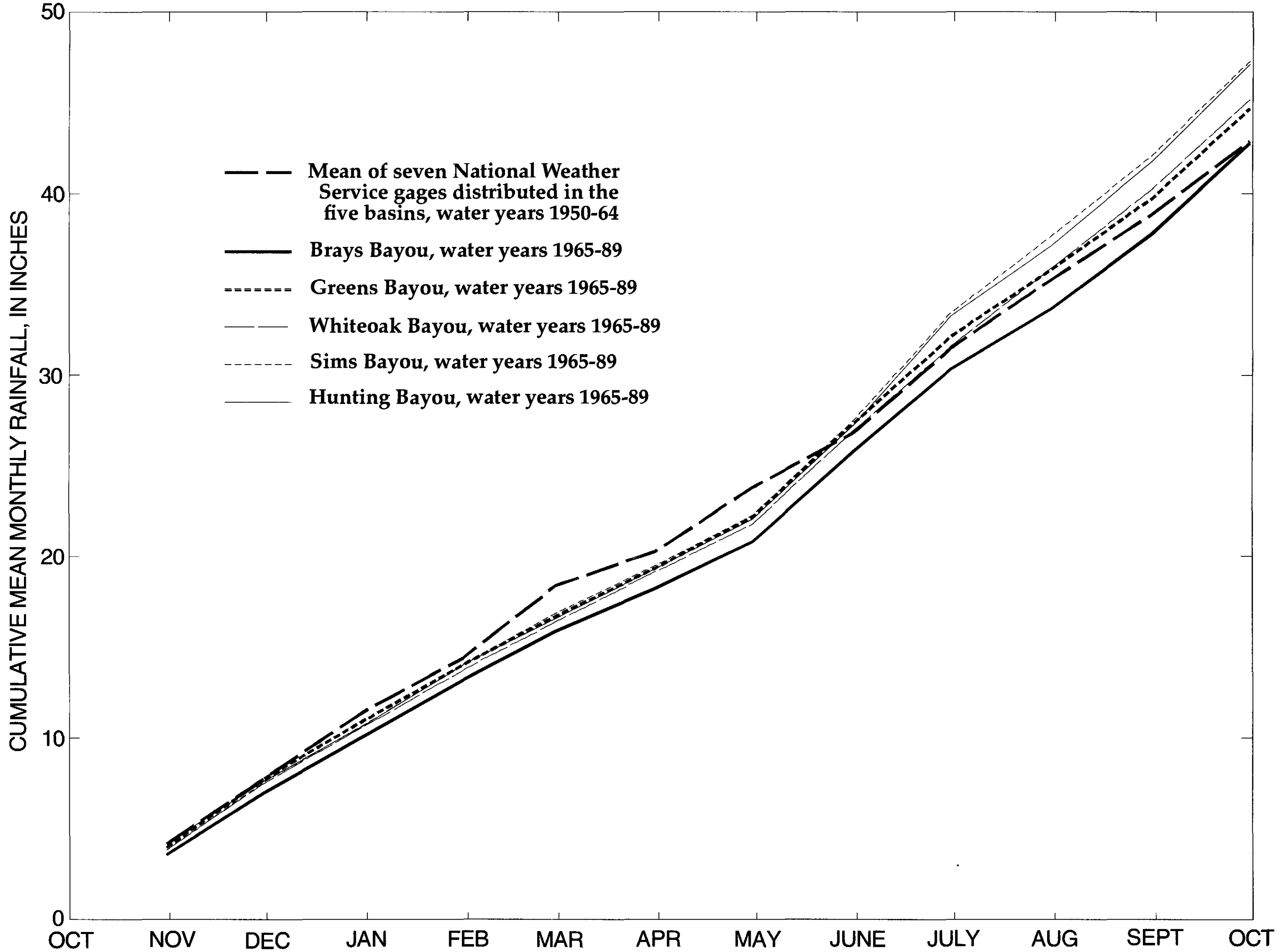


Figure 4. Cumulative mean monthly rainfall in five drainage basins, Houston metropolitan area, water years 1965–89, compared with rainfall from the National Weather Service gages, water years 1950–64.

occurred during the study period (table 5 at the end of this report). The fact that these 5 sites have been urbanized more rapidly than the 4 other long-term sites supports a presumed effect of urbanization—that urbanization increases the magnitude of annual flood peaks.

(2) Storm hydrographs—Discharge hydrographs (and for some sites, stage hydrographs) were determined for a selected number of storms during each water year at selected sites. The discharge (or stage) hydrograph of a storm, combined with associated rainfall data, yields a wealth of information about how a drainage basin responds to a rainstorm. Understanding this response, and understanding how changes in the drainage basin affect this response, allows the development of measures to alleviate potential damage from future storms. A total of 1,125 storm hydrographs, representing 289 rainstorms, are available from this study. Forty-three of the 54 USGS sites have storm hydrographs available; the most available at a single site is 55 at station 08074250 (table 6 at the end of this report). To understand the hydrologic response of these urbanizing basins, it is important that extreme storms be included in the data base. For this reason, the data base includes the storm hydrograph data (table 6) for the peak for the period of record at 26 of 35 sites with periods of record greater than 10 years (table 5). These data are included on the diskettes.

(3) Daily mean flows—Daily mean discharges were computed for continuous streamflow stations. These data are available in the USGS annual publication series Water Resources Data for Texas. Daily mean flows are computed for the continuous streamflow-gaging stations. These flows can be used to study trends in surface runoff over the period of the study. A comparison of cumulative mean monthly runoff for the five main basins in the study area (Buffalo, Whiteoak, Brays, Sims, and Greens Bayous) for a period before the study (and before substantial urban development), water years 1953–64, with cumulative mean monthly runoff computed for these basins during the study period, water years 1965–89 (fig. 5), supports a presumed effect of urbanization—that urbanization increases runoff. Steeper slopes of the cumulative runoff curves during the more recent period could indicate man-made changes in the watersheds, such as increased urban development, channel rectification (including channel straightening and (or) concrete-lining), and an increase in return flows from industry and (or) sewage-treatment facilities.

Water-Quality Data

Water-quality data have been collected for the study since water year 1968. Initially, single samples were collected to represent various flow conditions over a 1-year period. However, Waddell and others (1979) suggested that a better data base for the study would result if samples were collected during storms as defined by the response of the storm hydrograph (for example, at first flush; at rising side of hydrograph; and near or at peak, recession, and base flow). These suggestions were implemented in 1978. Subsequently, samples have been collected manually or using a flow-activated automatic sampler during storms. The locations of the data-collection sites for water-quality sampling are shown in figure 2c.

Water-quality data obtained include physical, biological, and chemical parameters. Physical analyses comprise measurements of pH, temperature, color, turbidity, and suspended and volatile solids. Biological analyses comprise measurements of 5-day biochemical oxygen demand and bacteriological analyses for total coliform, fecal coliform, and fecal streptococci. Chemical analyses comprise specific conductance, dissolved oxygen, standard inorganic constituents (major ions), and selected nutrients consisting of total organic carbon, nitrogen, and phosphorus. Selected samples were analyzed for trace elements and pesticides. These data are included on the computer diskettes. Data formats are explained in the next section.

Water-quality samples are available for 30 USGS stations (fig. 2c) from the study for a total of 3,242 samples (table 7 at the end of this report). Samples collected were of two types, discrete and composite. Discrete samples are those collected at a single location over a finite time interval so that a sample is considered representative of a single point in space and time. Composite samples also are representative of a single location but are a combination of samples collected at different times and composited on the basis of flow for the stream when each sample was collected. Forty-four of the 3,242 samples collected are composite samples (table 7). Station 08074800 was sampled most frequently (227 discrete samples); station 08074400, located at a storm sewer, had the most composite samples, 12 (table 7).

Water-quality samples were analyzed for 102 water-quality properties and constituents. As many as 3,025 samples were analyzed for specific conductance and as few as 4 samples were analyzed for total orthophosphate phosphorous. Summary statistics indicate

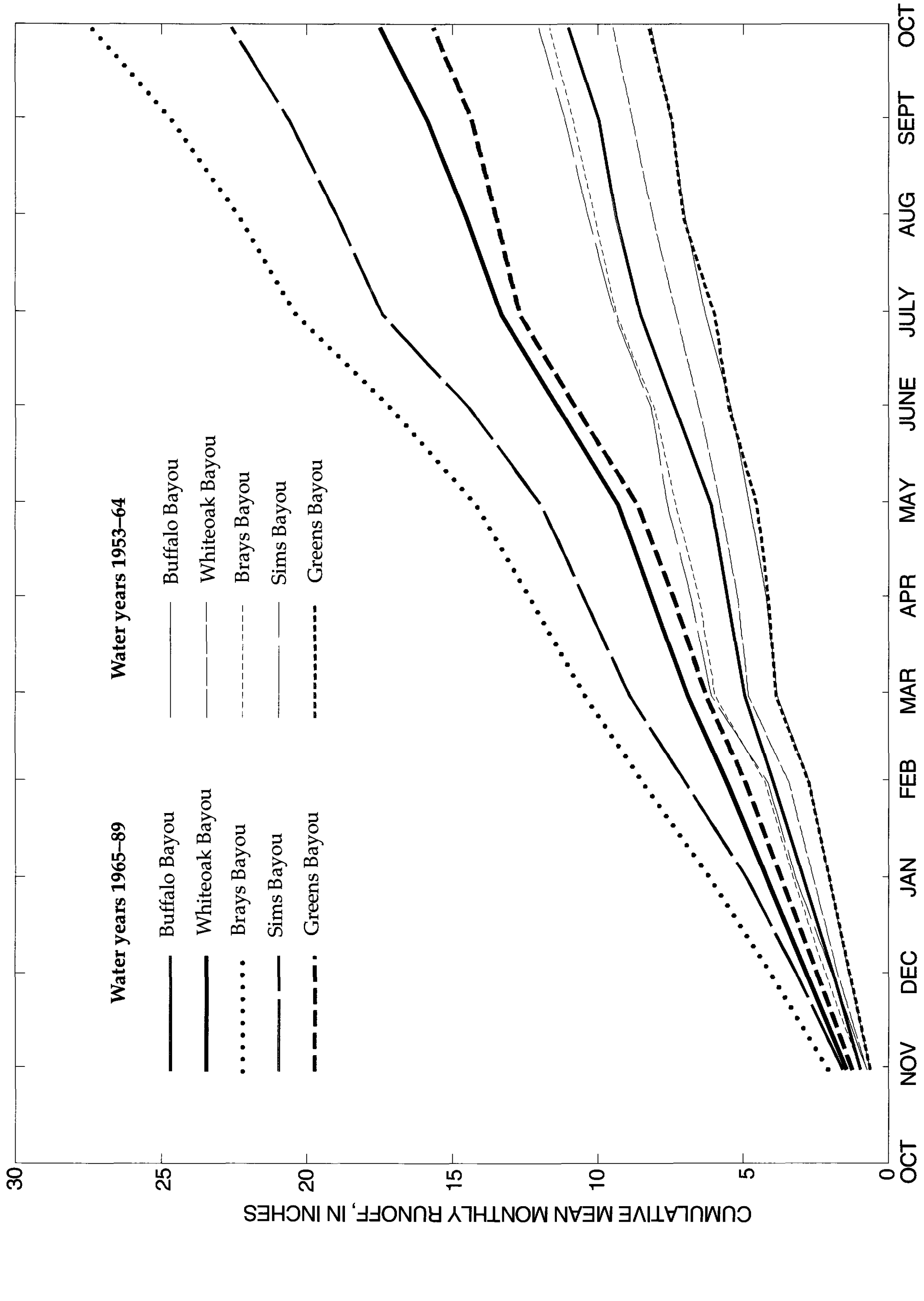


Figure 5. Cumulative mean monthly runoff in five drainage basins, Houston metropolitan area, water years 1965–89 and 1953–64.

STATION—08074800 KEEGANS BAYOU AT ROARK ROAD NEAR HOUSTON, TX
(Flood-hydrograph partial-record station)

BASIN—SAN JACINTO RIVER BASIN

LOCATION—Lat 29°39'23", long 95°33'43", Harris County, Hydrologic Unit 12040104 on left bank on downstream side of bridge on Roark Road in southwest Houston.

DRAINAGE AREA—12.7 mi^2. Prior to Sept. 30, 1976, 11.6 mi^2. Oct. 1, 1976, to Dec. 31, 1977, 12.0 mi^2; Jan. 1, 1978 to Sept. 30, 1987, 11.5 mi^2. Drainage area changes were the result of ditch relocations or extensions.

PERIOD OF RECORD—Discharge: August 1964 to current year. (Station converted to flood-hydrograph partial-record station on Oct. 1, 1981.) Water-quality records—Chemical, biochemical and pesticide analyses: October 1968 to September 1983.

GAGE—Water-stage recorder and crest-stage gage. Datum of gage is National Geodetic Vertical Datum of 1929, 1957 adjustment; unadjusted for land-surface subsidence.

REMARKS—Channel was rectified during latter part of 1981 water year. Stage and rainfall are transmitted by radio telemetry, owned and operated by Harris County Flood Control District, from this site.

EXTREMES FOR PERIOD OF RECORD—Maximum discharge, 4,250 ft^3/s Sept. 19, 1983 (elevation 75.00 ft).

Figure 6. Example of station manuscript.

how the water-quality properties and constituents determined for the study vary across the study area (table 8 at the end of this report).

DATA AVAILABILITY AND FORMATS

The data for this study are on two computer diskettes. Each diskette contains a "READ-ME" file that explains how to extract the data and the data formats for the files. All files consist of 80-character plain-text records.

Up to four types of data are available for each USGS streamflow-gaging station, depending on the station type. This results in up to four data files for each station. The four types of data are:

(1) station manuscript;

(2) annual peaks, including peaks above a base discharge (if computed)'

(3) storm hydrographs; and

(4) analytical results determined for water-quality samples.

One-hundred seventy-seven files (54 manuscript files, 50 annual peak files, 43 storm hydrograph files, and 30 water-quality files) are on the two diskettes. These files require about 10.5 megabytes of storage under MS–DOS. To reduce the number of diskettes, the files have been compressed and then run through a computer program that produces executable extractable files (.EXE files). Each diskette has the "READ-ME" file and one .EXE file. The data are grouped so that data for USGS streamflow-gaging stations north of Buffalo Bayou are on the diskette labeled HURP NORTH, and data for stations on and south of Buffalo Bayou are on the diskette labeled HURP SOUTH.

Station manuscript—The station manuscript provides pertinent information about the gaging station consisting of identification of the major river basin where the site is located, a detailed station location, discussion of drainage area, period of record, gage description, a remarks section, and a list of the extremes for the period of record (fig. 6). Station manuscript files are identified on the diskette with a leading "M." For example, the manuscript file for USGS station 08075000 would be M75000.dat.

Annual peaks—Annual peaks are the maximum discharge and (or) stage that occurred during a water year at a gaging station. This file also will contain peaks that exceed a base discharge, if computed. The formats for these files are shown in figure 7. These data files are identified on the diskette with a leading "P." Thus, the annual peak data for station 08075000 are in file P75000.dat.

Storm hydrographs—Storm hydrograph data include precipitation, runoff (discharge) and supporting

```
Example of peak data

Peak data for station 08076000

col.     1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

2 08076000
3 08076000         19530518   3280C                61.38
4 08076000         19530503   1090C                54.65
4 08076000         19530513   1430C                55.79
4 08076000         19530515   1340C                55.54
```

Explanation of data formats

Record type	Columns	Field name	Explanation
2	1	Record type	Station ID
	2–16	Station ID	USGS 8-digit ID no.
	17–80	--	Blank
3	1	Record type	Peak flow data
	2–16	Station ID	USGS 8-digit ID no.
	17–24	Date of annual peak	YYYYMMDD (YYYY = calendar year)
	25–31	Annual peak	Discharge, in cubic feet per second
	32–43	Codes	Discharge qualification codes. See Appendix 1
	44–51	Annual peak gage height	Gage height at time of annual peak, in feet above datum
	52–55	Codes	Gage height qualification codes. See Appendix 1
	56–59	Highest year since	Annual peak is highest since YYYY (calendar year). Usually coded only for earliest years of record
	60–63	Month and day of maximum gage height for year	MMDD columns 60–75 only coded when gage height associated with annual peak (columns 44–51) has been exceeded sometime during year
	64–71	Maximum annual gage height for year	In feet above datum
	72–75	Codes	Gage height qualification codes. See Appendix 1
	76–80	Blank	
4	1	Record type	Partial-duration peak-flow data
	2–16	Station ID	USGS 8-digit ID no.
	17–24	Date of annual peak	Calendar year in 17–20; month, 21–22; day, 23–24
	25–31	Partial duration peak	Discharge, in cubic feet per second
	32–43	Codes	Discharge qualification codes. See Appendix 1
	44–51	Partial duration peak gage height	Gage height at time of partial duration peak, in feet above datum
	52–55	Codes	Gage height qualification codes. See Appendix 1
	56–80	Blank	

Figure 7. Example of peak data and explanation of formats.

data (Thiessen weights for rain gages; basin drainage areas; and, possibly, adjusting factors for rainfall) for selected storms recorded at a station. These selected storms usually include, at least, the annual peak. Storm data are presented using two main types of 80-character plain-text records (one with a "2" in position 1, and one with a "B" in position one) plus additional types that contain the supporting data (fig. 8). These files are identified with a leading "S." Thus, storm data for station 08075000 are in file S75000.dat.

Water quality—Water quality files provide data on the water samples collected and analyzed for selected constituents at a station. Data are presented for each constituent for which samples were analyzed, grouped by date and time, using two types of 80-character plain-text records referred to as 1- and *-records (fig. 9). These files are identified with a leading "Q." Thus, water-quality data for station 08075000 are in file Q75000.dat.

Example of storm hydrograph data

```
Storm hydrograph data for station 08075780
col.     1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
A   30    60                                                                   A
 100                                                                        8.06
208075780                   0004500006
B08075780        19840212001500   96       0.01     0.01     0.08     0.59     0.07     0.01
 .........
B08075780        19840212091500   96       0.01     0.01     0.04
9
208075780                   0006000011                                         1
B08075780        19840212003000   48        7.4      8.8      18.      27.      30.      33.
 .........
B08075780        19840212213000   48        14.      13.      13.      13.      12.      12.
9
208075780                   0006000011                                         1
B08075780        19840213003000   48        12.      12.      11.      11.      11.      10.
 .........
B08075780        19840213213000   48        7.5      7.5      7.5      7.5      7.4      7.4
9
8
********************************************************************************
```

Explanation of data formats

Record type	Columns	Field name	Explanation	
A	1	Record type	Begin storm	
	2–76	Printout interval for each day of storm; maximum no. days = 15	Interval, in minutes, that a USGS support program uses to print data to table. Number of entries equals number days of runoff data	
	80	Record type	Record type is repeated	
Theissen weights	1	--	Blank	
	2–60	Theissen weight	Theissen weight X 100 for each rain gage used to define storm. Number of entries equals number of rain gages for storm. Sum of Theissen weights = 100	
	61–72	--	Blank	
	73–80	Drainage area	Drainage area for runoff station, in square miles	
2	1	Record type	Station ID	
	2–16	Station ID	USGS 8-digit ID no.	
	17–28	--	Blank	
	29–38	Parameter and statistics code ID	Indicates type of data that follows for station: 0004500006 indicates rainfall, in inches, during interval 0006000011 indicates discharge, in cubic feet per second, at start of interval 0006500011 indicates stage, in feet above datum, at start of interval	
B	1	Record type	Storm data	
	2–16	Station ID	USGS 8-digit ID no.	
	17–24	Date for storm data	YYYYMMDD (YYYY = calendar year)	
	25–30	Time of first value in data field	In hours and minutes (2400 = midnight)	
	31–35	Number of recording intervals per day (RPD)	RPD	Recording interval, in minutes
			288	5
			144	10
			96	15
			48	30
			24	60
	39–80	Data	6 entries per record	
9	1	Record type	Signifies end of data for 1 day. (Data records for each day preceded by a 2–record and followed by a 9–record)	
	2–80	--	Blank	
8	1	Record type	Signifies end of data for 1 storm. (Each storm requires 1 A–record and 1 8–record)	
	2–80	--	Blank	

Figure 8. Example of storm hydrograph data and explanation of data formats.

Example of water-quality data

```
Water-quality sample data for station 08074500
col.     1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
1 08074500       97012011500                    7AA99
*P00010= 25.000( :A: :3),P00049= 84.701( :A: :2),P00060= 14.000( :A: :2),
..........
..........
*P70302= 25.400( :A: :3),P70303= 0.9200( :A: :2),P72000= -7.350( :A: :2)
*****************************************************************************
```

Explanation of data format for 1-record:

Record Type	Columns	Field Name	Explanation
1	1	Record type	Analysis information
	2–16	Station ID	USGS 8-digit ID no.
	17	Medium code	See Appendix 2
	18–27	Begin date and time	YYMMDDHHMM. (YY = calendar year; 2400 is midnight)
	28–35	End date and time	MMDDHHMM.
	36–43	Geologic unit code	For ground water only. For explanation, contact USGS at address at beginning of this file
	44	Analysis status code	See Appendix 2
	45	Analysis source code	See Appendix 2
	46	Hydrologic condition code	See Appendix 2
	47	Sample type code	See Appendix 2
	48	Hydrologic event code	See Appendix 2
	49–51	Blank	
	52–53	Left 2 digits of year	Optional. Default = 19
	54–61	Blank	
	62–63	Data category, default = QW	
	64–68	Agency code, default = USGS	
	69–80	Blank	

Explanation of data format for *-record:

Record Type	Columns	Field Name	Explanation
*	1	Record type	Data
	2–76	Free format for parameter description and measured or determined value. The format of the parameter description is: Pnnnnn = value (R:Q:M:N) where: nnnnn = a valid 5-digit parameter code as contained in the WRD Parameter Code Dictionary. A list of parameters and associated codes used in this study is in table 8 value = the measurement for or analytical determination of the constituent identified by the parameter code R = the remark code qualifying the parameter value. Remark codes listed in Appendix 2 Q = the quality assurance code for the parameter value. Quality assurance codes are listed in Appendix 2 M = the method code identifying the USGS National Water-Quality Laboratory (NWQL) method used to determine the parameter value. For explanation, contact USGS NWQL at 5293 Ward Rd., Arvada, CO 80002 N = the number of significant digits of the printed parameter value	

Figure 9. Example of water-quality data and explanation of data formats.

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Table 1. Summary of period of record for U.S. Geological Survey sites used in study and type of data collected at each station

[X, data available during indicated water year; *, data available before 1964]

Station no. (fig. 2b,c)	Station name and type of data collected	Water year																									
		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
08068400	Panther Branch near Conroe, Tex.																										
	Continuous-record streamflow											X	X	X													
	Flood hydrograph																	X	X	X	X	X	X	X	X	X	
	Water quality											X	X														
	Rainfall											X	X	X				X	X	X	X	X	X	X	X	X	
08068438	Swale No. 8 at Woodlands, Tex.																										
	Flood hydrograph												X	X				X	X	X	X	X	X	X	X	X	
	Rainfall																							X	X	X	
08068440	Lake Harrison at drop inlet at Woodlands, Tex.																										
	Continuous-record streamflow												X	X													
08068450	Panther Branch near Spring, Tex.																										
	Continuous-record streamflow									X	X	X	X	X													
	Flood hydrograph																	X	X	X	X	X	X	X	X	X	
	Water quality									X	X	X	X														
	Rainfall									X	X	X	X	X				X	X	X	X	X	X	X	X	X	
08069000	Cypress Creek near Westfield, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality															X	X	X	X	X	X						
	Rainfall	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08072500	Barker Reservoir near Addicks, Tex.																										
	Reservoir contents	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08073000	Addicks Reservoir near Addicks, Tex.																										
	Reservoir contents	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08073500	Buffalo Bayou near Addicks, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality							X	X	X	X	X	X	X	X	X	X	X	X	X							
08073600	Buffalo Bayou at West Belt Dr. at Houston, Tex.																										
	Continuous-record streamflow								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality															X	X	X	X	X	X	X	X	X	X	X	X
08073630	Bettina St. ditch at Houston, Tex.																										
	Flood hydrograph																X	X	X	X	X	X	X				
	Water quality																			X	X	X	X				
	Rainfall																X	X	X	X	X	X	X				
08073700	Buffalo Bayou at Piney Point, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X									X	X	X	X	X
	Flood hydrograph, stage only														X	X	X	X	X	X	X	X					
	Water quality								X	X	X	X	X	X	X	X											

Table 1. Summary of period of record for U.S. Geological Survey sites used in study and type of data collected at each station—Continued

Station no. (fig. 2b,c)	Station name and type of date collected	Water year																									
		1964	1965	1966	1967	1968	1989	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
08073750	Stoney Brook St. ditch at Houston, Tex.																										
	Flood hydrograph				X	X	X	X	X	X																	
	Rainfall				X	X	X	X	X	X																	
08073800	Bering ditch at Woodway Dr., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X																
	Rainfall	X	X	X	X	X	X	X	X	X	X																
08074000	Buffalo Bayou at Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X								
08074050	Cole Creek at U.S. Highway 290, Houston, Tex.																										
	Flood hydrograph	X	X																								
	Rainfall	X	X																								
08074100	Cole Creek at Guhn Rd. at Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Rainfall	X	X	X	X	X	X	X	X	X																	
08074145	Bingle Rd. storm sewer at Houston, Tex.																										
	Flood hydrograph																	X	X	X	X	X	X	X	X	X	
	Water quality																	X	X	X	X	X	X	X	X		
	Rainfall																	X	X	X	X	X	X	X	X	X	
08074150	Cole Creek at Deihl Rd., Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Flood hydrograph																								X	X	X
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08074200	Brickhouse Gully at Clarblak St., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
08074250	Brickhouse Gully at Costa Rica St., Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
	Flood hydrograph																			X	X	X	X	X	X	X	X
	Water quality							X	X	X	X	X	X	X	X	X	X	X	X	X	X						
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08074400	Lazybrook St. storm sewer at Houston, Tex.																										
	Flood hydrograph																X	X	X	X	X	X	X	X	X	X	
	Water quality																	X	X	X	X	X	X	X	X		
	Rainfall																X	X	X	X	X	X	X	X	X	X	
08074500	Whiteoak Bayou at Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 1. Summary of period of record for U.S. Geological Survey sites used in study and type of data collected at each station—Continued

Station no. (fig. 2b,c)	Station name and type of data collected	Water year 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
08074540	Little Whiteoak Bayou at Trimble St., Houston, Tex.																										
	Flood hydrograph																X	X	X	X	X	X	X				
	Flood hydrograph, stage only																							X	X	X	X
	Water quality																X	X	X	X	X	X					
	Rainfall																X	X	X	X	X	X	X				
08074550	Little Whiteoak Bayou at Houston, Tex.																										
	Partial-record low flow								X	X	X	X	X	X	X	X	X	X									
	Water quality								X	X	X	X	X	X	X	X	X	X									
08074750	Brays Bayou at Addicks-Clodine Rd., Houston, Tex.																										
	Flood hydrograph											X	X	X	X												
	Rainfall											X	X	X	X												
08074760	Brays Bayou at Alief Rd., Alief, Tex.																										
	Flood hydrograph														X	X	X	X	X	X	X	X					
	Flood hydrograph, stage only																						X	X	X	X	X
	Rainfall														X	X	X	X	X	X	X	X	X	X	X	X	X
08074780	Keegans Bayou at Keegan Rd. near Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X					
	Flood hydrograph, stage only																						X	X	X	X	X
	Water quality							X	X	X																	
	Rainfall	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08074800	Keegans Bayou at Roark Rd. near Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
	Flood hydrograph																			X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08074810	Brays Bayou at Gessner Dr., Houston, Tex.																										
	Flood hydrograph														X	X	X	X	X	X	X	X	X	X	X	X	X
08074850	Bintliff ditch at Bissonnet at Houston, Tex.																										
	Flood hydrograph					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
	Rainfall					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
08074900	Willow Waterhole Bayou at Landsdowne St., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Water quality						X	X	X	X																	
	Rainfall	X	X	X	X	X	X	X	X	X																	
08074910	Hummingbird St. ditch at Houston, Tex.																										
	Flood hydrograph																X	X	X	X	X	X	X				
	Rainfall																X	X	X	X	X	X	X				
08075000	Brays Bayou at Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 1. Summary of period of record for U.S. Geological Survey sites used in study and type of data collected at each station—Continued

Station no. (fig. 2b,c)	Station name and type of data collected	Water year																									
		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1988	1987	1988	1989
08075100	Brays Bayou at Scott St., Houston, Tex.																										
	Partial-record low flow								X	X	X	X	X	X	X	X	X	X	X								
	Water quality								X	X	X	X	X	X	X	X	X	X	X								
08075300	Sims Bayou at Carlsbad St., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Rainfall	X	X	X	X	X	X	X	X	X																	
08075400	Sims Bayou at Hiram Clarke St., Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
08075470	Sims Bayou at Martin Luther King Blvd., Houston, Tex.																										
	Flood hydrograph, stage only															X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall															X	X	X	X	X	X	X	X				
08075500	Sims Bayou at Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08075550	Berry Bayou at Gilpin St. at Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
08075600	Berry Bayou Tributary at Globe St., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Rainfall	X	X	X	X	X	X	X	X	X																	
08075650	Berry Bayou at Forest Oaks St., Houston, Tex.																										
	Continuous-record streamflow	X	X	X																							
	Flood hydrograph				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
	Flood hydrograph, stage only																				X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X								
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08075700	Berry Creek at Galveston Rd. at Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Water quality												X														
	Rainfall	X	X	X	X	X	X	X	X	X																	
08075730	Vince Bayou at Pasadena, Tex.																										
	Continuous-record streamflow									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Partial-record low flow								X																		
	Water quality								X	X	X				X	X	X										

Table 1. Summary of period of record for U.S. Geological Survey sites used in study and type of data collected at each station—Continued

Station no. (fig. 2b,c)	Station name and type of data collected	Water year																									
		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
08075750	Hunting Bayou Tributary at Calvalcade St., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X																	
	Water quality						X																				
	Rainfall	X	X	X	X	X	X	X	X	X																	
08075760	Hunting Bayou at Falls St. at Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
08075770	Hunting Bayou at IH–610, Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08075780	Greens Bayou at Cutten Rd. near Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08075900	Greens Bayou at U.S. Hwy. 75 near Houston, Tex.																										
	Continuous-record streamflow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08076000	Greens Bayou near Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Rainfall	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08076200	Halls Bayou at Deertrail St. at Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
08076500	Halls Bayou at Houston, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Water quality						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
	Rainfall	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08076700	Greens Bayou at Ley Rd., Houston, Tex.																										
	Continuous-record streamflow									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Discharge measurements only	*X	X						X																		
	Water quality					X	X	X	X	X	X	X	X	X	X	X	X	X	X								
08077000	Clear Creek near Pearland, Tex.																										
	Continuous-record streamflow	*X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
08077100	Clear Creek Tributary at Hall Rd., Houston, Tex.																										
	Flood hydrograph	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
	Rainfall	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											

Table 2. Descriptors of basin topography

[[1]mi^2, square mile; ft/mi, feet per mile; ft, feet; mi, mile; mi/mi^2, mile per square mile; in., inch; ft^3/s, cubic foot per second; --, value not determined]

Station no.	Drainage area (mi^2)	Channel slope (ft/mi)	Channel rise (ft)	Shape factor (dimensionless)	Basin length (mi)	Drainage density (mi/mi^2)	Soil index (in.)	Impervious area (mi^2)	Storm-sewered area (mi^2)	Urban-location ratio (dimensionless)	Bank-full channel conveyance (ft^3/s)
08073750	0.50	3.10	1.80	4.10	0.80	2.70	0.20	0.17	0.42	1.00	--
08073800	2.74	3.50	7.00	1.70	3.70	3.20	.20	.66	1.86	1.00	--
08074100	7.05	5.30	14.50	1.60	3.10	.86	2.00	.29	.02	1.60	--
08074150	8.81	5.90	24.30	.80	4.90	.86	2.00	.36	.18	2.20	170,000
08074200	2.05	4.80	9.00	1.00	2.60	1.11	2.00	.07	.07	1.90	21,000
08074250	10.50	7.40	36.00	1.60	6.10	1.49	2.00	1.10	2.09	1.40	230,000
08074500	84.70	4.90	79.00	.90	20.00	1.40	2.00	7.62	15.20	1.90	1,700,000
08074780	5.77	2.50	11.00	.90	5.80	1.38	.20	.11	.02	1.00	35,000
08074800	9.28	3.00	16.50	.90	9.90	.54	.20	.19	.61	1.50	56,000
08074850	4.29	3.90	7.30	2.80	2.50	3.24	.20	1.11	3.58	1.10	82,000
08074900	11.20	5.00	18.00	1.90	5.10	.99	.20	.67	1.55	3.30	--
08075000	88.40	3.60	50.00	1.20	17.20	1.75	.20	13.30	28.70	2.10	2,800,000
08075300	4.99	5.50	13.30	1.90	3.20	.70	.20	.21	.02	1.60	--
08075400	20.20	5.20	25.70	2.80	6.60	1.33	.20	1.07	1.70	1.90	280,000
08075500	64.00	3.20	42.00	1.30	15.30	1.35	.20	7.04	15.40	1.30	530,000
08075550	3.26	3.90	7.50	3.30	2.00	1.53	.20	1.53	.88	1.40	36,000
08075600	1.58	3.90	4.60	2.00	1.70	1.27	.20	.24	.40	1.50	--
08075650	11.10	8.50	31.00	2.10	4.60	1.81	.20	1.61	2.69	1.30	450,000
08075700	4.86	6.00	18.00	.70	3.00	2.11	.20	.44	.86	1.50	--
08075730	8.21	--	--	--	--	--	--	--	--	--	200,000
08075760	3.42	8.80	9.00	2.70	1.30	2.61	2.00	.72	.87	1.00	51,000
08075770	14.40	3.20	13.50	1.70	5.00	1.99	1.30	2.13	2.00	.80	270,000
08075780	8.73	5.10	18.00	2.20	4.20	.51	2.00	.17	.02	1.00	12,000
08075900	36.10	--	--	--	--	--	--	--	--	--	89,000
08076000	72.70	4.40	69.00	1.10	17.30	1.07	2.00	2.18	.78	1.40	290,000
08076200	6.31	6.80	22.00	2.10	4.30	1.29	2.00	.23	.31	2.30	31,000
08076500	24.70	4.50	41.00	1.90	8.20	1.34	2.00	1.73	1.19	1.70	100,000
08076700	182.0	--	--	--	--	--	--	--	--	--	930,000
08077100	1.33	5.00	8.50	2.60	1.50	2.56	.20	.11	.40	1.00	20,000

[1] Descriptors from Johnson and Sayre (1973) except for bank-full channel conveyance which is from Liscum and Massey (1980).

Table 3. Descriptors of urban development

[*PAd*, percentage of urban development; *DegD*, degree of development; *TypeD*, type of development; *BDF*, basin development factor; *CI*, channel improvements; *CL*, channel lining; *SS*, storm sewers; *CAG*, curb and gutters]

Station no.	Year	PAd (percent)	DegD[1]	TypeD[2]	BDF[3] (range 0–12.0)	BDF–CI (range 0–3.0)	BDF–CL (range 0–3.0)	BDF–SS (range 0–3.0)	BDF–CAG (range 0–3.0)
08073630	1966	78.6	3	4	8.0	3.0	2.0	3.0	0
	1976	95.1	3	4	10.5	3.0	3.0	3.0	1.5
	1984	97.6	3	4	12.0	3.0	3.0	3.0	3.0
08074145	1966	19.6	1	1	0	0	0	0	0
	1976	49.8	2	4	7.5	2.0	2.0	2.0	1.5
	1984	69.4	2	4	12.0	3.0	3.0	3.0	3.0
08074150	1966	39.0	2	1	3.0	2.0	0	1.0	0
	1976	52.2	2	2	4.0	2.0	0	2.0	0
	1984	71.7	3	2	6.0	2.0	0	3.0	1.0
08074200	1966	36.4	2	1	3.0	2.0	0	1.0	0
	1976	50.5	2	2	6.5	3.0	0	3.0	.5
	1984	68.0	2	2	8.0	3.0	1.0	3.0	1.0
08074250	1966	50.2	2	2	7.0	3.0	0	2.0	2.0
	1976	80.5	3	2	10.5	3.0	2.0	3.0	2.5
	1984	85.0	3	2	12.0	3.0	3.0	3.0	3.0
08074400	1966	100.0	3	2	12.0	3.0	3.0	3.0	3.0
	1976	100.0	3	2	12.0	3.0	3.0	3.0	3.0
	1984	100.0	3	2	12.0	3.0	3.0	3.0	3.0
08074500	1966	39.8	2	2	6.0	2.0	1.0	2.0	1.0
	1976	63.8	2	2	8.5	3.0	2.0	2.0	1.5
	1984	76.2	3	2	10.0	3.0	2.0	3.0	2.0
08074540	1966	87.0	3	2	6.0	3.0	0	3.0	0
	1976	95.8	3	2	6.0	3.0	0	3.0	0
	1984	97.8	3	2	8.0	3.0	1.5	3.0	.5
08074760	1966	17.4	1	1	0	0	0	0	0
	1976	28.6	1	1	3.5	2.0	0	1.0	.5
	1984	70.4	3	2	7.5	3.0	0	3.0	1.5
08074780	1966	19.0	1	1	0	0	0	0	0
	1976	34.4	2	1	3.0	1.0	0	1.0	1.0
	1984	66.2	2	2	7.0	3.0	0	2.0	2.0

Footnotes at end of table.

Table 3. Descriptors of urban development—Continued

Station no.	Year	*PAd* (percent)	*DegD*[1]	*TypeD*[2]	*BDF*[3] (range 0–12.0)	*BDF–CI* (range 0–3.0)	*BDF–CL* (range 0–3.0)	*BDF–SS* (range 0–3.0)	*BDF–CAG* (range 0–3.0)
08074800	1966	24.6	1	1	0	0	0	0	0
	1976	53.9	2	2	5.0	2.0	0	2.0	1.0
	1984	73.6	3	2	8.5	3.0	0	3.0	2.5
08074810	1966	24.7	1	1	1.5	1.5	0	0	0
	1976	47.1	2	2	6.5	2.0	1.0	2.0	1.5
	1984	72.7	3	2	10.0	2.0	2.0	3.0	3.0
08074850	1966	71.9	3	4	9.0	3.0	3.0	3.0	0
	1976	88.8	3	4	10.5	3.0	3.0	3.0	1.5
	1984	93.0	3	4	12.0	3.0	3.0	3.0	3.0
08074910	1966	98.5	3	2	3.0	3.0	0	0	0
	1976	100.0	3	2	7.5	3.0	0	3.0	1.5
	1984	100.0	3	2	9.0	3.0	0	3.0	3.0
08075000	1966	43.8	2	1	5.0	3.0	1.0	1.0	0
	1976	68.0	2	2	7.0	3.0	1.0	2.0	1.0
	1984	83.8	3	2	10.0	3.0	1.0	3.0	3.0
08075400	1966	39.0	2	2	4.0	3.0	0	1.0	0
	1976	60.5	2	2	7.0	3.0	0	3.0	1.0
	1984	85.7	3	2	8.5	3.0	0	3.0	2.5
08075470	1966	41.4	2	2	5.0	3.0	0	2	0
	1976	73.7	3	2	6.5	3.0	0	3	.5
	1984	80.9	3	2	8.0	3.0	0	3	2.0
08075500	1966	45.0	2	2	4.0	3.0	0	1	0
	1976	68.0	2	2	6.5	3.0	0	3	.5
	1984	79.8	3	2	8.0	3.0	0	3	2.0
08075550	1966	66.1	2	2	5.0	3.0	0	2	0
	1976	71.2	3	2	7.0	3.0	0	3	1.0
	1984	74.8	3	2	7.0	3.0	0	3	1.0
08075650	1966	75.9	3	2	6.0	3.0	0	3	0
	1976	77.7	3	2	7.0	3.0	0	3	1.0
	1984	88.6	3	2	8.0	3.0	0	3	2.0

Footnotes at end of table.

Table 3. Descriptors of urban development—Continued

Station no.	Year	*PAd* (percent)	*DegD*[1]	*TypeD*[2]	*BDF*[3] (range 0–12.0)	*BDF–CI* (range 0–3.0)	*BDF–CL* (range 0–3.0)	*BDF–SS* (range 0–3.0)	*BDF–CAG* (range 0–3.0)
08075730	1966	56.6	2	2	4.0	2.0	0	2.0	0
	1976	86.1	3	2	8.5	3.0	1.0	3.0	1.5
	1984	92.2	3	2	10.0	3.0	1.0	3.0	3.0
08075760	1966	76.4	3	2	6.0	3.0	0	3.0	0
	1976	91.6	3	2	6.0	3.0	0	3.0	0
	1984	93.7	3	2	6.0	3.0	0	3.0	0
08075770	1966	72.6	3	5	6.0	3.0	0	3.0	0
	1976	85.5	3	5	6.0	3.0	0	3.0	0
	1984	89.7	3	5	6.0	3.0	0	3.0	0
08075780	1966	23.2	1	1	3.0	1.0	0	2.0	0
	1976	45.9	2	2	4.0	2.0	0	2.0	0
	1984	63.7	2	2	6.0	3.0	0	3.0	0
08075900	1966	15.3	1	1	1.0	1.0	0	0	0
	1976	35.2	2	1	5.5	3.0	0	1.0	1.5
	1984	58.9	2	2	9.0	3.0	0	3.0	3.0
08076000	1966	22.6	1	1	0	0	0	0	0
	1976	41.0	2	2	6.0	3.0	0	2.0	1.0
	1984	61.2	2	2	8.0	3.0	0	3.0	2.0
08076200	1966	23.7	1	1	0	0	0	0	0
	1976	54.2	2	2	6.0	3.0	0	3.0	0
	1984	74.6	3	2	6.5	3.0	0	3.0	.5
08076500	1966	49.9	2	2	4.0	2.0	0	2.0	0
	1976	74.8	3	2	6.0	3.0	0	3.0	0
	1984	83.4	3	2	6.0	3.0	0	3.0	0
08076700	1966	31.4	2	2	1.0	0	0	1.0	0
	1976	47.1	2	2	5.5	3.0	0	2.0	.5
	1984	60.0	2	2	7.0	3.0	0	3.0	1.0

[1] Indicates range of percentage of urban development. 1, 0–30 percent; 2, 30–70 percent; 3, 70–100 percent.
[2] Indicates predominant land use. 1, rural; 2, single family residential; 3, multi-family residential; 4, commercial; and 5, industrial.
[3] Sum of basin development factors: 0, selected drainage aspects are not prevalent; 12, full development (Sauer and others, 1983).

Table 4. Description and summary of usage of rain gages for study

[NWS XXXX, National Weather Service station index; HCMCD, Harris County Mosquito Control District]

No.	Rain gage ID (fig. 2a)	Latitude	Longitude	Rain gage station name	Period data used (water year)		Data used for storms	No. of sites used for storms	Total no. of storms
					Begin	End			
1	8400	30°11'28"	95°28'44"	Panther Branch near Conroe, Tex.	1981	1988	Yes	3	16
2	8438	30°08'38"	95°28'09"	Swale No. 8 at Woodlands, Tex.	1986	1988	Yes	2	5
3	8450	30°08'02"	95°28'38"	Panther Branch near Spring, Tex.	1981	1986	Yes	2	11
4	3630	29°46'32"	95°32'23"	Bettina St. ditch at Houston, Tex.	1979	1985	Yes	1	18
5	3750	29°44'05"	95°30'22"	Stoney Brook St. ditch at Houston, Tex.	1967	1971	Yes	3	23
6	3800	29°45'22"	95°29'44"	Bering ditch at Woodway Dr., Houston, Tex.	1965	1972	Yes	3	25
7	4050	29°51'57"	95°33'03"	Cole Creek at U.S. Hwy. 290 at Houston, Tex.	1965	1965	Yes	2	2
8	4100	29°51'24"	95°30'55"	Cole Creek at Guhn Rd. at Houston, Tex.	1965	1971	Yes	4	33
9	4145	29°51'31"	95°29'09"	Bingle Rd. storm sewer at Houston, Tex.	1980	1984	Yes	3	23
10	4150	29°51'04"	95°29'16"	Cole Creek at Deihl Rd., Houston, Tex.	1965	1989	Yes	9	135
11	4200	29°49'53"	95°31'42"	Brickhouse Gully at Clarblank at Houston, Tex.	1965	1984	Yes	5	72
12	4250	29°49'40"	95°28'09"	Brickhouse Gully at Costa Rica St., Houston, Tex.	1965	1986	Yes	4	79
13	4400	29°48'15"	95°26'04"	Lazybrook St. storm sewer at Houston, Tex.	1979	1984	Yes	3	49
14	4540	29°47'33"	95°22'06"	Little Whiteoak Bayou at Trimble St., Houston, Tex.	1980	1984	Yes	1	15
15	4750	29°43'02"	95°39'38"	Brays Bayou at Addicks-Clodine Rd., Houston, Tex.	1975	1976	Yes	2	3
16	4760	29°42'39"	95°35'13"	Brays Bayou at Alief Rd., Alief, Tex.	1983	1984	Yes	4	12
17	4780	29°39'55"	95°35'42"	Keegans Bayou at Keegan Rd. near Houston, Tex.	1968	1984	Yes	4	70
18	4800	29°39'23"	95°33'43"	Keegans Bayou at Roark Rd. near Houston, Tex.	1965	1989	Yes	9	129
19	4850	29°41'16"	95°30'20"	Bintliff ditch at Bissonnet at Houston, Tex.	1968	1980	Yes	4	23
20	4900	29°39'01"	95°29'11"	Willow Waterhole Bayou at Landsdowne St., Houston, Tex.	1965	1971	Yes	3	21
21	4910	29°39'44"	95°29'11"	Hummingbird St. ditch at Houston, Tex.	1979	1984	Yes	3	26
22	5300	29°37'33"	95°29'56"	Sims Bayou at Carlsbad St. Houston, Tex.	1965	1971	Yes	3	31
23	5400	29°37'07"	95°26'45"	Sims Bayou at Hiram Clarke St., Houston, Tex.	1965	1984	Yes	4	56
24	5470	29°38'42"	95°20'13"	Sims Bayou at Martin Luther King Blvd., Houston, Tex.	1979	1984	Yes	2	18
	306R	29°38'42"	95°20'13"	South Park (at same location as 5470)	1976	1978	Yes	1	1

Table 4. Description and summary of usage of rain gages for study—Continued

No.	Rain gage ID (fig. 2a)	Latitude	Longitude	Rain gage station name	Period data used (water year) Begin	End	Data used for storms	No. of sites used for storms	Total no. of storms
25	5500	29°40'27"	95°17'21"	Sims Bayou at Houston, Tex.	1975	1989	Yes	3	29
26	5550	29°38'32"	95°13'22"	Berry Bayou at Gilpin St. at Houston, Tex.	1965	1984	Yes	4	55
27	5600	29°39'00"	95°14'48"	Berry Bayou Trib. at Globe St., Houston, Tex.	1965	1972	Yes	5	28
28	5650	29°40'35"	95°14'37"	Berry Bayou at Forest Oaks St., Houston, Tex.	1965	1989	Yes	6	69
29	5700	29°40'59"	95°15'11"	Berry Creek at Galveston Rd. at Houston, Tex.	1965	1972	Yes	1	11
30	5750	29°48'00"	95°20'02"	Hunting Bayou Trib. at Cavalcade St., Houston, Tex.	1965	1972	Yes	3	42
31	5760	29°48'22"	95°19'50"	Hunting Bayou at Falls St. at Houston, Tex.	1965	1984	Yes	4	65
32	5770	29°47'35"	95°16'04"	Hunting Bayou at IH–610, Houston, Tex.	1965	1989	Yes	2	52
33	5780	29°56'56"	95°31'10"	Greens Bayou at Cutten Rd. near Houston, Tex.	1965	1988	Yes	6	92
34	5900	29°57'24"	95°25'04"	Greens Bayou at U.S. Hwy. 75 near Houston, Tex.	1966	1989	Yes	5	94
35	6000	29°55'05"	95°18'24"	Greens Bayou near Houston, Tex.	1973	1989	Yes	3	72
36	6200	29°54'07"	95°25'21"	Halls Bayou at Deertrail St. at Houston, Tex.	1966	1984	Yes	6	76
37	6500	29°51'42"	95°20'05"	Halls Bayou at Houston, Tex.	1981	1989	Yes	5	39
38	7100	29°36'09"	95°16'41"	Clear Creek Trib. at Hall Rd., Houston, Tex.	1966	1970	Yes	2	10
39	8350	30°13'15"	95°34'02"	Egypt rain gage near Conroe, Tex.	1981	1983	Yes	2	12
40	5725	29°39'40"	95°11'55"	Lafferty St., rain gage, Pasadena, Tex.	1984	1989	Yes	2	10
	405R	29°39'40"	95°11'55"	Lafferty St. (at same location as 5725)	1983	1983	Yes	1	2
41	10S	29°47'00"	95°26'00"	Houston-Heights (NWS 4321)	1972	1989	No	0	0
42	11R	29°49'00"	95°21'15"	Linder Lake	1965	1966	Yes	2	11
43	12R	29°46'00"	95°22'00"	Houston-WB City (NWS 4305)	1965	1984	Yes	3	4
44	13S	29°52'00"	95°25'00"	Houston Indep. Height (NWS 4323)	1965	1989	No	0	0
45	14R	29°49'54"	95°19'47"	Sayer St. (located from Persimmon St. 8/4/69)	1966	1977	Yes	5	40
46	20R	29°59'00"	95°22'00"	Houston WSO Airport (NWS 4300)	1972	1989	Yes	3	45
47	21R	29°51'02"	95°33'46"	Brittmore Rd.	1965	1984	Yes	6	143
48	22R	29°54'00"	95°37'00"	Houston-Satsuma (NWS 4329)	1965	1989	Yes	8	64
49	23S	29°53'00"	95°31'00"	Houston-North Houston (NWS 4327)	1965	1989	No	0	0
50	24S	29°48'00"	95°30'00"	Houston-Spring Branch (NWS 4331)	1965	1989	No	0	0
51	25R	29°58'00"	95°34'12"	Jones Rd.	1966	1968	Yes	2	8
52	26R	29°56'57"	95°33'58"	Louedda St.	1968	1969	Yes	3	9

Table 4. Description and summary of usage of rain gages for study—Continued

No.	Rain gage ID (fig. 2a)	Latitude	Longitude	Rain gage station name	Period data used (water year) Begin	End	Data used for storms	No. of sites used for storms	Total no. of storms
53	27R	29°49'17"	95°31'09"	Kempwood Dr.	1968	1970	Yes	4	4
54	29R	29°57'29"	95°33'40"	Mills Rd.	1970	1981	Yes	7	53
55	30S	29°49'00"	95°44'00"	Houston-Barker (NWS 4313)	1965	1989	No	0	0
56	31R	29°36'43"	95°32'58"	Stafford	1965	1984	Yes	8	92
57	32R	29°43'00"	95°36'00"	Houston-Alief (NWS 4311)	1965	1989	Yes	5	82
58	33R	29°46'00"	95°39'00"	Houston-Addicks (NWS 4309)	1965	1989	Yes	4	48
59	34S	29°43'00"	95°41'00"	Clodine (NWS 1838)	1965	1989	No	0	0
60	35S	29°40'00"	95°28'00"	Houston-Westbury (NWS 4325)	1965	1989	No	0	0
61	36S	29°37'00"	95°38'00"	Sugarland (NWS 8728)	1966	1989	No	0	0
62	38S	29°42'01"	95°31'10"	Lugary St.	1969	1971	No	0	0
63	39R	29°43'25"	95°30'06"	KHTV	1967	1980	Yes	2	14
64	41R	29°37'54"	95°12'32"	Gulf Palms	1965	1967	Yes	4	12
65	42S	29°39'00"	95°17'00"	Houston-FAA Airport (Hobby) (NWS 4307)	1965	1989	No	0	0
66	44R	29°37'41"	95°14'06"	Almeda-Genoa	1967	1968	Yes	4	5
67	45R	29°37'35"	95°14'30"	Minnesota St.	1968	1973	Yes	5	54
68	101R	29°47'19"	95°18'50"	Liberty Rd.	1973	1981	Yes	2	14
69	201S	30°00'00"	95°15'00"	Humble (NWS 4362)	1972	1989	No	0	0
70	202S	29°55'00"	95°09'00"	Houston-San Jacinto Dam (NWS 4328)	1972	1989	No	0	0
71	203R	29°59'53"	95°28'39"	Mintz Lane	1973	1984	Yes	4	56
72	204R	29°53'57"	95°27'28"	Breen St.	1973	1984	Yes	7	88
73	205R	29°50'08"	95°31'22"	Frontier St.	1973	1984	Yes	4	71
74	301R	29°40'20"	95°37'53"	Old Richmond Rd.	1973	1975	Yes	3	6
75	302R	29°35'32"	95°27'45"	Blue Ridge Rd.	1973	1976	Yes	2	5
76	303R	29°40'07"	95°39'36"	Four Corners	1976	1982	Yes	5	50
77	304R	29°36'32"	95°29'57"	Chasewood	1976	1984	Yes	4	15
78	305R	29°37'45"	95°22'45"	Furman	1976	1984	Yes	2	21
79	308R	29°42'27"	95°23'30"	Public Health, City of Houston	1976	1984	Yes	3	18
80	309R	29°41'45"	95°39'00"	Mission Bend	1984	1985	No	0	0

Table 4. Description and summary of usage of rain gages for study—Continued

No.	Rain gage ID (fig. 2a)	Latitude	Longitude	Rain gage station name	Period data used (water year) Begin	End	Data used for storms	No. of sites used for storms	Total no. of storms
81	401R	29°39'11"	95°12'07"	Llano St.	1973	1982	Yes	3	25
82	402R	29°38'06"	95°15'04"	Klondike	1974	1983	Yes	3	23
83	403R	29°38'55"	95°13'23"	Edgebrook	1979	1983	Yes	3	9
84	404S	29°43'00"	95°08'00"	Deer Park (NWS 4315)	1965	1989	No	0	0
85	P1R	30°08'07"	95°28'27"	Panther Branch near Spring	1973	1976	Yes	2	6
86	P2S	30°14'06"	95°28'56"	W.G. Jones State Forest office	1974	1976	No	0	0
87	P3R	30°11'38"	95°28'42"	Panther Branch near Conroe (Rice Univ.)	1974	1976	Yes	2	5
88	P4R	30°13'12"	95°33'40"	Egypt	1974	1976	Yes	2	6
89	P5R	30°08'25"	95°28'16"	Woodlands (Rice Univ.)	1974	1976	Yes	3	3
90	1M	29°44'05"	95°31'50"	Winsome St. (HCMCD)	1966	1968	No	0	0
91	3M	29°51'25"	95°20'45"	Hollis St. (HCMCD)	1966	1968	No	0	0
92	7M	29°37'00"	95°16'40"	Teekskill St. (HCMCD)	1966	1972	No	0	0
93	16M	29°37'15"	95°11'35"	Rhea St. (HCMCD)	1966	1972	No	0	0
94	37M	29°45'45"	95°31'00"	Piney Point Rd. (HCMCD)	1966	1968	No	0	0
95	39M	29°46'45"	95°18'20"	Hillsboro St. (HCMCD)	1966	1968	No	0	0
96	64M	29°39'15"	95°12'35"	Avenue M, South Houston (HCMCD)	1966	1968	No	0	0
97	68M	29°37'05"	95°28'50"	Warkworth St. (HCMCD)	1966	1968	No	0	0
98	75M	29°51'20"	95°17'50"	Rhobell St. (HCMCD)	1966	1968	No	0	0
99	76M	29°41'05"	95°28'55"	Grape St. (HCMCD)	1966	1968	No	0	0
100	81M	29°37'00"	95°19'10"	Allison Rd. (HCMCD)	1966	1968	No	0	0
101	94M	30°01'00"	95°26'55"	Westfield Rd. (HCMCD)	1966	1968	No	0	0
102	111M	29°38'30"	95°13'10"	Gilpin St. (HCMCD)	1966	1968	No	0	0

Table 5. Observed annual peak discharges for sites with 10 or more years of record during water years 1964–89

[All peak discharges are in cubic feet per second except where noted. Past, maximum peak for period prior to 1964; --, not defined; g, gage height in feet above datum; Record, maximum peak for entire period of record]

Water	U.S. Geological Survey station number								
year	08068400	08068438	08068450	08069000	08073500	08073600	08073700	08074000	08074150
Past	--	--	--	26,000	11,200	--	--	40,000	--
1964	--	--	--	4,970	2,810	--	2,520	2,650	400
1965	--	--	--	1,480	1,020	--	974	1,920	338
1966	--	--	--	3,320	2,160	--	2,180	5,150	950
1967	--	--	--	2,520	1,050	--	1,280	2,100	160
1968	--	--	--	5,360	3,230	--	3,540	4,400	810
1969	--	--	--	4,780	2,300	--	2,420	2,930	966
1970	--	--	--	3,690	984	--	1,580	4,050	453
1971	--	--	--	3,220	2,960	--	3,170	7,320	762
1972	--	--	--	4,030	2,970	3,770	3,760	9,200	2,020
1973	--	--	5,550	6,710	3,030	3,750	4,470	8,570	1,790
1974	--	--	1,410	5,680	1,880	2,000	2,410	6,070	489
1975	1,350	122	1,330	3,560	2,660	2,430	2,380	5,430	1,100
1976	364	53	468	4,060	1,470	2,330	2,350	5,650	1,000
1977	--	--	--	2,930	1,450	1,610	g 44.42	2,810	772
1978	--	--	--	4,860	2,790	3,520	g 52.71	5,660	850
1979	--	--	--	4,490	2,810	3,710	g 55.15	9,210	815
1980	511	130	923	3,320	1,800	1,810	g 45.63	3,630	642
1981	1,940	257	2,240	6,580	4,200	5,350	5700	8,830	1,400
1982	2,790	434	3,040	4,540	2,050	1,580	g 50.12	5,770	800
1983	2,070	318	2,330	5,990	2,310	3,810	g 55.60	8,490	1,340
1984	633	110	554	1,430	1,400	1,940	g 45.20	2,090	787
1985	1,890	313	2,180	7,920	2,990	3,340	3,500	6,800	1,560
1986	4,420	505	5,650	4,150	2,090	2,930	3,090	5,670	850
1987	504	410	1,600	4,380	2,250	2,590	2,510	5,270	868
1988	3,210	677	4,700	5,950	1,370	2,090	2,210	3,550	592
1989	--	--	--	12,400	3,580	4,850	4,930	9,000	1,900
Record	4,420	677	5,650	26,000	11,200	5,350	5,700	40,000	2,020

Table 5. Observed annual peak discharges for sites with 10 or more years of record during water years 1964–89—Continued

Water year	U.S. Geological Survey station number								
	08074200	08074250	08074500	08074540	08074760	08074780	08074800	08074810	08074850
Past	--	--	14,750	--	--	--	--	--	--
1964	--	--	2,270	--	--	--	--	--	--
1965	54	550	2,390	--	--	94	140	--	--
1966	121	1,040	8,320	--	--	206	588	--	--
1967	73	323	3,330	--	--	59	43	--	--
1968	328	2,280	9,120	--	--	192	352	--	1,030
1969	294	1,370	8,760	--	--	136	659	--	968
1970	169	925	3,750	--	--	128	547	--	808
1971	314	2,800	10,600	--	--	201	751	--	1,120
1972	399	5,800	17,300	--	--	--	1,060	--	930
1973	412	3,600	13,600	--	--	--	1,570	--	1,130
1974	163	2,640	6,060	--	--	--	984	--	1,040
1975	230	3,520	6,180	--	--	622	966	--	1,050
1976	240	2,830	8,480	--	--	485	785	--	1,170
1977	120	2,250	6,410	--	505	369	700	3,080	1,080
1978	278	3,180	8,290	--	1,510	225	558	3,570	1,020
1979	296	3,090	11,800	4,750	3,120	748	1,640	9,250	1,250
1980	282	2,190	4,810	2,870	920	330	846	4,370	1,030
1981	409	3,880	12,700	4,070	4,580	1,370	2,270	13,000	1,350
1982	247	2,540	9,090	2,620	2,150	808	2,190	9,220	1,200
1983	300	4,050	11,500	4,860	5,090	2,760	4,250	16,800	--
1984	307	2,610	3,830	2,610	597	216	320	2,960	--
1985	--	2,850	12,700	g 40.25	g 13.29	g 77.09	2,220	6,240	--
1986	--	4,420	10,900	g 38.36	g 17.43	g 78.65	3,140	10,600	--
1987	--	3,690	7,660	g 37.49	g 14.23	g 78.71	3,900	12,000	--
1988	--	2,860	5,440	--	g 11.86	g 76.19	1,400	4,080	--
1989	--	5,630	18,310	--	g 16.81	g 79.89	g 75.05	11,700	--
Record	412	5,800	18,310	4,860	5,090	2,760	4,250	16,800	1,350

Table 5. Observed annual peak discharges for sites with 10 or more years of record during water years 1964–89—Continued

Water year	U.S. Geological Survey station number								
	08075000	08075400	08075470	08075500	08075550	08075650	08075730	08075760	08075770
Past	12,600	--	--	8,030	--	--	--	--	--
1964	4,060	--	--	2,120	--	350	--	--	166
1965	3,160	960	--	3,800	290	800	--	236	355
1966	9,400	2,280	--	6,700	607	2,630	--	485	1,150
1967	4,730	350	--	1,260	235	886	--	399	920
1968	12,000	2,200	--	4,680	738	3,110	--	445	1,460
1969	9,240	2,280	--	7,720	535	1,410	--	380	1,050
1970	11,500	2,320	--	8,800	285	816	--	377	880
1971	15,500	2,230	--	5,750	339	1,540	--	666	2,260
1972	11,700	2,020	--	3,930	362	1,530	1,730	660	3,130
1973	24,800	4,220	--	10,000	658	4,500	3,360	778	3,380
1974	8,660	1,360	--	3,720	472	1,290	2,630	284	830
1975	18,000	2,830	--	11,200	454	5,080	2,490	359	890
1976	29,000	4,500	--	11,200	322	1,570	1,440	553	2,520
1977	8,710	1,440	--	4,250	326	1,210	1,910	272	790
1978	6,260	800	1,500	2,000	260	1,010	1,470	345	1,370
1979	25,500	3,400	g 37.49	10,900	538	4,650	3,940	640	2,470
1980	11,300	2,640	g 34.10	7,210	394	2,180	1,940	384	1,710
1981	25,400	3,820	g 37.33	8,610	628	4,950	4,720	664	2,600
1982	17,700	2,240	g 35.88	7,860	476	1,850	2,400	500	2,500
1983	29,000	4,660	g 37.82	11,400	547	g 22.58	3,720	640	3,440
1984	8,640	1,500	g 25.90	2,540	378	g 12.60	1,800	263	785
1985	13,200	1,860	g 29.93	4,010	--	g 17.49	2,400	--	2,500
1986	17,300	4,470	g 37.61	9,180	--	g 16.08	2,740	--	1,660
1987	22,400	3,490	g 34.46	7,400	--	g 15.80	2,750	--	2,610
1988	8,290	1,320	g 21.31	1,410	--	g 8.40	1,000	--	542
1989	21,500	5,190	g 38.15	9,120	--	g 20.15	4,540	--	3,470
Record	29,000	5,190	1,500	11,400	738	5,080	4,720	778	3,470

Table 5. Observed annual peak discharges for sites with 10 or more years of record during water years 1964–89—Continued

Water year	U.S. Geological Survey station number							
	08075780	08075900	08076000	08076200	08076500	08076700	08077000	08077100
Past	--	--	7,000	--	3,400	--	2,170	--
1964	--	--	5,950	g 85.11	1,470	--	820	--
1965	151	--	540	130	1,250	--	1,020	100
1966	514	2,730	5,360	614	2,640	--	2,050	150
1967	468	2,060	2,540	710	1,110	--	245	132
1968	390	1,140	2,580	318	2,340	--	1,800	390
1969	508	2,600	4,000	596	2,560	--	1,470	294
1970	268	1,670	3,600	618	2,340	--	1,430	450
1971	318	1,860	3,000	451	2,300	--	863	291
1972	190	2,940	6,500	1,180	3,780	14,100	1,220	249
1973	520	2,860	5,000	992	3,550	16,700	1,370	400
1974	282	1,580	2,590	510	1,720	5,980	1,210	323
1975	301	2,580	3,390	856	1,940	5,300	1,040	203
1976	223	1,750	7,730	905	2,460	10,400	1,300	170
1977	198	1,240	2,460	687	1,450	5,280	1,150	175
1978	169	2,530	3,790	813	1,800	11,400	801	200
1979	576	2,950	5,760	922	3,100	14,700	1,950	--
1980	409	1,660	2,570	649	2,030	9,540	1,800	--
1981	498	3,570	5,840	1,020	2,040	11,700	1,650	--
1982	418	2,940	4,130	810	2,300	7,140	1,230	--
1983	768	5,910	4,760	1,200	3,120	14,800	1,570	--
1984	265	1,420	2,150	397	1,840	5,010	390	--
1985	2,110	6,920	12,500	--	4,670	14,900	1,320	--
1986	1,260	2,520	3,480	--	1,890	6,700	1,450	--
1987	433	2,490	3,920	--	2,400	11,500	1,240	--
1988	663	1,380	2,230	--	1,260	3,780	270	--
1989	1,920	13,000	16,500	--	5,000	32,500	1,190	--
Record	2,110	13,000	16,500	1,200	5,000	32,500	2,170	450

Table 6. Summary of storm hydrographs available for all U.S. Geological Survey streamflow-gaging stations used in study, water years 1964–89

[maximum, largest runoff value for all storms; ft³/s, cubic feet per second; ft, feet; --, no storms available; s, stage]

No.	Station no.	Storm hydrographs available	Total no. of storms	Maximum discharge (ft³/s) or maximum stage (ft)	Water year 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	08068400	Yes	12	4,420	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	3	1	1	--	1	1	1	1	--
2	08068438	Yes	10	677	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	2	1	2	--	1	1	1	1	--
3	08068440	Yes	2	114	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	08068450	Yes	17	5,650	--	--	--	--	--	--	--	--	--	2	1	3	--	--	--	--	--	3	2	2	--	1	1	1	1	--
5	08069000	No																												
6	08072500	No																												
7	08073000	No																												
8	08073500	No																												
9	08073600	No																												
10	08073630	Yes	18	562	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	4	5	4	1	1	--	--	--	--
11	08073700	No																												
12	08073750	Yes	17	247	--	--	--	4	5	3	3	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13	08073800	Yes	21	1,900	--	3	1	4	3	3	3	2	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	08074000	No																												
15	08074050	No																												
16	08074100	Yes	14	878	--	1	3	2	1	1	3	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	08074145	Yes	19	127	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	5	3	10	2	--	--	--	--	--
18	08074150	Yes	42	2,020	--	2	1	2	2	1	4	3	1	1	2	2	--	1	--	1	2	4	3	5	1	--	1	1	1	1
19	08074200	Yes	39	412	--	1	2	2	3	2	3	3	--	1	2	2	--	--	2	2	2	2	4	5	1	--	--	--	--	--
20	08074250	Yes	55	5,800	--	4	4	3	3	3	4	3	1	2	2	2	--	1	2	2	2	2	5	5	1	--	1	1	1	1
21	08074400	Yes	23	119	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	3	4	3	5	3	--	2	1	--	--
22	08074500	Yes	30	18,300	--	--	--	--	--	--	--	--	1	1	1	--	--	--	1	3	5	4	4	3	2	--	1	1	1	2
23	08074540	Yes	26	4,860, s 40.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	3	4	6	8	1	1	1	1	--	--
24	08074550	No																												
25	08074750	Yes	2	25	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--
26	08074760	Yes	20	5,090, s 17.43	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	2	3	2	3	3	1	1	1	1	1	1
27	08074780	Yes	33	2,760, s 79.89	--	1	2	--	2	2	1	1	--	--	--	3	2	--	1	3	--	3	2	4	1	1	1	1	1	1
28	08074800	Yes	52	4,250, s 69.00	--	2	3	--	2	2	3	1	1	2	2	1	1	1	1	4	2	4	6	8	2	--	1	1	1	1

Table 6. Summary of storm hydrographs available for all U.S. Geological Survey streamflow-gaging stations used in study, water years 1964–89—Continued

No.	Station no.	Storm hydrographs available	Total no. of storms	Maximum discharge (ft^3/s) or maximum stage (ft)	Water year 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
29	08074810	Yes	25	16,800	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	2	1	3	3	5	2	2	1	1	1	1
30	08074850	Yes	24	1,170	--	--	--	--	3	7	--	3	2	2	2	2	1	--	1	--	1	--	--	--	--	--	--	--	--	--
31	08074900	Yes	15	1,680	--	5	3	3	3	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	08074910	Yes	13	227	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	3	3	4	1	--	--	--	--	--
33	08075000	Yes	25	29,000	--	--	--	--	--	--	--	--	--	2	1	1	1	--	--	3	2	3	3	1	3	1	1	1	1	1
34	08075100	No																												
35	08075300	Yes	14	470	--	1	4	2	2	--	3	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
36	08075400	Yes	41	5,190	--	2	3	3	2	4	3	2	2	2	1	1	1	--	--	--	2	2	3	2	2	--	1	1	1	1
37	08075470	Yes	15	s [1]38.15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	3	3	2	1	1	1	1	1
38	08075500	Yes	22	11,400	--	--	--	--	--	--	--	--	--	2	--	1	1	--	--	2	2	2	3	3	2	--	1	1	1	1
39	08075550	Yes	36	738	--	--	6	1	3	3	3	2	1	2	2	--	--	--	1	3	1	3	2	2	1	--	--	--	--	--
40	08075600	Yes	20	308	--	2	5	2	3	4	3	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
41	08075650	Yes	40	5,080, s 22.58	--	2	3	3	4	3	2	1	2	3	2	1	--	--	--	3	1	2	2	2	1	--	--	1	1	1
42	08075700	Yes	15	607	--	3	4	1	3	2	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
43	08075730	Yes	22	4,720	--	--	--	--	--	--	--	--	--	1	--	2	--	1	--	3	--	3	2	2	2	1	1	2	1	1
44	08075750	Yes	20	275	--	3	2	3	3	2	2	4	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
45	08075760	Yes	39	778	--	3	2	3	3	2	2	3	2	1	--	1	2	--	1	2	2	4	2	3	1	--	--	--	--	--
46	08075770	Yes	51	3,470	--	3	3	3	4	3	3	4	1	--	1	3	2	--	1	2	2	4	3	4	1	--	1	--	1	2
47	08075780	Yes	41	2,110	--	2	2	2	1	--	2	2	1	2	--	3	1	2	--	1	1	4	2	5	3	1	1	1	1	1
48	08075900	Yes	50	13,000	--	--	3	2	1	2	4	2	1	2	1	3	2	1	1	2	2	3	3	5	3	1	1	2	1	2
49	08076000	Yes	37	16,500	--	--	--	--	--	--	--	--	1	2	1	--	2	1	1	3	2	6	2	7	2	1	1	2	1	2
50	08076200	Yes	39	1,180	--	1	2	3	1	1	3	2	1	1	2	4	1	1	1	1	2	3	4	3	2	--	--	--	--	--
51	08076500	Yes	30	5,000	--	--	--	--	--	--	--	--	1	1	1	1	2	1	1	2	2	4	4	5	--	1	1	1	1	1
52	08076700	Yes	21	32,500	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1	2	2	4	3	1	1	2	1	1	2
53	08077000	No																												
54	08077100	Yes	18	390	--	1	2	3	4	3	2	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

[1]Stage only at this station.

Table 7. Summary of water-quality samples available for all U.S. Geological Survey sampling sites used in study, water years 1964–89

[--, no water-quality samples available; composite, sample composited from several discrete samples]

No.	Station no. (fig. 2c)	Total samples	Total discrete samples	Total composite samples	Water year and number of water-quality samples available																									
					1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	08068400	16	16	0	--	--	--	--	--	--	--	--	--	--	5	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	08068450	73	73	0	--	--	--	--	--	--	--	--	2	15	43	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	08069000	120	111		--	--	--	--	--	--	--	--	--	--	--	--	--	5	9	4	--	--	--	4	3	4	5	33	20	24
	Composite			9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	4	1	2
4	08073500	125	125	0	--	--	--	--	--	--	1	5	6	11	13	12	11	6	10	28	9	9	2	--	--	--	--	--	--	--
5	08073600	93	93	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	12	25	17	8	5	4	4	4	4	4	4
6	08073630	109	105		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	85	11	7	2	--	--	--	--
	Composite			4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	1	--	--	--	--
7	08073700	73	73	0	--	--	--	--	--	--	1	5	5	10	13	12	11	8	8	--	--	--	--	--	--	--	--	--	--	--
8	08074000	119	119	0	--	--	--	--	--	5	7	13	13	11	13	12	11	10	7	7	4	6	--	--	--	--	--	--	--	--
9	08074145	176	167		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	40	80	32	3	2	4	5	--	--
	Composite			9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	3	4	--	--
10	08074250	110	110	0	--	--	--	--	--	--	1	5	6	9	13	13	13	8	12	12	7	4	6	1	--	--	--	--	--	--
11	08074400	179	167		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	18	61	53	22	9	1	1	2	--	--
	Composite			12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	2	3	2	--	--
12	08074500	187	187	0	--	--	--	--	--	7	7	14	19	12	13	14	15	13	11	12	11	9	5	7	7	1	--	5	2	3
13	08074540	44	43		--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	12	9	10	8	3	--	--	--	--	--
	Composite			1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--
14	08074550	110	110	0	--	--	--	--	--	--	--	9	14	10	12	13	12	8	8	14	10	--	--	--	--	--	--	--	--	--
15	08074780	12	12	0	--	--	--	--	--	7	4	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	08074800	227	227	0	--	--	--	--	--	10	15	10	5	8	14	13	12	9	13	12	9	16	34	47	--	--	--	--	--	--
17	08074900	14	14	0	--	--	--	--	--	4	4	4	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	08075000	193	193	0	--	--	--	--	--	25	22	11	4	13	11	13	12	17	7	12	6	10	5	7	7	1	--	5	2	3
19	08075100	88	88	0	--	--	--	--	--	--	--	11	15	9	12	12	11	8	3	5	1	1	--	--	--	--	--	--	--	--
20	08075400	113	110		--	--	--	--	--	--	1	5	6	11	13	13	12	10	9	4	5	4	7	2	7	1	--	--	--	--
	Composite			3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--
21	08075500	170	170	0	--	--	--	--	--	5	8	12	17	12	12	13	16	13	8	10	4	6	6	6	3	4	5	5	2	3
22	08075650	103	103	0	--	--	--	--	--	2	5	9	17	8	12	12	13	9	4	6	2	4	--	--	--	--	--	--	--	--

Table 7. Summary of water-quality samples available for all U.S. Geological Survey sampling sites used in study, water years 1964–89—Continued

No.	Station no. (fig. 2c)	Total samples	Total discrete samples	Total composite samples	Water year and number of water-quality samples available																									
					1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
23	08075700	1	1	0	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	08075730	67	67	0	--	--	--	--	--	--	--	10	15	12	--	--	--	9	9	12	--	--	--	--	--	--	--	--	--	--
25	08075750	1	1	0	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
26	08075760	122	122	0	--	--	--	--	--	1	5	5	10	11	14	13	9	7	12	8	8	11	5	3	--	--	--	--	--	--
27	08075770	176	170		--	--	--	--	--	7	8	13	17	11	13	14	11	11	11	12	8	8	9	6	3	--	1	1	1	5
	Composite			6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	2	3	--	--
28	08076000	164	164	0	--	--	--	--	--	6	7	5	6	11	12	12	14	15	19	12	7	8	9	5	3	1	--	5	2	5
29	08076500	145	145	0	--	--	--	--	--	6	7	7	5	11	13	14	13	11	11	12	7	8	11	5	4	--	--	--	--	--
30	08076700	112	112	0	--	--	--	--	5	--	1	12	14	6	13	12	17	13	9	5	3	2	--	--	--	--	--	--	--	--

Table 8. Summary statistics of water-quality data collected for study, water years 1968–89

[μS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; NTU, nephelometric turbidity units; mg/L; milligrams per liter; cols./100 mL, colonies per 100 milliliters; μg/L, micrograms per liter; --, value not defined]

Parameter code	Water-quality parameter description	No. of samples	No. of detections	No. below detection limit	Mean	Standard deviation	Minimum	25th percentile	50th percentile	75th percentile	Maximum
P00095	Specific conductance (μS/cm)	3,025	3,025	0	589	697	30.0	198	460	826	17,700
P00400	pH (standard units)	2,492	2,492	0	7.3	1.4	4.0	7.0	7.3	7.7	10.3
P00010	Temperature, water (°C)	2,603	2,603	0	21.8	6.10	1.00	18.0	23.0	27.0	38.5
P00076	Turbidity (NTU)	1,051	1,051	0	82	100	.60	15	45	110	810
P00080	Color (platinum-cobalt units)	2,492	2,482	10	70	73	0	30	50	90	1,100
P00300	Oxygen, dissolved (DO) (mg/L)	2,473	2,467	6	6.9	3.2	.10	5.0	6.7	8.4	20
P00301	Oxygen, dissolved (percent saturation)	2,465	2,460	5	77.5	37.5	1.00	56.0	76.3	90.0	278
P00310	Oxygen demand, biochemical, 5 day at 20 °C (mg/L)	2,535	1,506	29	10	10	.10	4.5	7.5	13	150
P31501	Fecal coliform, membrane filter, m-endo (cols./100 mL)	1,984	1,978	6	777,000	3,430,000	1.00	22,800	170,000	740,000	130,000,000
P31625	Fecal coliform, 0.7-um membrane filter (cols./100 mL)	1,113	1,054	59	89,000	210,000	1.0	2,200	20,000	100,000	2,800,000
P31673	Streptococci, fecal, membrane filter, kf agar (cols./100 mL)	1,112	1,063	49	30,000	62,000	1.0	620	5,800	29,000	520,000
P00900	Hardness, total (mg/L as $CaCO_3$)	1,593	1,593	0	130	79	5.0	68	120	180	1,100

Table 8. Summary statistics of water-quality data collected for study, water years 1968–89—Continued

Parameter code	Water-quality parameter description	No. of samples	No. of detections	No. below detection limit	Mean	Standard deviation	Minimum	25th percentile	50th percentile	75th percentile	Maximum
P00902	Hardness, noncarbonate, water, whole, total (mg/L as $CaCO_3$)	1,405	1,405	0	6.6	23	0	0	0	6.0	520
P00915	Calcium, dissolved (mg/L as Ca)	1,593	1,593	0	38	22	2.1	22	35	51	360
P00925	Magnesium, dissolved (mg/L as Mg)	1,593	1,592	1	8.4	6.4	.30	3.3	6.9	12	54
P00930	Sodium, dissolved (mg/L as Na)	1,025	1,025	0	63	65	2.0	16	48	96	810
P00931	Sodium adsorption ratio	1,562	1,562	0	3.0	5.2	0	.91	2.1	3.4	100
P00933	Sodium plus potassium, dissolved (mg/L as Na)	631	631	0	121	260	.10	20	67	120	3,800
P00935	Potassium, dissolved (mg/L as K)	975	975	0	4.8	2.9	.70	3.1	4.4	6.2	47
P00440	Bicarbonate, water, whole, total, field (mg/L as HCO_3)	1,202	1,202	0	190	110	0	89	190	280	740
P00445	Carbonate, water, whole, total, field (mg/L as CO_3)	1,201	1,201	0	.55	5.4	0	0	0	0	89
P00410	Alkalinity, water, whole, total, field (mg/L as $CaCO_3$)	1,597	1,597	0	149.2	93.1	2.00	67.0	139	223	610
P00945	Sulfate, dissolved (mg/L as SO_4)	1,589	1,589	0	30	37	.40	13	24	37	660
P00940	Chloride, dissolved (mg/L as Cl)	1,593	1,593	0	100	270	1.9	19	55	96	5,800
P00950	Fluoride, dissolved (mg/L as F)	1,506	1,444	62	0.41	0.38	0	0.20	0.30	0.50	6.0
P00955	Silica, dissolved (mg/L as SiO_2)	1,593	1,591	2	13	7.6	0	7.0	12	19	47
P70301	Solids, sum of constituents, dissolved (mg/L)	1,585	1,585	0	375	490	11.0	126	303	478	9,920
P00530	Solids, residue at 105 °C, suspended (mg/L)	2,325	2,316	9	178	271	0	29.0	76.0	216	3,670
P00535	Residue, volatile nonfiltrable (mg/L)	2,200	2,167	33	35.4	59.7	0	10.0	20.0	40.0	1,050
P00620	Nitrogen, nitrate, total (mg/L as N)	2,648	2,648	0	.940	1.56	0	.200	.480	.960	35.0
P00615	Nitrogen, nitrite, total (mg/L as N)	2,632	2,554	78	.180	.230	0	.040	.100	.240	3.20
P00630	Nitrogen, nitrite plus nitrate, total (mg/L as N)	1,794	1,756	38	1.21	1.60	0	.300	.680	1.40	21.0
P00631	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	63	63	0	2.63	2.27	.130	.760	1.80	3.90	9.90
P00610	Nitrogen, ammonia, total (mg/L as N)	2,651	2,628	23	1.91	2.68	0	.290	.800	2.40	35.0
P00608	Nitrogen, ammonia, dissolved (mg/L as N)	108	107	1	2.47	3.03	0	.230	1.20	3.80	18.0
P00605	Nitrogen, organic, total (mg/L as N)	2,546	2,546	0	1.5	2.6	0	.55	1.2	1.8	87
P00625	Nitrogen, ammonia plus organic, total (mg/L as N)	1,895	1,893	2	3.4	3.4	0	1.6	2.5	4.0	52
P00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	43	43	0	3.4	7.3	.65	1.1	1.4	2.5	48
P00600	Nitrogen, total (mg/L as N)	1,897	1,897	0	4.6	3.7	.22	2.2	3.6	5.8	53
P00665	Phosphorus, total (mg/L as P)	2,678	2,667	11	2.08	2.22	0	.560	1.20	3.00	25.0
P00666	Phosphorus, dissolved (mg/L as P)	69	69	0	2.18	1.68	.040	.690	2.10	3.50	7.00
P70507	Phosphorus, orthophosphate, total (mg/L as P)	4	4	0	1.24	.320	.880	.930	1.25	1.55	1.60
P00671	Phosphorus, orthophosphate, dissolved (mg/L as P)	23	23	0	1.47	1.25	.130	.570	1.20	2.10	5.10
P01000	Arsenic, dissolved (µg/L as As)	820	757	63	10	25	0	3.0	5.0	10	400

Table 8. Summary statistics of water-quality data collected for study, water years 1968–89—Continued

Parameter code	Water-quality parameter description	No. of samples	No. of detections	No. below detection limit	Mean	Standard deviation	Minimum	25th percentile	50th percentile	75th percentile	Maximum
P01005	Barium, dissolved (µg/L as Ba)	463	389	74	150	113	0	70	110	200	600
P01010	Beryllium, dissolved (µg/L as Be)	15	4	11	.95	.33	.50	.62	1.0	1.2	1.3
P01025	Cadmium, dissolved (µg/L as Cd)	565	187	378	.93	2.6	0	0	0	1.0	30
P01030	Chromium, dissolved (µg/L as Cr)	494	296	208	7.3	19	0	0	0	10	230
P01035	Cobalt, dissolved (µg/L as Co)	213	149	64	.9	2	0	0	0	1	20
P01040	Copper, dissolved (µg/L as Cu)	795	723	72	6.3	7.3	0	3.0	4.0	7.0	95
P01046	Iron, dissolved (µg/L as Fe)	828	756	72	110	170	0	29	50	100	1,800
P01049	Lead, dissolved (µg/L as Pb)	622	445	177	5.3	9.0	0	0	3.0	6.0	100
P01130	Lithium, dissolved (µg/L as Li)	182	57	125	28	33	0	19	20	22	160
P01056	Manganese, dissolved (µg/L as Mn)	826	590	236	86	160	0	9.0	37	99	1,600
P71890	Mercury, dissolved (µg/L as Hg)	764	241	523	1.2	10	0	.10	.20	.50	160
P01060	Molybdenum, dissolved (µg/L as Mo)	15	0	15	--	--	--	--	--	--	--
P01065	Nickel, dissolved (µg/L as Ni)	284	245	39	6.2	12	0	1.0	3.0	7.0	130
P01145	Selenium, dissolved (µg/L as Se)	466	203	263	.7	.7	0	0	1	1	4
P01075	Silver, dissolved (µg/L as Ag)	321	130	191	.25	.55	0	0	0	0	3.0
P01080	Strontium, dissolved (µg/L as Sr)	183	177	6	240	170	20	90	210	400	700
P01085	Vanadium, dissolved (µg/L as V)	15	0	15	--	--	--	--	--	--	--
P01090	Zinc, dissolved (µg/L as Zn)	807	713	94	50	92	0	19	30	50	1,200
P39034	Perthane, total (µg/L)	172	171	1	.00	.01	0	0	0	0	.15
P39250	Naphthalenes, polychlorinated (µg/L)	256	255	1	0	0	0	0	0	0	0
P39330	Aldrin, total (µg/L)	796	793	3	.00	.04	0	0	0	0	.90
P39340	Lindane, total (µg/L)	791	786	5	.02	.06	0	0	0	.02	.72
P39350	Chlordane, total (µg/L)	781	780	1	.25	2.5	0	0	.10	.15	68
P39360	DDD, total (µg/L)	795	794	1	.01	.04	0	0	0	0	.51
P39365	DDE, total (µg/L)	794	791	3	.00	.02	0	0	0	0	.33
P39370	DDT, total (µg/L)	795	794	1	.03	.12	0	0	0	.01	2.1
P39380	Dieldrin, total (µg/L)	795	792	3	.03	.06	0	0	.01	.03	.60
P39388	Endosulfan, total (µg/L)	248	245	3	.00	.00	0	0	0	0	.05
P39390	Endrin, total (µg/L)	795	794	1	0	0	0	0	0	0	0
P39400	Toxaphene, total (µg/L)	467	466	1	.01	.07	0	0	0	0	1.0
P39410	Heptachlor, total (µg/L)	795	792	3	.00	.09	0	0	0	0	2.4
P39420	Heptachlor epoxide, total (µg/L)	794	792	2	.00	.01	0	0	0	0	.25

Table 8. Summary statistics of water-quality data collected for study, water years 1968–89—Continued

Parameter code	Water-quality parameter description	No. of samples	No. of detections	No. below detection limit	Mean	Standard deviation	Minimum	25th percentile	50th percentile	75th percentile	Maximum
P39480	Methoxychlor, total (µg/L)	94	93	1	.00	.00	0	0	0	0	.02
P39516	PCB, total (µg/L)	586	581	5	.04	.29	0	0	0	0	5.6
P39755	Mirex, total (µg/L)	204	203	1	.00	.00	0	0	0	0	.02
P39398	Ethion, total (µg/L)	325	325	0	.00	.00	0	0	0	0	.04
P39530	Malathion, total (µg/L)	743	743	0	0.15	1.0	0	0	0	0.03	20
P39540	Parathion, total (µg/L)	745	745	0	.00	.05	0	0	0	0	1.1
P39570	Diazinon, total (µg/L)	747	747	0	.26	.31	0	.05	.15	.35	2.7
P39600	Methyl parathion, total (µg/L)	746	746	0	.00	.02	0	0	0	0	.24
P39730	2,4-D, total (µg/L)	774	770	4	.46	3.7	0	0	0	.10	83
P39740	2,4,5-T, total (µg/L)	775	772	3	.13	.86	0	0	.02	.10	23
P39760	Silvex, total (µg/L)	775	774	1	.01	.08	0	0	0	0	1.8
P39786	Trithion, total (µg/L)	318	318	0	.00	.01	0	0	0	0	.09
P39790	Methyl trithion, total (µg/L)	318	318	0	0	0	0	0	0	0	0
P39024	Propazine, total (µg/L)	155	10	145	.48	.68	0	.10	.15	.62	2.1
P39051	Methomyl, total (µg/L)	145	2	143	1.0	1.4	0	0	1.0	2.0	2.0
P39052	Propham, total (µg/L)	142	2	140	1.0	1.4	0	0	1.0	2.0	2.0
P39054	Simetryne, total (µg/L)	154	2	152	.05	.07	0	0	.05	.10	.10
P39055	Simazine, total (µg/L)	154	52	102	.21	.34	0	.10	.10	.20	2.5
P39056	Prometone, total (µg/L)	155	104	51	.60	1.1	.10	.10	.30	.60	8.5
P39057	Prometryne, total (µg/L)	154	2	152	.05	.07	0	0	.05	.10	.10
P39630	Atrazine, total (µg/L)	155	113	42	.91	3.4	0	.10	.30	.60	35
P39750	Sevin, total (µg/L)	144	2	142	1.0	1.4	0	0	1.0	2.0	2.0
P81757	Cyanazine total (µg/L)	154	2	152	.05	.07	0	0	.05	.10	.10
P82184	Ametryne, total (µg/L)	154	2	152	.05	.07	0	0	.05	.10	.10
P00680	Carbon, organic, total (mg/L as C)	2,159	2,158	1	16	16	0	9.7	14	19	510
P00681	Carbon, organic, dissolved (mg/L as C)	13	13	0	10	4.8	1.7	7.1	11.	14	19

Appendix 1—EXPLANATION OF PEAK DATA CODES

Discharge Qualification Codes:

Code	Description
1	Discharge is a maximum daily average.
2	Discharge is an estimate.
3	Discharge affected by dam failure.
4	Discharge less than indicated value, which is minimum recordable discharge at this site.
5	Discharge affected to unknown degree by regulation or diversion.
6	Discharge affected by regulation or diversion.
7	Discharge is a historical peak.
8	Discharge actually greater than indicated value.
9	Discharge due to snowmelt, hurricane, ice jam or debris dam breakup.
A	Year of occurrence is unknown or not exact.
B	Month or day of occurrence is unknown or not exact.
C	All or part of the record affected by urbanization, mining, agricultural changes, channelization or other man-made influence.
D	Base discharge changed during this year.
E	Only annual maximum peak available for this year.

Gage Height Qualification Codes:

1	Gage height affected by backwater.
2	Gage height not the maximum for the year.
3	Gage height at different site and (or) datum.
4	Gage height below minimum recordable elevation.
5	Gage height is an estimate.
6	Gage datum changed during this year.

Notes:

Base discharge (if reported) may not be effective for entire period of record; current value is used.
Gage datum (if reported) may not be effective for entire period of record; current value is used.

Appendix 2—CODES USED IN U.S. GEOLOGICAL SURVEY WATER-QUALITY DATA PROCESSING SYSTEM

Medium Code Description:

Code	Description
0	Not determined
A	Artificial – Any substance that is not part of an aquatic environment and cannot be described by the Sample Medium Codes B-J or 1-9.
B	Solids (street sweepings, etc.) - Dry unconsolidated materials that are collected from a street or paved area, including the total array of materials that are collected as part of a "clean sweep," and cannot be described by Sample Medium Codes C–J or 1–9.
C	Animal tissue - Any type of tissue that comprises either whole or parts of insects, fish, or other organisms living in an aquatic environment, or warm bodied animals that may or may not have been collected from a water body.
D	Plant tissue - Any type of non-animal tissue that comprises either whole or parts of plants, aquatic or non-aquatic.
E	Core material Consolidated or unconsolidated material removed from a pipe or casing during a drilling (coring) operation.
F	Interstitial water - Water occurring in the small openings, spaces, and voids between particles of unconsolidated materials in that portion of the vadose water zone between the root zone and the water table. The water is held in place by entrapment, ionic attraction, and capillary or adhesive forces rather than from upward pressure components of saturation.
G	Soil - A wet or dry substance composed of unconsolidated fine grain rock fragments (minerals) and organic material that has been modified sufficiently by physical, chemical, or biological processes to support terrestrial plant growth.
H	Bottom material - A mixture of mineral and organic matter that compose the top bed deposits (usually the first few inches) underlying a body of water.
J	Sludge - An unconsolidated material, from an anthropogenic source, covering the ground or the bed of a water body, usually originating as a result of processes such as domestic or industrial waste treatment.
K	Soil moisture - Water occupying voids between loose soil particles within the aerated root zone. The water is held in place by surface tension, capillary and hydroscopic forces in opposition to the pull of gravitational forces.
L–P	Taxonomic data – Biological data distinct from non-taxonomic data which cannot be described by Sample Medium Codes A–K or 1–9. (L) Phytoplanktonic species composition and enumeration - Phytoplanktonic species composition and enumeration. (M) Phytoplanktonic species composition - Phytoplanktonic species composition. (N) Periphytic species composition - Periphytic species composition. (O) Benthic invertebrates species composition and enumeration - Benthic invertebrates species composition and enumeration. (P) Periphytic diatoms species composition and enumeration - Periphytic diatoms species composition and enumeration.
Q	Quality-assurance sample—Artificial
R	Quality-assurance sample—Surface water
S	Quality-assurance sample—Ground water
T	Quality-assurance sample—Wet deposition
U	Quality-assurance sample—Bulk deposition
V	Quality-assurance sample—Suspended sediment
W	Quality-assurance sample—Bottom material
X	Quality-assurance sample—Animal tissue
Y	Quality-assurance sample—Plant tissue
Z	Quality-assurance sample—Interstitial water

1 Suspended sediment - Sediment that is carried in suspension by the turbulent components of the fluid or by the Brownian movement (a law of physics).

2 Leachate - A solution obtained by passing a liquid (usually aqueous) through an unconsolidated solid medium, thereby dissolving materials (from the solid medium) that become a part of the solution. It also contains those precipitates that are the result of the solution process and subsequent chemical or biological reactions.

3 Dry deposition - Solid, aerosol or gaseous materials deposited from the atmosphere during dry weather periods.

4 Landfill effluent - A liquid material (usually water) that is drained or pumped from a landfill. It usually is a liquid that has percolated through solid landfill material to become a transport medium for materials dissolved from the landfill.

5 Elutriation - A process by which a mixture of an unconsolidated solid medium (usually soil) and a liquid medium (usually water) has been agitated for a given period of time to dissolve materials from the solid. The solid/liquid mixture is finally separated and the resulting solution is analyzed for materials dissolved during the elutriation process.

6 Ground water - Water below the surface of the earth contained in the saturated zone. It does not include soil moisture or interstitial water.

7 Wet deposition - Water reaching the earth's surface through precipitation as rain, snow, sleet, hail or condensation of fog and dew. The water may contain undissolved particulate and gaseous materials acquired from the atmosphere during precipitation.

8 Bulk deposition - A mixture of undesignated proportions of wet and dry deposition sampled by a continuously open container.

9 Surface water - Water on the surface of the earth stored or transported in rivers, streams, estuaries, lakes, ponds, swamps, glaciers or other aquatic areas. It may also refer to water in urban drains and storm-sewer systems.

Quality-assurance sample - Blank samples taken to ensure that environmental samples have not been contaminated by the data-collection process.

Analysis Status Code:

Code	Description
A	Not determined
H	Initial entry
1	Retrieved, in review
3	Data in temporary hold status
7	Reviewed, approved for transfer to EPA STORET
9	Proprietary data (Regional Hydrologist approval required)

Analysis Source Code:

Code	Description
A	Not determined
B	Non-USGS field
C	Non-USGS lab only
D	Non-USGS lab and field
F	USGS field and non-USGS field
G	USGS field and non-USGS lab
H	USGS field and non-USGS lab and field
1	USGS lab and non-USGS field
2	USGS lab and non-USGS lab
3	USGS lab and non-USGS lab and field
4	USGS lab and field and non-USGS field
5	USGS lab and field and non-USGS lab
6	USGS lab and field and non-USGS lab and field
7	USGS field only
8	USGS lab only
9	USGS lab and field

Hydrologic Condition Code:

Code	Description
A	Not determined
4	Stable, low stage
5	Falling stage
6	Stable, high stage
7	Peak stage
8	Rising stage
9	Stable, normal stage

Sample Type Code:

Code	Description
A	Not determined
B	Other QA
1	Spike
2	Blank
3	Reference
4	Blind
5	Duplicate
6	Reference material
7	Replicate
8	Spike solution
9	Regular

Hydrologic Event Code:

Code	Description
A	Spring breakup
B	Under ice cover
C	Glacial lake outbreak
D	Mudflow
E	Tidal action
H	Dambreak
J	Storm
1	Drought
2	Spill
3	Regulated flow
4	Snowmelt
5	Earthquake
6	Hurricane
7	Flood
8	Volcanic action
9	Routine sample

Remark Code:

Code	Description
Blank	Not remarked.
0,E	Estimated value.
1,<	Actual value is known to be less than the value shown.
2,>	Actual value is known to be greater than the value shown.
3,M	Presence of material verified but not quantified.
4,N	Presumptive evidence of presence of material.
U	Material specifically analyzed for but not detected.
B,K	Results based on colony count outside the acceptable range. (non-ideal colony count).
A	Average value.
V	Variance.
P	Most probable value.
L	Biological organism count less than 0.5 percent (only may be observed).
D	Biological organism count equal to or greater than 15 percent (dominant).
&	Biological organism estimated as dominant.
#	Delete the remark.

Quality-Assurance Code:

Code	Description
A	Not reported.
B	Non-USGS lab value—failed edit.
C	Non-USGS field value—failed edit.
D	USGS lab value—failed edit.
E	USGS field value—failed edit.
F	Non-USGS lab value—in review.
G	Non-USGS field value—in review.
H	USGS lab value—in review.
I	USGS field value—in review.
1	Non-USGS lab value—approved for transfer to EPA STORET.
2	Non-USGS field value—approved for transfer to EPA STORET.
3	USGS lab value—approved for transfer to EPA STORET.
4	USGS field value—approved for transfer to EPA STORET.