WATER IN ALABAMA, 1984

Geological Survey of Alabama
Circular 122B

Cover photograph by Paul H. Moser:
Tuscumbia Springs, Colbert County, Alabama.

GEOLOGICAL SURVEY OF ALABAMA

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CIRCULAR 122B

WATER IN ALABAMA, 1984

By

James D. Moore and Karen E. Richter

Tuscaloosa, Alabama
1985

GEOLOGICAL SURVEY OF ALABAMA

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September 30, 1985

Honorable George C. Wallace
Governor of Alabama
Montgomery, Alabama

Dear Governor Wallace:

I have the honor to transmit herewith a report entitled "Water in Alabama, 1984," by James D. Moore and Karen E. Richter, which has been prepared and published by the Geological Survey of Alabama as Circular 122B.

Water is one of Alabama's most valuable resources. In order to plan for the most efficient use of this resource, basic data must be collected and presented in readily usable form. This report, and its companion basic data volumes, Circulars 112 and 116, provide an overview of water conditions in the State, and are data sources needed in dealing with water resource problems.

Respectfully,

Ernest A. Mancini
State Geologist

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WATER IN ALABAMA, 1984

By

James D. Moore and Karen E. Richter

INTRODUCTION

Alabama's most important natural resource is its abundant water. Because of this abundance of water, there has been little emphasis in Alabama on conserving a resource that, in many areas of the United States, is becoming increasingly overdeveloped. As in other parts of the nation, use of water in Alabama has increased due to an increasing population and industrial growth. Per capita water use increased 170 percent between the years 1955 and 1980. In 1984, an average of 9.6 billion gallons of water per day was withdrawn for use from surface and underground sources.

The Water Resources Division of the Geological Survey of Alabama is responsible for a number of programs to monitor the use, quality, and quantity of surface and ground waters in the state, and to collect basic data necessary to develop new water supplies, expand current systems, and minimize water contamination. The basic-data collection program is implemented through a statewide network of stream-gaging stations, observation wells, water-quality sampling stations, and field observation. Data on streamflow, ground-water levels, and water quality collected through this program form the basis for many water-related research activities. Figure 1 shows the status of county water-availability reports by the Geological Survey of Alabama.

Water-resources data and water-use information are used by Geological Survey of Alabama staff members in answering information requests, by personnel from other government agencies, and by the public. This report and its companion basic data volumes, Circulars 112 and 116, are intended for use as comprehensive references to water data collected by the Geological Survey of Alabama and cooperating agencies.

CLIMATIC CONDITIONS

TEMPERATURE

Alabama's climate is characterized as humid subtropical, with mild winters, hot summers, and precipitation during all months of the year. Average annual temperatures range from 60°F in north Alabama to 68°F in southwest Alabama near Mobile Bay (fig. 2). Average January temperatures range from 44°F in the northern part of the state to 54°F on the Gulf Coast, and average July temperatures range from 81°F in north and coastal Alabama to 82°F in central Alabama. No climatic data station in the state has reported an average monthly temperature below freezing (Lineback and others, 1974). Average temperatures and departures from normal in calendar year 1984 for each of the climatological divisions of the state are given in table 1.

Climatological divisions are based roughly upon physiographic regions (fig. 3) because topography has a profound influence on temperature and on the type, amount, and distribution of precipitation. For example, the position and elevation of a mountain range may determine whether precipitation is rain or snow, and where it falls; the elevation of an area and its proximity to large bodies of water may have an influence on temperatures.

Lower than normal average monthly temperatures were recorded in nearly all divisions for most months of 1984 except October and December. During these two months, above-average temperatures occurred in all climatological divisions of the state. These high fall and winter temperatures raised the average annual figures for 1984 (fig. 4), and these temperatures and distribution patterns are similar to the 1931-80 average annual temperatures and distribution patterns shown in figure 2.

Figure 1.--Status of county water-availability reports published by the Geological Survey of Alabama.

Table 1.--Total precipitation, average temperatures, and departures from normal by climatological division for Alabama, 1984 (from National Climatic Data Center, 1984).

Climatological division	Total annual precipitation (inches)	Departure from normal (inches)	Average annual temperature (°F)	Departure from normal (°F)
Northern Valley	53.90	-0.68	60.2	-0.3
Appalachian Mountains	52.12	+ 3.19	60.3	+ 0.19
Upper Plains	53.04	-2.95	61.4	-6.1
Eastern Valley	56.90	+ 1.98	61.8	+ 3.1
Piedmont Plateau	49.96	-6.55	61.8	+ 0.4
Prairie	48.78	-4.03	63.8	-4.2
Coastal Plain	50.74	-5.68	64.9	-0.8
Gulf	55.71	-6.92	66.3	-8.0

Climatological Divisions

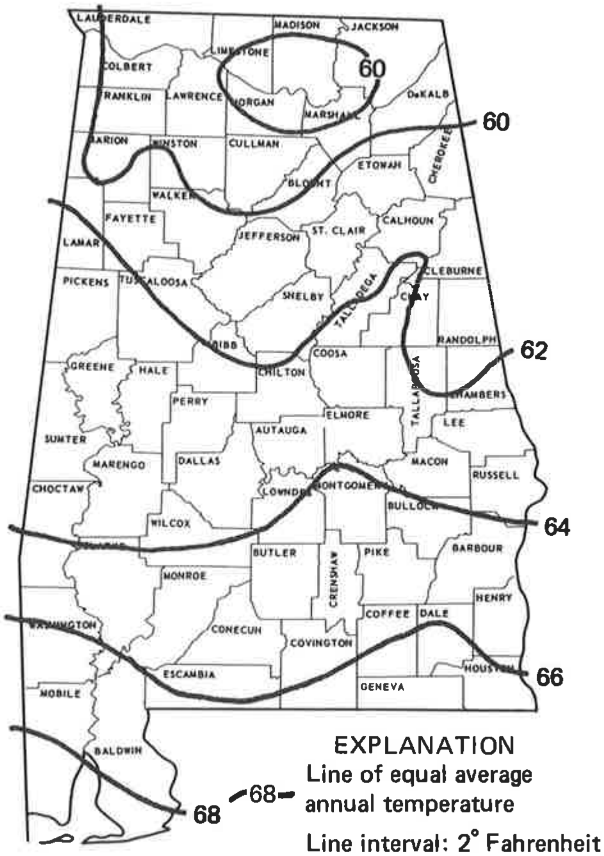


Figure 2.--Average annual temperatures (°F) (from Lineback and others, 1974).

PRECIPITATION

Rainfall in Alabama, as in most of the southeastern states, is abundant. The average annual precipitation ranges from a low of 48 inches in west-central and east-central Alabama to a high of 68 inches on the coast (fig. 5).

Very little snow falls in Alabama in normal years. Average annual snowfall ranges from 5 inches in the Tennessee Valley region to less than 1 inch in the southernmost part of the state. For most years, the southern half of the state receives no snowfall.

In dry years, the southeastern part of the state, which normally receives the least amount of rainfall, may have only 30 inches of precipitation. In wet years, precipitation in coastal Alabama, which normally receives the greatest amount of rainfall, may be more than 90 inches. Total annual precipitation and departures from normal in 1984 for each of the climatological divisions of the state are given in table 1.

Precipitation in 1984 was considerably less than in the two preceding years. Average annual precipitation was below normal in all climatological divisions except the Appalachian Mountains and Eastern Valley. Precipitation deficiency was greatest in the east-central, southeastern, west-central, and southwestern parts of the state, as shown in figure 6.

Only a part of the state's precipitation results in runoff. Much of the water either evaporates, is transpired by plants, or enters the ground-water system. By comparing figure 5 and figure 7, it is possible to see the great difference in the average amount of precipitation and the amount that can be accounted for as runoff.

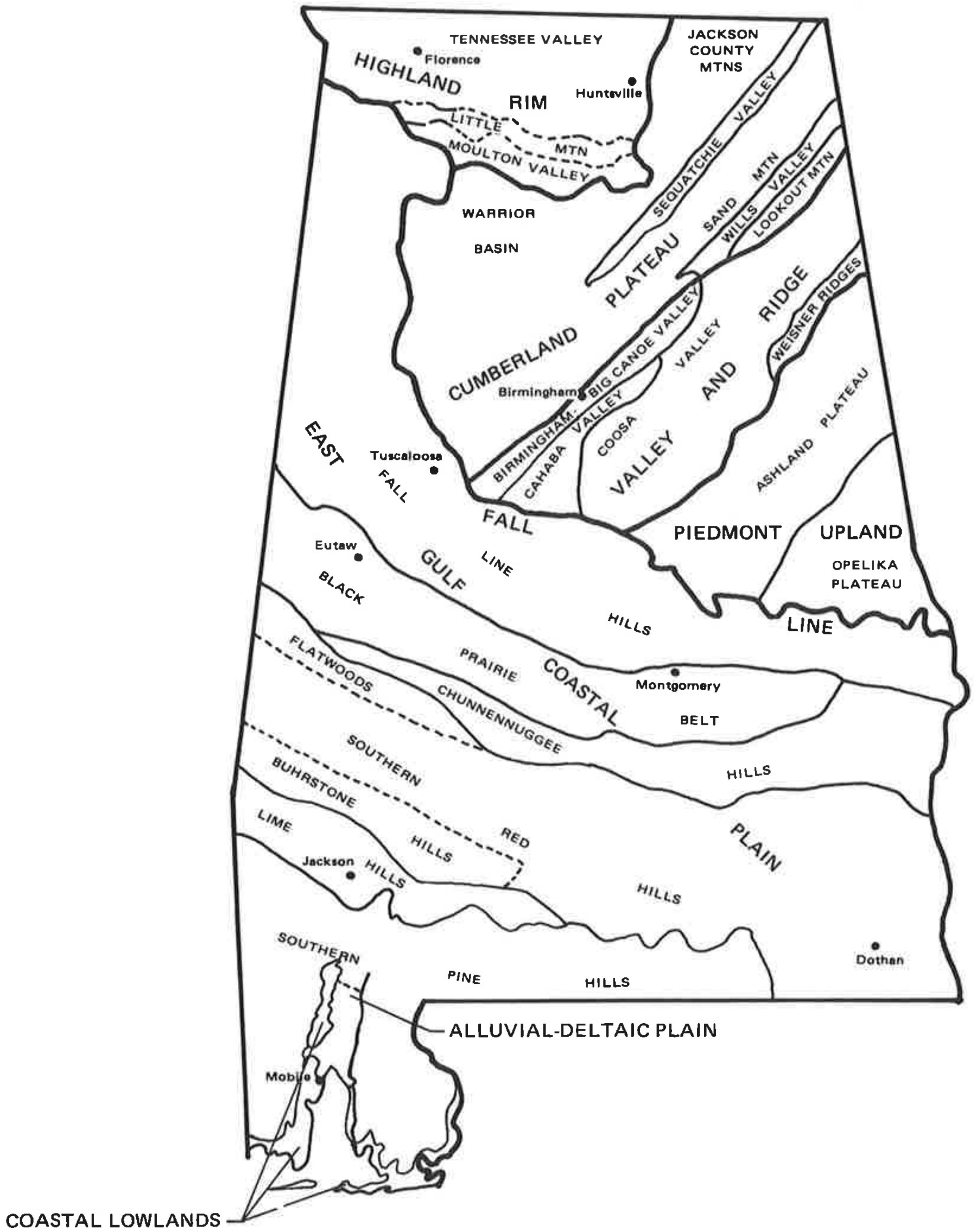


Figure 3.--Physiographic provinces of Alabama.

GROUND WATER

Although the availability of ground water is variable from one area to another within the state, ground water is a reliable source of water for many people in Alabama. Several large cities and many smaller towns use ground water for municipal supply, especially in south Alabama where ground water is readily available and of good quality. Also, there are uncounted wells throughout the state that supply rural domestic users and semipublic facilities such as campgrounds and marinas. The general availability of ground water from aquifers in different parts of the state is shown in figure 8.

The water-bearing characteristics of aquifers are controlled by geologic factors such as the type, permeability, and structure of rocks comprising the aquifers. Each of the general geologic terranes in

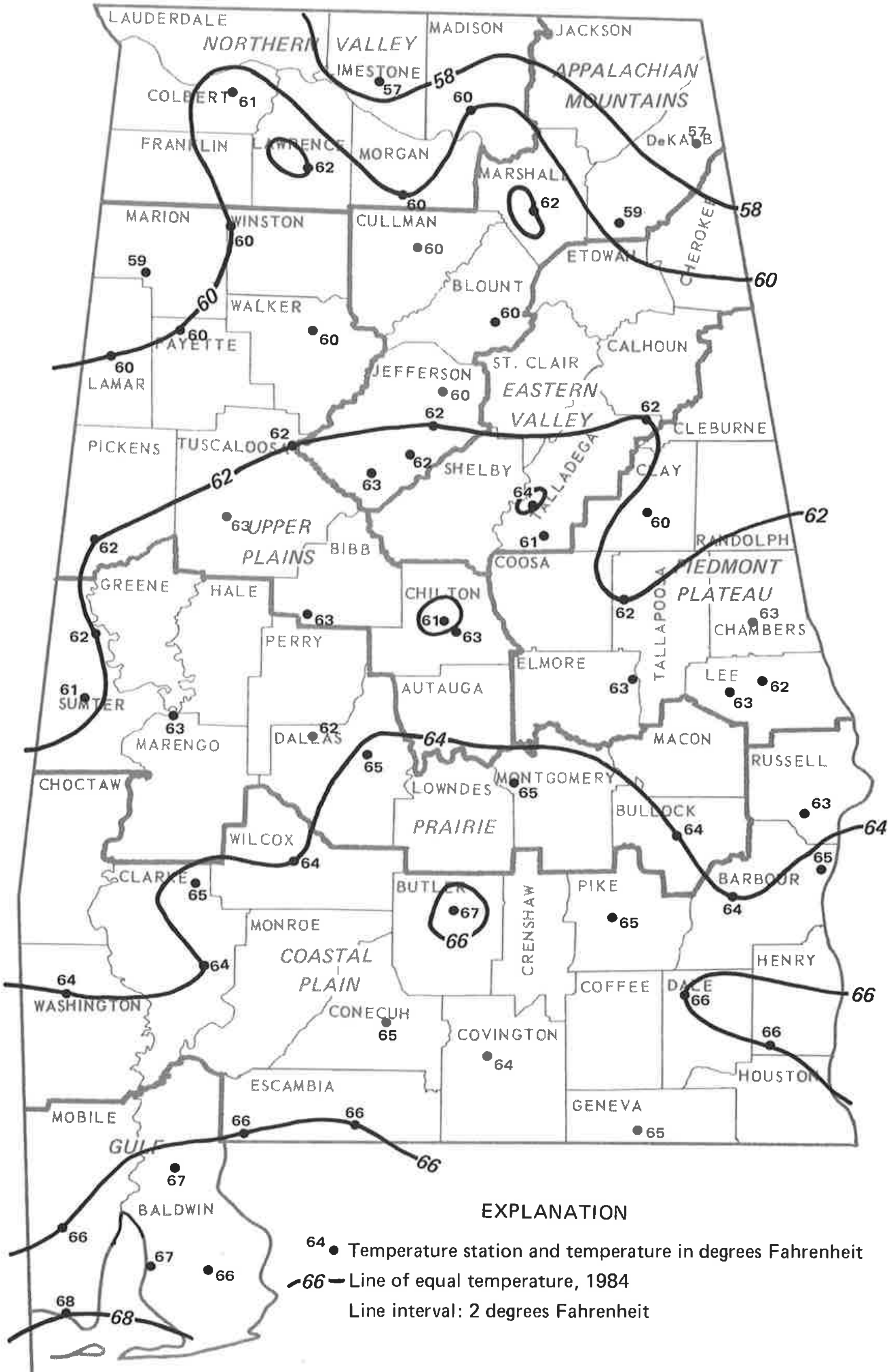


Figure 4.--Average temperatures (°F), 1984.

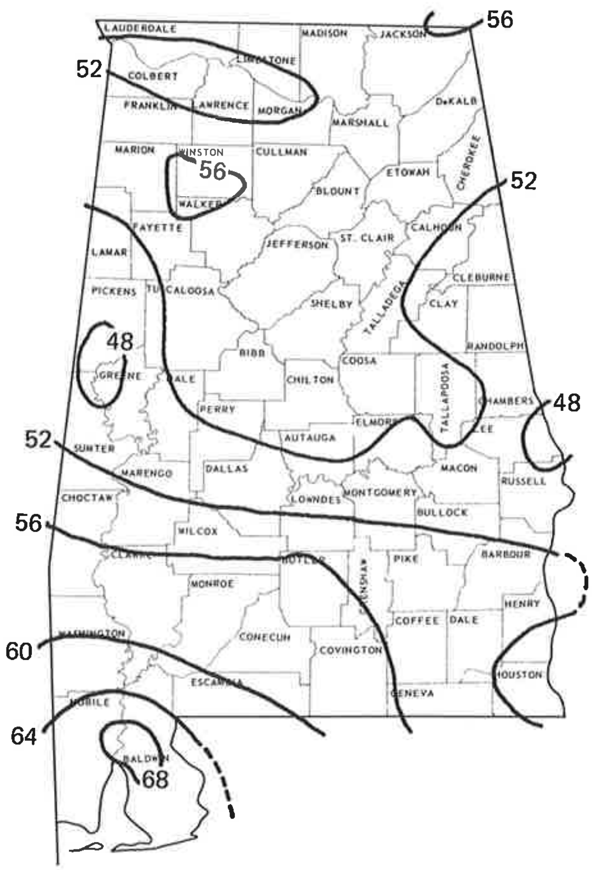


Figure 5.--Average annual precipitation, in inches, 1931-80 (from Lineback and others, 1974).

the state provides different conditions for ground-water occurrence. The geology of the state is shown in generalized form in plate 1.

WATER LEVELS

The Geological Survey of Alabama maintains a statewide network of monitoring wells to record ground-water levels in the important aquifers (pl. 2). Data from each well are published each year by the U.S. Geological Survey in its State Water Year Water Resources Data Report, and summary reports have been published by the Geological Survey of Alabama for Water Years 1981, 1982, and 1983 (Moore, 1984; Moore, 1984; and Moore and Moser, 1985).

Several types of observation wells are maintained. A few wells, usually those in the most important aquifers, are equipped with continuous water-level recorders. Data collected by these recorders are used in the preparation of hydrographs, which graphically depict the rise and fall of the water level in the well for the period of years the gage has been in operation.

Water levels in other wells are measured on a semiannual basis, in the fall and spring of each year, because the low and high water levels are expected to occur during those seasons. These water-level measurements are made either with electric tapes or steel tapes to as many significant figures as can be accurately read. Readings are usually most accurate for water levels close to ground level, as compared to readings of levels 200 or 300 feet below the measuring point of the well.

The data resulting from these water-level measurements can be compared with historic water-level data to determine long-term water-level changes in aquifer systems of the state. In addition, the water-level data can be used to prepare potentiometric or water-level maps for the major aquifer systems. Figure 9 shows the potentiometric surface for the Midway-Wilcox aquifer system.

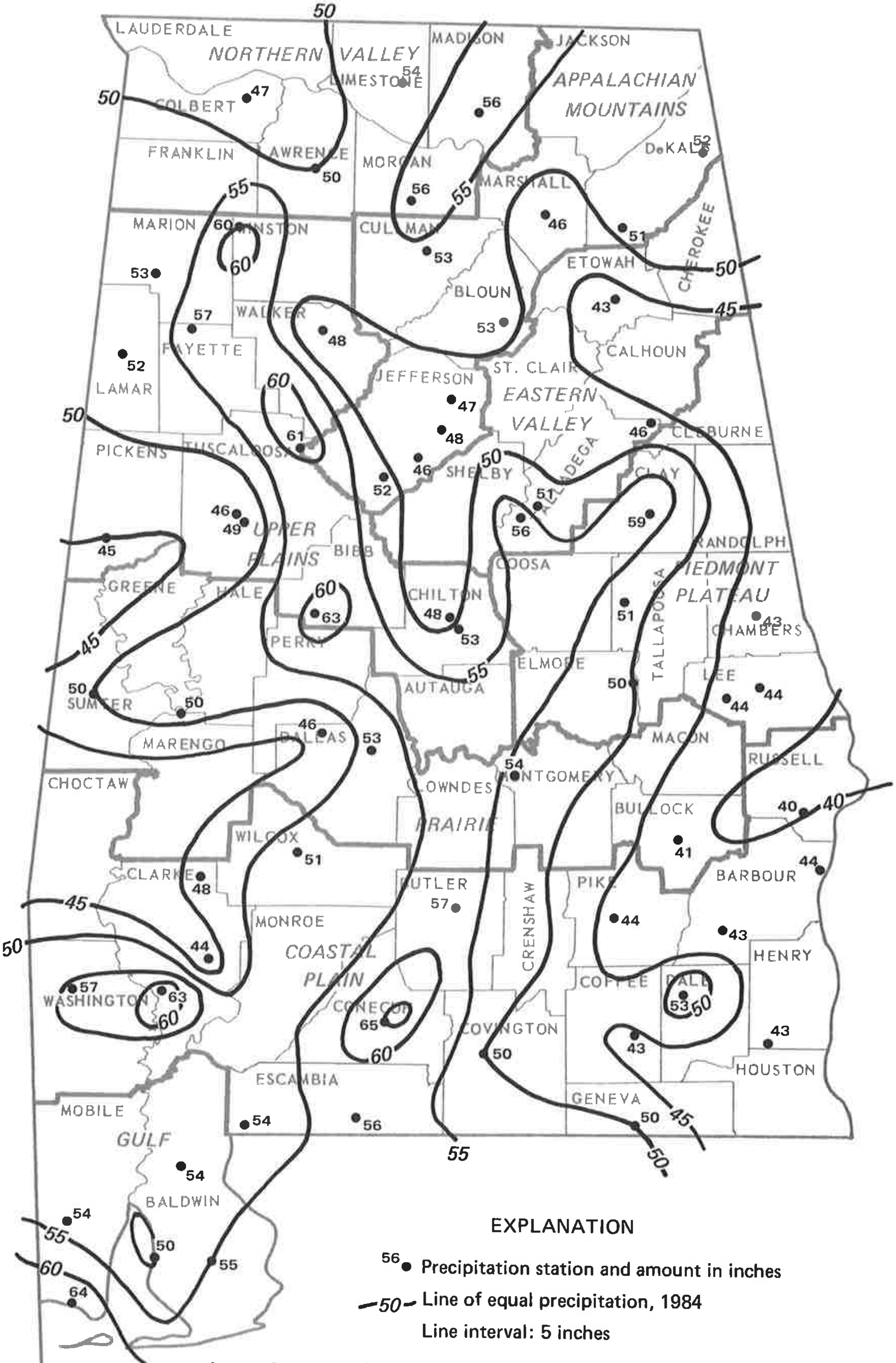


Figure 6.--Annual precipitation, in inches, 1984.

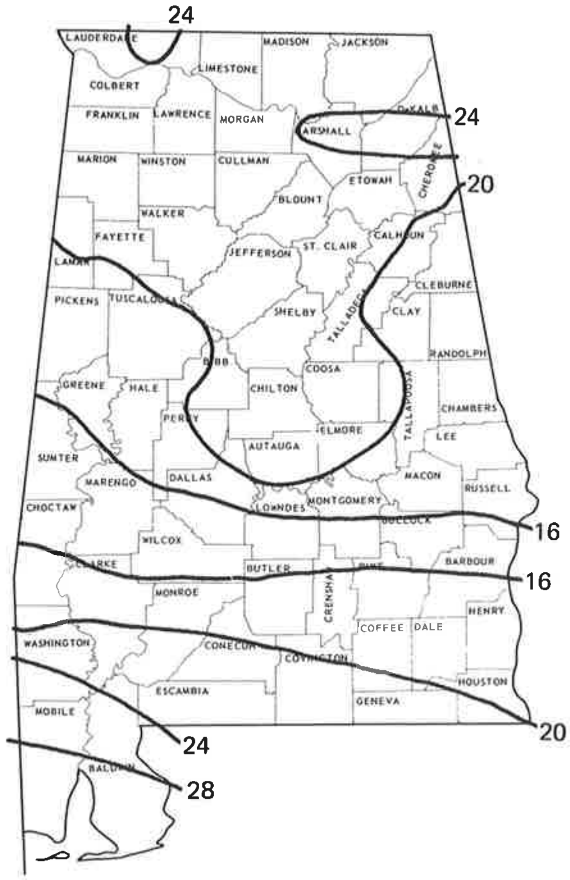


Figure 7.--Average annual runoff, in inches (from Lineback and others, 1974).

This aquifer system is used extensively as a source of water for irrigation and public supplies in southeast Alabama. The map was prepared primarily from water-level data collected during the fall of 1984.

WATER-LEVEL TRENDS

Many municipalities in Alabama, primarily those in the coastal plain, depend on ground water either as the primary water source or as the sole water source. In the coastal plain, where pumpage has steadily increased for many years, water levels have declined in the vicinity of the major pumping centers. In most other areas of the state, surface-water sources supply most of the water, and ground water level declines are not as common. Water-level trends at selected sites are shown in figure 10. The hydrograph for the well developed in the Eutaw aquifer in Greene County shows that the water level has been declining since 1952. Most of the hydrographs show seasonal water-level fluctuations. The seasonal fluctuation of the water level in the well in Jackson County is often 20 feet or more. The water level in this well is affected by pumpage of nearby wells, but no significant long-term water-level declines have occurred.

LEGAL ASPECTS OF GROUND-WATER MANAGEMENT

Legal aspects of ground water are poorly defined in Alabama. The principal legal decisions concerning underground water in Alabama have arisen from mining controversies (Cohen, 1972).

The "reasonable use" rule applies to ground water in Alabama. This rule recognizes the right of a landowner to a reasonable and beneficial use of the waters upon or underneath his land, provided the waters are not wasted or do not cause injury to others.

Figure 8.--Potential yields of aquifers in Alabama.

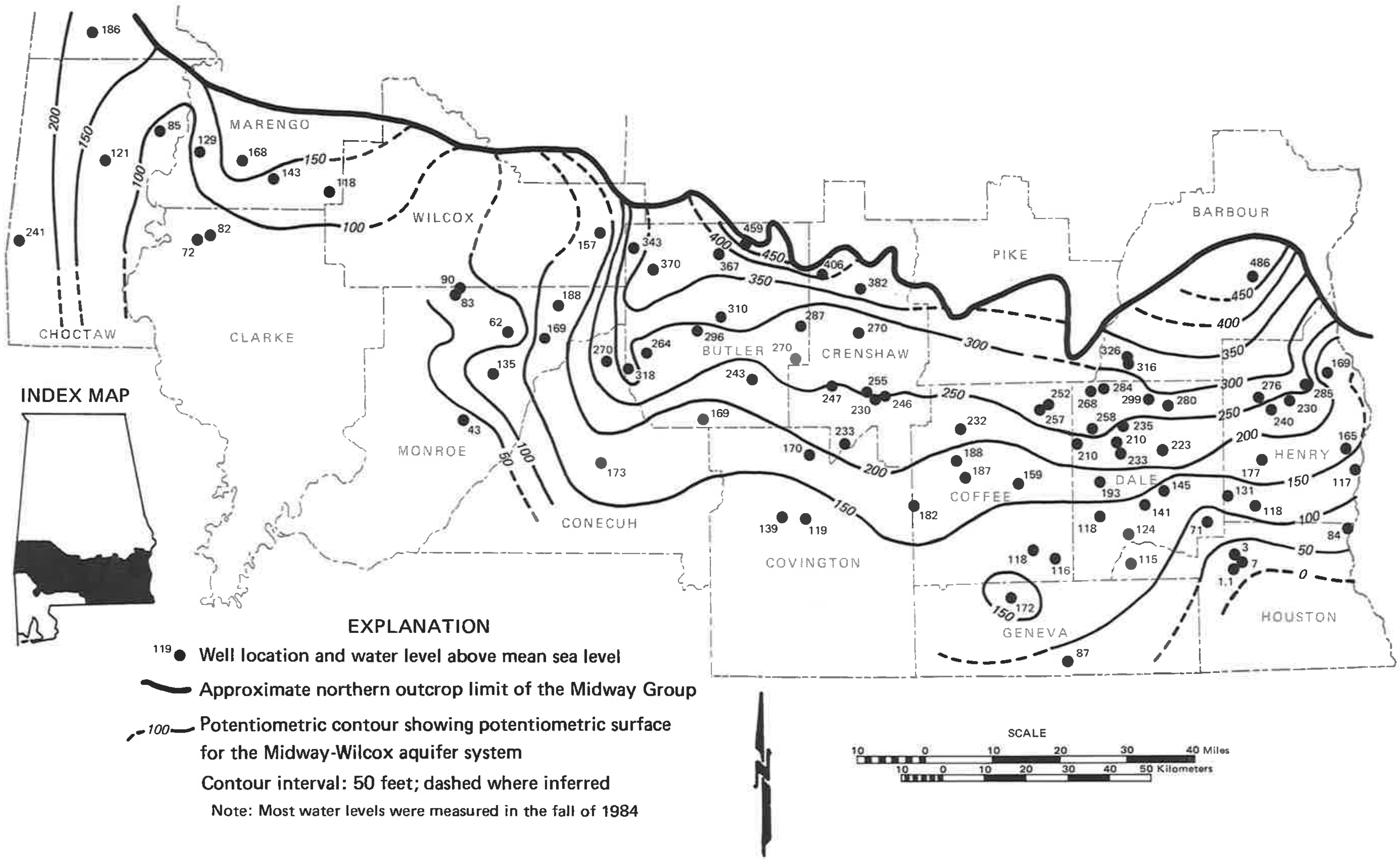


Figure 9.--Potentiometric surface for the Midway-Wilcox aquifer system, 1984.

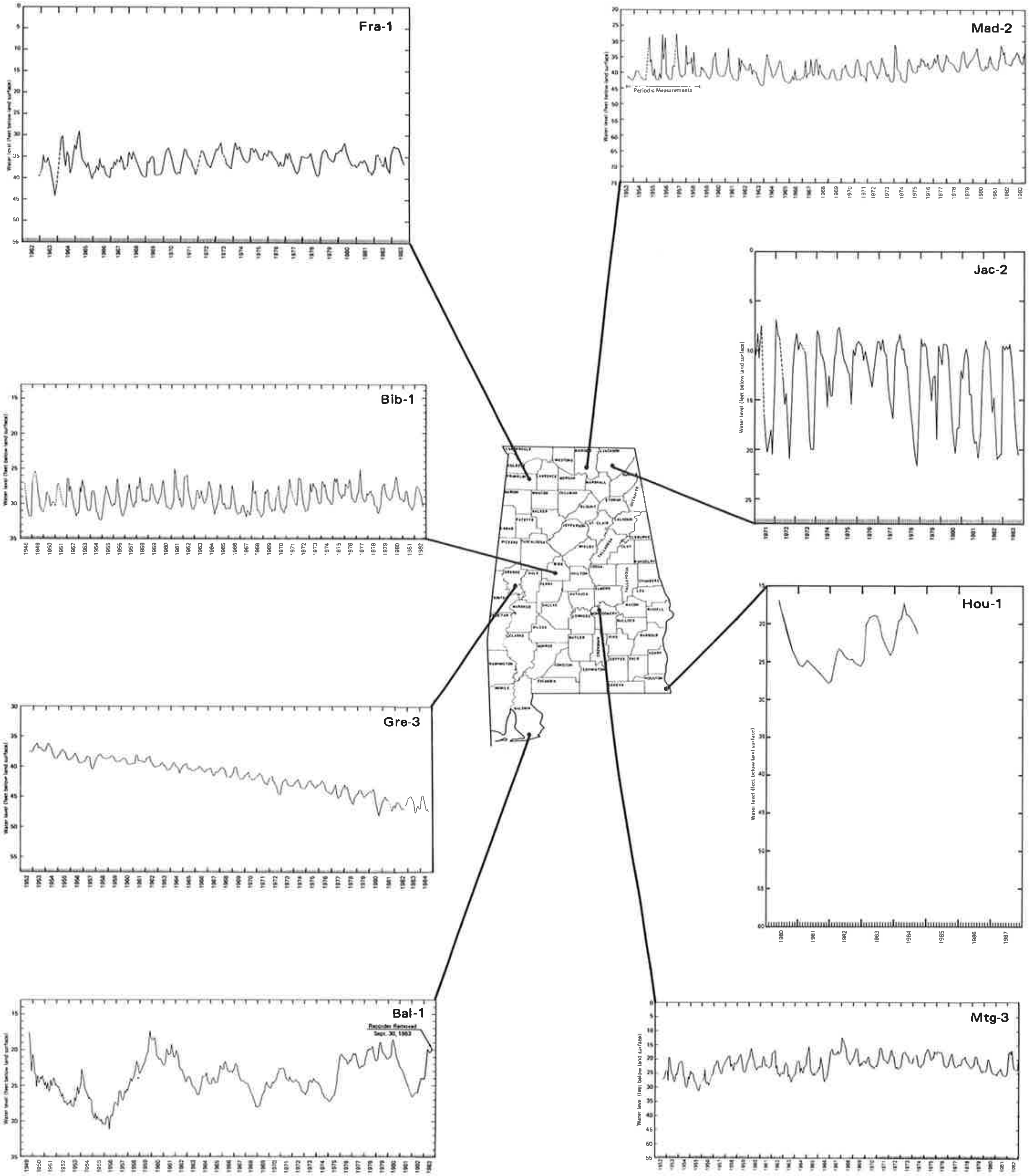


Figure 10.--Hydrographs of monthly low water levels in selected wells.

Cases involving misuse or overuse have become increasingly frequent in Alabama. For example, a case was presented in 1982 by several landowners whose properties surrounded land bought by a municipality to be used as a municipal-supply well field. The landowners contended that the pumping of wells in the area at the rates required to supply municipal needs would depress water levels in their nearby wells, thereby depriving them of the reasonable use of waters beneath their land.

Litigation involving dewatering of mines and quarries has also been initiated. Several suits have been filed to enjoin industrial or quarrying operations from pumping excess water from mines or pits because the pumpage lowered surrounding water levels and allegedly triggered ground-collapse mechanisms.

These newer cases indicate that care must be taken by those who withdraw large volumes of ground water to minimize effects of their pumpage on the water system. In addition, users of large volumes of ground water should be prepared to compensate owners of adjacent properties for any depletion of their ground-water supplies or any damages caused by withdrawals.

As new cases of ground-water contamination are discovered and as public concern with pollution increases, protection of ground-water resources is becoming a major issue in legislative actions. In late 1984, Congress enacted amendments to the Resource Conservation and Recovery Act that were designed to improve the act and to reduce some of its inconsistencies. Also, Congress created a National Ground Water Commission to study problems and policy issues (Bird, 1985).

In August 1984, the U.S. Environmental Protection Agency established its national ground-water protection strategy. As part of the strategy, the U.S. Environmental Protection Agency concludes that state governments have the primary responsibility for establishment of ground-water protection policies and for implementation of these policies. The strategy is intended to assist states in developing ground-water management programs and to assist in improving coordination among existing U.S. Environmental Protection Agency programs (Bird, 1985).

GROUND-WATER REGULATIONS

In 1984, permits were not required for water-well drilling in Alabama, except in the Coastal Area Zone. In this zone, which includes coastal areas with surface elevations of 10 feet or less, permits are required for development of wells producing 50 gallons per minute or more. Well drillers, however, are required by the Alabama Department of Environmental Management to submit in quadruplicate a form (ADEM Form 60 1/83, Report of Drilled Well) for each water well drilled in the state. A copy of this form is reproduced in appendix 1. Completed copies of the form must be provided to the Public Water Supply Section of the Alabama Department of Environmental Management and to the Water Resources Division of the Geological Survey of Alabama, where they are then filed as part of the water-information records of the State. Water wells in Alabama must be drilled by drillers licensed by the Alabama Department of Environmental Management. A list of water-well drillers licensed in Alabama in 1984 is provided in appendix 2.

The Public Water Supply Section of the Water Division of the Alabama Department of Environmental Management regulates public water supplies. A public water supply system is one that provides or sells water to the public for human consumption and has at least 15 service connections or regularly serves an average of 25 people at least 60 days during the year. Self-supplied industrial/commercial and agricultural users of ground water generally are not regulated by the State. However, some local governing bodies in Alabama have some control over ground-water management in their areas of jurisdiction; some cities have adopted ordinances that require a permit for the construction and operation of a water-supply well. A list of Federal and State agencies responsible for ground-water regulation is given in appendix 3.

SURFACE WATER

Surface water is abundant and well distributed in Alabama and has been developed extensively for many uses. Streams and reservoirs provide water for domestic consumption, industrial uses, transportation, power generation, waste dilution, and recreation. Streamflow information is needed for the proper construction of bridges, dams, causeways, and other structures. Data on discharge amounts and stream-stage heights are necessary in designing these structures. In order to use and develop surface-water resources effectively and to plan for land use and construction in areas affected by watercourses, several types of surface-water data are required. Among the most important of these are data on streamflow duration, average annual discharge, low flow, seasonal distribution of flow, and maximum stream stage. To obtain these and various other types of streamflow information, the Geological Survey of Alabama and the U.S. Geological Survey maintain a network of stream-gaging stations on streams throughout Alabama (pl. 3). Stream-discharge measurements are also made for research projects at various sites by both agencies.

HYDROLOGIC REGIONS

Surface-water data are collected and organized by hydrologic units, corresponding to river drainage basins and aggregates of basins. Hydrologic regions may contain several major river basins; subregions correspond to the drainage area of a major river; and accounting units correspond to the basins of major tributaries (fig. 11). Cataloging units (not shown) correspond to the drainage basins of smaller tributaries. Each unit is assigned a two-digit number. These numbers are combined in a sequence from larger to smaller basins, enabling an eight-digit number to delineate the position of a tributary basin within a major river basin and a multi-river basin. This numbering system is used by several agencies, including the U.S. Geological Survey, U.S. Department of Agriculture, Soil Conservation Service, and Alabama Department of Environmental Management.

Within accounting units, gaging stations are assigned arbitrary numbers in downstream order along the main stream. No distinction in numbering is made between partial-record stations, where limited streamflow data are collected periodically, and continuous-record stations, where systematic observations of gage height and/or discharge are measured continuously.

STREAMFLOW

Streamflow is monitored at several gaging stations throughout the state. These stations may vary from complex installations containing continuous recorders, flow-through sampling chambers, climatological instruments, and small automatic laboratories, to simple gage-height scales marked on spillway walls or other structures. The most common type of station is the continuous recorder that is mounted on galvanized pipes on stream banks or attached to bridges. Automated recorders may give either a continuous graph of stage measurements or a tape with values represented by punch holes at selected timed intervals; nonrecording gages are read directly.

Large streams and rivers are well distributed throughout the state and their average discharges range from less than 200 to more than 52,000 cubic feet per second (ft^3/s). Table 2 is a summary of streamflow data at gaging stations on selected streams.

The discharge data for streams in 1984 given in table 2 show that the 1984 mean discharges were greater than the average discharges, except for the three stations (02361000, 02369800, and 02371500) in southeast Alabama, which had below-average streamflow, and one station in north-central Alabama (02450180), which had near-average streamflow. The 1984 mean discharges at the stations with above-average flow were generally 10 to 35 percent greater than the average discharge. However, in southeast Alabama, where rainfall was much less than normal, 1984 mean discharges for streams were as much as 20 percent less than average discharges.

Natural low-flow values of streams are necessary in planning for water-supply availability, disposal of waste effluents into streams, hydroelectric power generation, and wildlife management. The most commonly used values are the annual 7-day low flows of 2-year and 10-year recurrence intervals, called the 7-day Q_2 and 7-day Q_{10}, respectively. The 7-day Q_2 represents the median low flow, or the lowest flow to which the stream will decline on an average of once every 2 years of normal flow. This value also provides an estimate of the amount of flow generally available without the need for storage. The 7-day Q_{10} is the lowest flow for 7 consecutive days that may be expected to occur once in 10 years. The 7-day Q_2 and 7-day Q_{10} values for some of the major streams and rivers in Alabama are provided in table 2. The reliability of low-flow values is dependent upon the length of

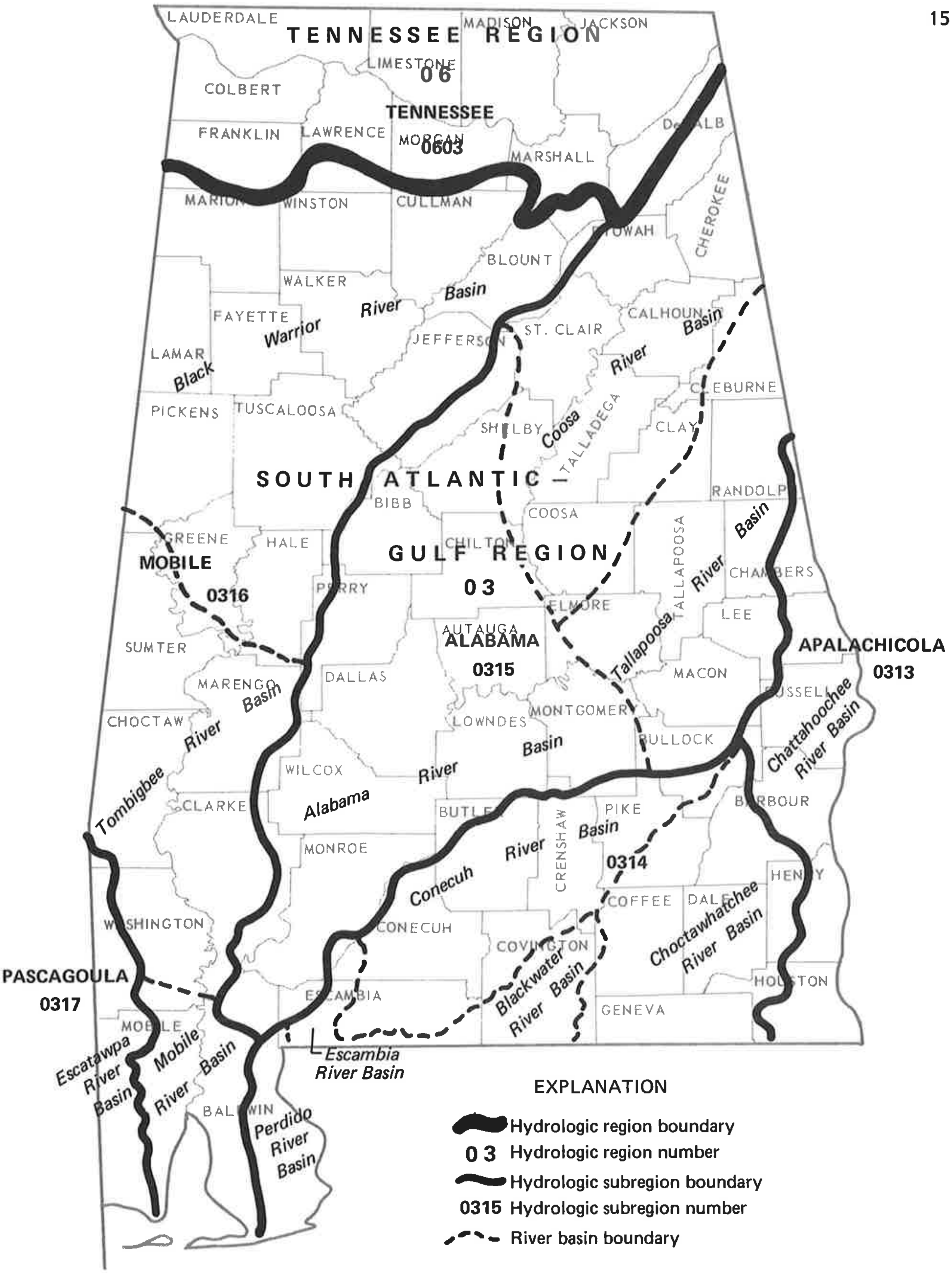


Figure 11.--Hydrologic regions and principal river basins in Alabama.

Table 2.--Low-flow (7-day Q_2 and Q_{10}) values and average discharge values for selected streams in Alabama[1]

Station number	Location of station	Discharge: Years of record[2]	Discharge: 1984 Average discharge (ft^3/s)	Discharge: 1984 Mean discharge (ft^3/s)	Low flow: Years of record[2]	Low flow: 7-day Q_2 (ft^3/s)	Low flow: 7-day Q_{10} (ft^3/s)
02361000	Choctawhatchee River near Newton	54	983	969	52	50	88
02369800	Blackwater River near Bradley	17	149	129	15	33	21
02371500	Conecuh River at Brantley	47	677	541	44	56	31
02411000	Coosa River at Jordan Dam	60	16,730	22,280	58	2,545	1,761
02413300	Little Tallapoosa River near Newell	9	669	821	7	75	51
02418500	Tallapoosa River below Tallassee	56	4,897	6,179	54	663	149
02425000	Cahaba River near Marion Junction	32	2,973	3,350	30	10	308
02428400	Alabama River at Claiborne Lock and Dam	9	38,030	43,130	7	6,610	5,900
02442500	Luxapallila Creek at Millport	8	394	543	6	54	37
02446500	Sipsey River near Elrod	41	794	1,146	39	53	28
02447025	Tombigbee River at Gainesville Lock and Dam	6	14,120	14,550	5	380	206
02448500	Noxubee River at Geiger	40	1,623	1,841	38	59	33
02450180	Mulberry Fork near Arkadelphia	8	916	911	6	17	14
02450250	Sipsey Fork near Grayson	18	176	235	16	3.8	2.5
02456500	Locust Fork at Sayre	46	1,483	1,744	44	51	29
02466030	Black Warrior River at Warrior Lock and Dam	8	10,710	10,930	6	1,025	582
02469761	Tombigbee River at Coffeeville Lock and Dam	24	31,170	35,410	22	2,445	1,754
02471065	Montlimar Creek at Mobile	14	24	--	13	10	5.8

Table 2.--Low-flow (7-day Q_2 and Q_{10}) values and average discharge values for selected streams in Alabama[1] - Continued

Station number	Location of station	Discharge: Years of record[2]	Discharge: 1984 Average discharge (ft^3/s)	Discharge: 1984 Mean discharge (ft^3/s)	Low flow: Years of record[2]	Low flow: 7-day Q_2 (ft^3/s)	Low flow: 7-day Q_{10} (ft^3/s)
03574500	Paint Rock River near Woodville	48	690	754	40	13	5.3
03575500	Tennessee River at Whitesburg	60	43,628	47,260	56	16,151	7,028
03575830	Indian Creek near Madison	16	66	82	10	4.6	3.3
03589500	Tennessee River at Florence	90	52,034	63,650	89	14,167	7,449

[1]Stations nearest mouth of each stream were used.
[2]"Years of record" indicates years for which discharge information was available. It does not necessarily indicate consecutive years of record. Data available through 1982 were used in determining low-flow values.

the period of record for which discharge records are available. Usually, the longer the period of record, the more reliable the low-flow values. Low-flow values, especially those determined for extensive periods of records, change very little from year to year except when affected by extreme drought or flood conditions.

The U.S. Geological Survey maintains computer files of streamflow data and publishes daily values for gaging stations in its annual Water Data Reports for the State. These data are also summarized in annual water reports of the Geological Survey of Alabama.

LEGAL ASPECTS OF SURFACE WATER

Surface-water rights in Alabama have not been the subject of legislation, and therefore court decisions involving surface-water rights and surface-water use have not been combined into a uniform code or body of statutes. One of the few compendiums of water-related rulings and opinions available to the public is "Water Laws of Alabama" (Griggs, 1978), published as Bulletin 89 of the Geological Survey of Alabama.

In Alabama, court decisions involving the use and ownership of water and lands overlain by water have been based on the distinction between navigable and nonnavigable waters. The legal title to waters and streambeds of navigable waterways is retained by the State, in trust for the people of Alabama. The legislature has authority to make laws pertaining to the use of public waters and lands underlying them and to establish authorities that can regulate use of these waters. Title to nonnavigable waters and streambeds may be vested in private owners, subject loosely to the rule of "reasonable use."

The "reasonable use" rule allows the use of waters for agricultural, industrial, mining, and other purposes, provided water is not wasted or allowed to cause injury to others. A landowner may not divert, dam, or otherwise alter the course of a stream flowing across his land, unless these operations neither deprive upstream or downstream owners of their right to use the water, nor adversely affect the lands of other owners. For example, a landowner may construct an impoundment on his land, but he may not cause the stream to cease flowing through downstream property, nor cause another owner's land upstream to be inundated by the impounded water.

The title to land bounded by a nonnavigable watercourse includes the bed of the stream to the center of the main channel, unless the landowner's instrument of title limits the boundary to the bank or to another designated point.

The judicial decisions in the following recent court cases affect surface-water litigation:

Kennedy* v *City of Montgomery, 423 So.2d 187 (1982)

Plaintiff landowners brought action against the city of Montgomery alleging that the city wrongfully allowed flooding of their homes. The Circuit Court granted the city's motion for summary judgment and the landowners appealed.

The question on appeal was the propriety of summary judgment on the following issues: 1) whether the city had a duty not to cause negligently the plaintiff's property and home to be flooded, 2) whether the city, as an upper property owner, had a common law duty not to injure lower property owners by interference with the natural drainage of water, 3) whether the city's employees acted wantonly in failing to provide adequate drainage, and 4) whether the conditions created by the city constituted a nuisance.

The Supreme Court of Alabama ruled that, where the city has undertaken control of the drainage system for the plaintiff's property and where waters from that drainage system injure property, the city does have a duty to control flooding. Thus, summary judgment was inappropriate and plaintiffs were entitled to a trial on counts 1 and 3. The court ruled that the count 2 cause of action was inapplicable because the city was not an upper property owner. The court reversed summary judgment on the nuisance count, finding that the plaintiffs may be able and are entitled to prove that the city violated a duty of care.

Ellis* v *Alabama Power Company, 431 So.2d 1242 (1983)

In this case, in which property owners sought recovery of damage from a dam operation when their property was flooded after a heavy rainfall, the plaintiffs failed to prove negligence by the dam owner, and damages were denied. It was also ruled that where essentially all property owners located on a reservoir were flooded and the power company operated its dam in accordance with the Department of Army's flood-control plan, the plaintiff property owners could not recover damages on a private nuisance theory.

SURFACE-WATER REGULATION

Several State agencies have responsibility for enforcement of different sets of regulations involving water. The Alabama Department of Environmental Management is responsible for regulating the quality of public drinking water supplies and for water-pollution control. The Alabama Surface Mine Reclamation Commission is responsible for regulating mining activities that may affect the quality of water, and the State Oil and Gas Board is responsible for regulating oil and gas exploration and development activities that may affect the quality of water. The State Department of Conservation and Natural Resources is responsible for enforcement of water-safety traffic laws on waterways and impoundments, and for regulating activities that may affect the quality of water in wildlife refuges and game management areas.

WATER QUALITY

WATER QUALITY STANDARDS

The quality or chemical character of water is one of the most important factors affecting its use. Any water supply must meet, or be amenable to treatment to meet, certain sets of standards for each type of use.

Water-quality standards are set and enforced for various water uses by Federal, State, and local government regulations. The most important of these regulations are those dealing with drinking water standards for public supply. All public water supplies must meet the standards for contaminant limits established by the Safe Drinking Water Act, Primary Drinking Water Regulations, Title 40, Part 141 of the Federal Code, and the National Revised Primary Drinking Water Regulations

Table 3.--Water-quality limits for public water supplies
(from U.S. Environmental Protection Agency, 1983)

INORGANIC CHEMICALS

Alkalinity	--
Ammonia	0.5 milligrams/liter (mg/L)
Arsenic (total)	0.05 mg/L
Barium	1 mg/L
Cadmium	0.010 mg/L or 10 micrograms/liter (µg/L)
Chromium	0.05 mg/L or 50 µg/L
Chloride	250 mg/L
Copper	1 mg/L
Cyanide	0.2 mg/L
Fluoride	(see chart below)
Hardness	(see chart below)
Iron	0.3 mg/L or 300 µg/L
Lead	0.05 mg/L or 50 µg/L
Manganese	0.05 mg/L or 50 µg/L
Mercury	0.002 mg/L or 2 µg/L
Nitrate as Nitrogen	10 mg/L
Nitrite as Nitrogen	1.0 mg/L
Phosphate	--
Selenium	0.01 mg/L or 10 µg/L
Silver	0.05 mg/L or 50 µg/L
Sodium	270 mg/L
Sulfate	250 mg/L
Zinc	5 mg/L

FLUORIDE

Average maximum daily air temperature (°F)	mg/L
50.0-53.7	1.8
53.8-58.3	1.7
58.4-63.8	1.5
63.9-70.6	1.4
70.7-79.2	1.2
79.3-90.5	1.1

ORGANIC CHEMICALS

Alkyl benzene sulfonate	0.5 mg/L
Carbon chloroform extract	0.2 mg/L
Endrin	0.0002 mg/L
Lindane	0.004 mg/L
Methoxychlor	0.1 mg/L
Toxaphene	0.005 mg/L
2, 4 D	0.01 mg/L
2, 4, 5 - TP Silvex	0.01 mg/L
Trihalomethane (total)	0.01 µg/L

TOTAL HARDNESS

Mg/L $CaCO_3$	Class
0- 60	soft
61-120	moderately hard
121-180	hard
more than 180	very hard

RADIOLOGICAL

Radium 226,228	5 picoCuries/liter (pCi/L)
Gross beta	4 millirem/year (50 pCi/L)
Gross alpha	15 pCi/L

OTHER PARAMETERS

Color	15 color units
Coliform bacteria	< 1/100 ml (mean)
pH	6.5-8.5
Threshold odor number	3
Total dissolved solids	500 mg/L
Turbidity	1-5 turbidity units

(U.S. Environmental Protection Agency, 1983, p. 45502-45521). These standards, shown in table 3, are specified by both the U.S. Environmental Protection Agency and the State of Alabama. For waters subject to these standards, samples must be collected and sent for analysis to the Public Water Supply Section, Water Division, of the Alabama Department of Environmental Management at intervals specified by the State. The sampling interval for ground-water-supplied public water systems is once per month. Surface-water treatment facilities must take and analyze at least one sample per day. Most public water-supply systems maintain their own sampling and analysis program at more frequent intervals than required by the State. Table 4 shows sampling frequencies required for different contaminants and for other factors such as color, odor, and turbidity. The U.S. Environmental Protection Agency issues updates of the drinking-water standards.

Table 4.--Sampling frequencies and locations for community and noncommunity water supplies (from Alabama Department of Environmental Management, 1982).

Community water system	Noncommunity water system
Inorganic Contaminants	**Inorganic Contaminants**
Surface water: 1-year intervals Ground water: 3-year intervals	Surface and ground water: nitrates--intervals specified by Alabama Department of Environmental Management (ADEM)
Organic Contaminants	**Organic Contaminants**
Surface water: 3-year intervals unless otherwise specified by ADEM Ground water: none, unless specified by ADEM	Surface and ground water: at intervals specified by ADEM for each system
Microbiological Contaminants	**Microbiological Contaminants**
Surface and ground water: required number of samples per month set by ADEM for each system, based on population served; samples taken at points representative of distribution system	Surface and ground water: minimum of 2 samples per month during each month the system provides water: taken at points representative of distribution system
Turbidity Levels	**Turbidity Levels**
Surface and ground water: minimum 1 per day, at a representative entry point to the distribution system	Surface and ground water: minimum 1 per day, at a representative entry point to the distribution system; sampling frequency may be reduced at discretion of ADEM
Radioactivity Levels	**Radioactivity Levels**
Surface and ground water: natural and man-made radionuclides--4 consecutive quarterly samples or the average of 4 quarterly samples--other sampling intervals at discretion of ADEM	Surface and ground water: natural and man-made radionuclides--4 consecutive quarterly samples or the average of 4 quarterly samples--other sampling intervals at discretion of ADEM

In areas where natural conditions have not been extensively altered by man's activities, water quality is controlled by three circumstances: the presence of gases or particulate matter in the atmosphere through which precipitation falls; the type of earth materials with which the water comes in contact; and the amount of time the water remains in contact with soils and rocks.

WATER-SAMPLE COLLECTION

The Geological Survey of Alabama and the U.S. Geological Survey maintain water-quality sampling stations on streams and rivers, and at wells and springs throughout the state (pl. 4). Stations are maintained to provide long-term records of water quality in the major aquifers and streams. Water samples are collected semiannually at some sites and quarterly at other sites. A few sites have continuous water-quality monitors. Also, water samples may be collected during specific projects at selected sites. If concentrations of chemical constituents in excess of allowed standards are detected in a sample, the location of the sample and a copy of the analysis are sent to the agency charged with enforcing water-quality standards.

Ground water is more likely to have a higher mineral content than surface water because it moves much more slowly and has more time to react with minerals present in the rocks through which it moves. Ground water is likely to be much less variable in quality over a period of time for a particular site than surface water. However, ground-water quality is variable with depth and location throughout Alabama, depending on the composition of the rocks comprising an aquifer, the depth of water within an aquifer, and local hydrogeologic conditions. The results of chemical analyses of ground-water samples from selected sites are given in table 5, and the locations of these sites are shown in plate 4. A comparison of analysis results with the drinking-water standards (table 3) reveals that few water-quality problems exist in the wells sampled. The most common problems are excessive hardness; high concentrations of iron, chlorides and dissolved solids; and low pH (high acidity). These water-quality problems are attributable to natural geohydrologic conditions.

Surface water at a given site may be highly variable in quality throughout the year, partly because of variations in flow due to climatic conditions, impounding, or diversion of water. Surface water is also accessible to pollutants of all types, especially those generated by man. Streambeds are less likely to contain concentrations of highly reactive natural minerals because alluvial processes tend to remove these minerals quickly and leave only the more chemically inert minerals in the streambed. The results of chemical analyses of surface-water samples from selected streams are given in table 6, and the locations of sample-collection sites are shown in plate 4. Water in the streams was generally of good chemical quality. However, most of the water was slightly acidic (less than pH 7), and more than half of the streams contained water with high concentrations of iron (greater than 300 µg/L).

WATER USE

In 1984, an average of 9.6 billion gallons of water per day was withdrawn from surface- and ground-water sources for use in Alabama. This figure represents approximately 2,300 gallons per day (gpd) for every person in the state. This is 400 gpd less than the estimated per capita use in 1980. Factors contributing to this decline were reduction in use at a large thermonuclear plant and shut-downs of large industrial users.

Water use is divided into two main categories: withdrawal or off-stream use, where water is withdrawn from its natural setting in streams, lakes, or aquifers prior to being used; and nonwithdrawal or in-stream use, where water is used without being withdrawn from its natural setting. Data were collected for 10 categories of use in Alabama, 6 of which were withdrawal uses and 4 nonwithdrawal uses. Figure 12 shows total amounts of withdrawal use for 1984, compared to 1980 total withdrawal uses.

WITHDRAWAL USE

The six withdrawal-use categories inventoried were public water systems, self-supplied industrial/commercial, agricultural, self-supplied domestic, power generation, and mining. Figure 13

Table 5.--Chemical analyses of samples collected from selected wells in Alabama (See plate 4 for sampling locations.)

Parameter	Site number									
	1	2	3	4	5	6	8	9	10	11
Date	5/14/84	5/15/84	5/14/84	5/14/84	5/14/84	5/15/84	5/15/84	5/16/84	5/25/84	5/16/84
Specific conductance (µmhos/cm)[1]	250	45	550	1495	170	295	295	260	630	1200
Temperature (°C)[2]	23	19	23	23	22	24	22	19	--	25
Bicarbonate (mg/L)[3]	120	3	190	230	88	170	170	150	280	280
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	110	2	160	190	73	140	140	120	230	230
pH	7.0	4.8	8.2	6.9	6.4	7.2	7.5	6.5	7.8	7.9
Silica (mg/L)	7.8	4.8	8.9	9.1	11	2.5	13	10	9.5	10
Calcium (mg/L)	0.7	1.9	4.1	50	17	34	19	50	1.1	6.6
Magnesium (mg/L)	0.2	1.1	0.4	34	1.7	6.3	9.2	1.9	0.2	3.0
Sodium (mg/L)	59	4.0	120	190	12	17	30	2.8	140	230
Potassium (mg/L)	1.1	0.3	1.3	12	2.2	4.1	7.1	0.7	1.0	5.1
Sulfate (mg/L)	1.2	ND[4]	2.6	ND	ND	5.2	6.2	3.6	2.8	21
Chloride (mg/L)	15	5.8	68	340	5.5	2.0	2.7	1.8	19	220
Fluoride (mg/L)	0.2	<0.1	0.4	0.3	<0.1	0.2	0.6	0.1	1.9	1.3
Nitrate as N (mg/L)	ND	1.18	ND	ND	ND	ND	ND	1.74	ND	0.32
Nitrite as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N (mg/L)	ND	0.03	0.45	1.75	0.06	0.13	0.21	0.02	0.30	0.79
Phosphorus as P (mg/L)	0.23	ND	0.21	0.02	ND	0.01	0.03	0.03	0.45	0.02
Arsenic (µg/L)[5]	1	<1	<1	<1	1	1	<1	<1	1	<1
Cadmium (µg/L)	1	1	1	<1	1	1	1	<1	<1	1
Chromium (µg/L)	<1	1	1	1	1	2	2	1	<1	2
Cobalt (µg/L)	ND	2	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	840	330	50	1200	6500	110	70	230	210	70
Lead (µg/L)	<1	1	1	11	1	2	2	2	1	5
Manganese (µg/L)	20	130	10	190	120	ND	<10	10	<10	60
Mercury (µg/L)	0.6	0.2	0.1	0.1	ND	0.2	ND	1.7	ND	0.3
Strontium (µg/L)	70	ND	60	220	180	400	420	190	70	510
Zinc (µg/L)	<10	30	ND	ND	<10	10	10	10	10	<10
Total dissolved solids (mg/L)	144	25	299	749	93	155	171	153	313	636
Hardness as $CaCO_3$ (mg/L)	3	9	12	270	50	110	86	130	4	29

[1]µmhos/cm - micromhos per centimeter.
[2]°C - degrees Centigrade.
[3]mg/L - milligrams per liter.
[4]ND - not detected.
[5]µg/L - micrograms per liter.

Table 5.--Chemical analyses of samples collected from selected wells in Alabama - Continued

Parameter	Site number									
	12	13	15	16	17	18	19	20	21	22
Date	5/16/84	5/15/84	5/16/84	5/16/84	5/17/84	5/17/84	5/17/84	5/24/84	5/17/84	5/16/84
Specific conductance (µmhos/cm)[1]	1480	775	360	310	700	320	600	840	83	290
Temperature (°C)[2]	27	28	22	22	22	21	22	18	20	--
Bicarbonate (mg/L)[3]	240	360	210	180	280	190	300	350	24	180
Carbonate (mg/L)	0	0	0	0	0	0	0	2	0	0
Alkalinity as $CaCO_3$ (mg/L)	200	300	170	150	230	160	250	290	20	150
pH	7.7	8.2	7.4	8.0	8.3	7.4	7.5	8.4	5.3	7.2
Silica (mg/L)	9.8	8.9	9.2	6.2	6.1	8.8	8.0	6.5	7.8	11
Calcium (mg/L)	12	2.4	18	2.9	3.0	19	5.7	1.7	9.5	35
Magnesium (mg/L)	6.1	0.6	6.6	1.0	0.8	3.3	2.5	0.7	1.0	6
Sodium (mg/L)	270	180	57	69	150	41	130	190	2.2	21
Potassium (mg/L)	5.8	1.7	2.3	1.4	1.9	4.4	2.2	1.9	1.0	2.3
Sulfate (mg/L)	24	25	11	9.2	30	2.5	31	32	ND[4]	9.6
Chloride (mg/L)	340	52	6.9	4.4	69	2.2	21	18	6.2	3.0
Fluoride (mg/L)	0.9	0.3	0.2	0.3	0.8	0.1	1.6	1.2	<0.1	0.1
Nitrate as N (mg/L)	1.43	0.03	1.92	1.26	0.04	ND	1.81	ND	3.55	1.37
Nitrite as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N (mg/L)	0.84	0.54	0.30	0.39	0.44	0.40	0.58	0.53	0.04	0.29
Phosphorus as P (mg/L)	0.03	0.10	0.04	0.04	0.03	0.03	0.05	0.01	0.02	0.03
Arsenic (µg/L)[5]	<1	<1	<1	<1	1	<1	<1	1	<1	<1
Cadmium (µg/L)	<1	1	<1	<1	<1	<1	<1	1	<1	1
Chromium (µg/L)	1	1	1	1	1	2	2	<1	1	1
Cobalt (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	320	20	60	40	20	40	30	10	50	50
Lead (µg/L)	ND	2	2	2	4	1	2	1	4	1
Manganese (µg/L)	10	<10	ND	<10	ND	<10	<10	<10	10	ND
Mercury (µg/L)	0.1	0.2	1.8	ND	0.4	ND	0.2	0.2	0.6	ND
Strontium (µg/L)	1500	110	500	170	200	400	460	200	60	390
Zinc (µg/L)	ND	ND	ND	10	ND	<10	ND	20	30	ND
Total dissolved solids (mg/L)	793	448	223	189	400	175	358	424	56	183
Hardness as $CaCO_3$ (mg/L)	55	9	72	11	11	61	25	7	28	110

[1]µmhos/cm - micromhos per centimeter.
[2]°C - degrees Centigrade.
[3]mg/L - milligrams per liter.
[4]ND - not detected.
[5]µg/L - micrograms per liter.

Table 5.--Chemical analyses of samples collected from selected wells in Alabama - Continued

Parameter	Site number									
	23	24	25	26	27	28	29	30	31	32
Date	5/25/84	5/24/84	5/11/84	5/11/84	5/24/84	5/21/84	5/24/84	5/17/84	5/21/84	5/16/84
Specific conductance (µmhos/cm)[1]	1900	520	2950	940	535	84	295	173	132	9100
Temperature (°C)[2]	19	19	--	22	20	--	26	24	--	25
Bicarbonate (mg/L)[3]	370	270	650	200	230	45	130	89	59	710
Carbonate (mg/L)	0	0	0	0	13	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	300	220	540	170	210	37	110	73	48	580
pH	7.9	8.1	7.9	7.8	8.5	5.6	7.9	7.8	7.7	7.4
Silica (mg/L)	6.5	9.5	6.9	6.0	5.7	4.0	7.4	9.2	9.6	11
Calcium (mg/L)	3.3	3.1	5.3	5.3	1.5	2.2	1.6	1.7	20	23
Magnesium (mg/L)	0.8	0.4	1.2	0.9	0.1	1.5	0.1	0.1	1.9	9.5
Sodium (mg/L)	360	110	550	180	120	1.6	64	34	2.8	1900
Potassium (mg/L)	3.6	0.9	2.8	2.9	0.6	3.2	0.6	0.7	2.3	10
Sulfate (mg/L)	1.4	9.8	1.2	0.4	28	2.2	9.0	6.0	7.0	ND
Chloride (mg/L)	380	6.4	460	180	9.6	0.8	9.3	5.1	4.0	2700
Fluoride (mg/L)	1.6	0.6	3.2	1.2	1.0	<0.1	0.1	0.1	0.2	2.5
Nitrate as N (mg/L)	ND[4]	ND	ND	ND	ND	ND	ND	0.93	0.01	4.15
Nitrite as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N (mg/L)	0.94	0.20	0.82	0.53	0.21	0.02	0.17	0.14	0.02	0.08
Phosphorus as P (mg/L)	0.12	0.06	0.03	0.03	0.08	0.03	0.01	0.03	0.02	0.02
Arsenic (µg/L)[5]	1	1	ND	ND	1	<1	1	1	<1	3
Cadmium (µg/L)	1	1	1	1	1	<1	1	<1	<1	1
Chromium (µg/L)	<1	<1	2	1	<1	2	<1	2	3	4
Cobalt (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	120	10	70	210	100	7800	20	70	60	30
Lead (µg/L)	7	1	8	ND	1	2	1	ND	1	ND
Manganese (µg/L)	20	<10	10	10	10	690	10	<10	20	10
Mercury (µg/L)	0.2	ND	0.2	0.2	ND	ND	0.1	0.2	ND	0.2
Strontium (µg/L)	210	160	260	280	70	60	70	90	120	2400
Zinc (µg/L)	30	20	<10	<10	10	440	30	10	ND	ND
Total dissolved solids (mg/L)	939	274	1200	475	280	38	156	105	77	5020
Hardness as $CaCO_3$ (mg/L)	12	9	18	17	4	12	5	5	58	97

[1]µmhos/cm - micromhos per centimeter.
[2]°C - degrees Centigrade.
[3]mg/L - milligrams per liter.
[4]ND - not detected.
[5]µg/L - micrograms per liter.

Table 5.--Chemical analyses of samples collected from selected wells in Alabama - Continued

Parameter	Site number									
	33	34	35	36	37	38	39	40	41	42
Date	5/11/84	4/30/84	5/11/84	5/17/84	5/11/84	5/17/84	5/21/84	5/23/84	5/23/84	5/21/84
Specific conductance (µmhos/cm)[1]	8400	170	33	370	220	500	208	315	520	370
Temperature (°C)[2]	23	19	19	23	--	32	17	18	20	17
Bicarbonate (mg/L)[3]	180	79	7	170	130	260	130	190	170	190
Carbonate (mg/L)	0	0	0	16	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	140	64	6	160	110	210	110	150	150	160
pH	7.1	6.0	4.9	8.6	7.3	8.3	7.4	6.8	6.3	6.9
Silica (mg/L)	5.8	16	11	10	6.4	10	11	11	20	4.1
Calcium (mg/L)	150	15	1.3	1.2	35	0.8	23	33	38	63
Magnesium (mg/L)	29	5.1	0.8	0.1	6.0	0.1	6.7	7.3	20	5.2
Sodium (mg/L)	1700	2.7	1.2	80	2.5	110	11	24	29	4.8
Potassium (mg/L)	12	4.3	3.0	0.5	3.9	0.6	2.1	1.4	1.9	0.4
Sulfate (mg/L)	ND[4]	8.3	1.4	4.5	4.6	25	ND	9.2	89	7.5
Chloride (mg/L)	2900	1.8	1.4	8.6	2.3	8.3	0.8	0.8	4.2	6.0
Fluoride (mg/L)	0.8	0.2	<0.1	0.5	0.2	0.7	0.1	0.1	0.2	0.1
Nitrate as N (mg/L)	ND	ND	ND	0.01	ND	0.35	ND	ND	ND	1.36
Nitrite as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N (mg/L)	3.05	0.02	ND	0.29	ND	0.23	0.06	0.28	0.30	ND
Phosphorus as P (mg/L)	ND	0.02	ND	0.08	ND	0.14	0.02	0.02	0.01	ND
Arsenic (µg/L)[5]	ND	2	ND	<1	ND	<1	<1	ND	2	<1
Cadmium (µg/L)	1	1	1	<1	<1	<1	<1	ND	<1	ND
Chromium (µg/L)	2	1	1	2	1	2	1	<1	<1	2
Cobalt (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	440	9300	40	90	130	70	100	540	6000	170
Lead (µg/L)	ND	3	ND	4	<1	3	1	1	1	ND
Manganese (µg/L)	30	370	70	<10	80	10	50	160	730	20
Mercury (µg/L)	1.7	<0.1	ND	0.7	ND	ND	1.5	0.2	0.4	0.1
Strontium (µg/L)	7900	520	20	70	310	70	160	440	350	170
Zinc (µg/L)	10	<10	20	30	<10	ND	ND	10	20	10
Total dissolved solids (mg/L)	4890	92	24	205	125	285	119	180	286	191
Hardness as $CaCO_3$ (mg/L)	490	59	7	4	110	3	85	110	180	180

[1]µmhos/cm - micromhos per centimeter.
[2]°C - degrees Centigrade.
[3]mg/L - milligrams per liter.
[4]ND - not detected.
[5]µg/L - micrograms per liter.

Table 5.--Chemical analyses of samples collected from selected wells in Alabama - Continued

Parameter	Site number								
	43	44	45	46	47	48	49	50	51
Date	5/23/84	5/22/84	5/21/84	5/22/84	5/23/84	5/22/84	5/11/84	5/23/84	5/24/84
Specific conductance (µmhos/cm)[1]	230	141	149	245	250	290	230	280	144
Temperature (°C)[2]	18	16	16	15	17	17	--	15	19
Bicarbonate (mg/L)[3]	140	72	74	130	160	160	140	150	30
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	120	59	61	110	130	130	120	130	25
pH	6.7	5.9	6.7	6.9	7.0	6.6	7.1	6.8	5.2
Silica (mg/L)	5.6	5.0	4.7	3.1	4.4	4.1	4.5	4.3	18
Calcium (mg/L)	48	23	21	40	50	51	33	31	12
Magnesium (mg/L)	1.7	3.0	5.0	5.0	2.4	4.9	13	15	1.7
Sodium (mg/L)	2.0	1.7	1.3	1.3	1.4	1.7	2.1	2.7	11
Potassium (mg/L)	0.8	0.3	0.3	0.6	0.6	0.6	0.7	0.9	2.5
Sulfate (mg/L)	3.6	3.2	2.2	3.2	3.6	5.4	3.8	4.8	7.0
Chloride (mg/L)	1.4	5.4	1.9	2.4	2.7	3.2	3.8	11	4.6
Fluoride (mg/L)	0.1	<0.1	0.1	0.1	<0.1	0.1	0.1	<0.1	0.1
Nitrate as N (mg/L)	0.20	1.12	1.93	2.04	0.36	2.08	0.53	1.20	3.58
Nitrite as N (mg/L)	ND[4]	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphorus as P (mg/L)	0.05	ND	0.01	ND	0.02	0.01	ND	ND	0.18
Arsenic (µg/L)[5]	<1	1	ND	1	1	<1	ND	1	2
Cadmium (µg/L)	<1	<1	<1	<1	<1	<1	1	<1	<1
Chromium (µg/L)	1	2	2	<1	ND	1	1	1	<1
Cobalt (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	1
Iron (µg/L)	10	10	20	10	210	190	20	30	60
Lead (µg/L)	1	1	3	1	1	1	<1	<1	1
Manganese (µg/L)	<10	10	ND	<10	10	10	ND	10	220
Mercury (µg/L)	ND	0.4	ND	ND	0.1	0.1	ND	ND	0.1
Strontium (µg/L)	80	70	50	160	80	120	ND	80	140
Zinc (µg/L)	10	10	20	10	90	50	<10	10	210
Total dissolved solids (mg/L)	133	82	82	129	146	159	132	149	88
Hardness as $CaCO_3$ (mg/L)	130	70	73	120	140	150	140	140	37

[1]µmhos/cm - micromhos per centimeter.
[2]°C - degrees Centigrade.
[3]mg/L - milligrams per liter.
[4]ND - not detected.
[5]µg/L - micrograms per liter.

Table 5.--Chemical analyses of samples collected from selected wells in Alabama - Continued

Site number	Owner	Local identifier	Depth (feet)	Aquifer
1	Citronelle	D-3	735	Miocene-Pliocene
2	Atmore	Z-71	130	Miocene-Pliocene
3	Theodore	KK-1	148	Miocene-Pliocene
4	Dauphin Island	UU-2	305	Miocene-Pliocene
5	Orange Beach	ZZ-8	120	Miocene-Pliocene
6	Brewton	O-95	661	Lisbon
8	Brewton	V-37		Ocala Limestone
9	Evergreen	S-2	180	Tallahatta
10	Butler	City Well No. 4	708	Nanafalia
11	Andalusia	M-8	1,090	Nanafalia
12	Geneva	R-11	1,040	Nanafalia
13	Monroeville	U-4	1,240	Nanafalia
15	Elba	K-4	585	Clayton Limestone
16	Ozark	F-16	880	Ripley
17	Greenville	H-12	577	Ripley
18	Troy	J-8	519	Ripley
19	Luverne	L-5	567	Ripley
20	Camden	O-38	441	Ripley
21	Clayton	S-1	195	Ripley
22	Dothan	I-19	860	Ripley
23	C. A. Boyd	J-8	940	Eutaw
24	Montgomery	K-95	275	Eutaw
25	Linden	L-26	1,240	Eutaw
26	Eutaw	R-12	429	Eutaw
27	Montgomery	J-31	631	Tuscaloosa Group
28	Vernon	K-13	335	Tuscaloosa Group
29	Hayneville	L-12	1,061	Tuscaloosa Group
30	Union Springs	L-3	1,105	Tuscaloosa Group
31	Carrollton	M-16	160	Tuscaloosa Group
32	Olympia Spa	Q-6	2,924	Tuscaloosa Group
33	Brydie Farms	AA-33	750	Tuscaloosa Group
34	Coker	FF-51	182	Tuscaloosa Group
35	Moundville	B-20	233	Tuscaloosa Group
36	Eufaula	V-1	1,752	Tuscaloosa Group
37	Marion Fish Hatchery	I-9	773	
38	Troy	J-11	2,240	
39	Hamilton	I-13	632	Pottsville
40	Gold Kist Poultry	X-2	450	Pottsville
41	Hanceville	W-9	363	Pottsville
42	Moulton	R-5	90	Bangor Limestone
43	Irondale	W-4	250	Bangor Limestone
44	Ardmore	A-13	133	Tuscumbia Limestone
45	Rogersville	T-32	150	Tuscumbia Limestone
46	Stevenson	N-40	165	Tuscumbia Limestone
47	Trussville	L-2	215	Tuscumbia Limestone
48	Huntsville	N-51	105	Tuscumbia Limestone
49	Centreville	P-5	200	Cambrian, Ordovician
50	Oneonta	P-7	175	Cambrian, Ordovician
51	Rockford	M-2	300	Piedmont

Table 6.--Chemical analyses of samples collected from selected streams in Alabama (See plate 4 for sampling locations.)

Parameter	Site number									
	1	2	3	4	5	6	7	8	9	10
Date	5/3/84	5/2/84	5/3/84	5/2/84	5/2/84	5/7/84	5/7/84	5/4/84	5/3/84	4/30/84
Time	1300	1400	0930	1325	1150	1440	1225	1010	1645	1330
Flow (ft³/s)[1]	1400	61	590	490	340	1100	440	8200	530	250
Specific conductance (µmhos/cm)[2]	57	22	69	43	39	27	115	22	48	33
Temperature (°C)[3]	20	19	19	19.5	18.5	19	18	14	20	18
Dissolved oxygen (mg/L)[4]	8.4	8.4	8.0	8.3	7.8	8.2	8.7	8.4	7.7	--
Bicarbonate (mg/L)	22	0	30	15	16	3	66	4	15	8
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	18	0	25	12	13	3	54	3	12	6
pH	6.5	4.5	6.3	6.0	6.1	5.7	6.7	5.6	6.2	5.8
Silica (mg/L)	2.8	2.5	2.8	5.5	3.2	1.6	3.0	1.2	1.8	9.2
Calcium (mg/L)	7.6	0.8	11	4.0	5.1	2.1	18	2.5	5.5	2.4
Magnesium (mg/L)	1.3	0.5	1.0	1.1	0.7	0.8	3.3	0.8	1.8	1.2
Sodium (mg/L)	1.9	1.5	1.9	2.5	1.5	0.7	1.3	1.0	2.6	1.6
Potassium (mg/L)	0.9	0.2	0.8	0.9	0.6	0.8	0.9	1.2	1.8	1.1
Sulfate (mg/L)	1.4	1.5	1.0	2.3	0.9	3.7	2.2	3.6	4.8	ND[5]
Chloride (mg/L)	3.1	2.6	2.4	2.6	2.2	0.5	1.0	1.0	3.4	1.8
Fluoride (mg/L)	<0.1	0.2	0.1	<0.1	0.1	0.1	0.1	<0.1	0.2	0.1
Nitrate as N (mg/L)	0.28	0.09	0.23	0.07	0.10	0.16	0.24	0.07	0.51	0.17
Nitrite as N (mg/L)	0.01	ND	0.01	0.01	ND	ND	ND	0.01	0.01	ND
Ammonia as N (mg/L)	0.04	ND	0.02	0.03	0.03	ND	ND	0.01	0.25	ND
Phosphorus as P (mg/L)	0.06	0.04	0.05	0.06	0.02	ND	0.04	0.05	0.09	0.02
Arsenic (µg/L)[6]	2	<1	<1	1	1	<1	1	2	2	1
Cadmium (µg/L)	<1	<1	<1	1	1	1	1	<1	1	<1
Chromium (µg/L)	1	1	1	1	1	1	1	1	1	1
Cobalt (µg/L)	1	1	<1	<1	ND	ND	ND	1	<1	ND
Iron (µg/L)	1300	340	1200	980	890	60	130	410	600	480
Lead (µg/L)	ND	1	ND	<1	1	1	2	5	4	2
Manganese (µg/L)	30	20	90	40	90	20	20	80	70	10
Mercury (µg/L)	3.2	ND	0.7	ND	ND	ND	ND	ND	ND	ND
Strontium (µg/L)	70	50	80	100	40	70	110	80	80	80
Zinc (µg/L)	ND	<10	<10	<10	<10	<10	<10	20	30	10
Total dissolved solids (mg/L)	31	10	37	27	23	13	64	14	32	22
Total suspended solids (mg/L)	114	8	107	29	18	10	51	142	1150	26

[1]ft³/s - cubic feet per second.
[2]µmhos/cm - micromhos per centimeter.
[3]°C - degrees Centigrade.
[4]mg/L - milligrams per liter.
[5]ND - not detected.
[6]µg/L - micrograms per liter.

Table 6.--Chemical analyses of samples collected from selected streams in Alabama - Continued

Parameter	Site number									
	11	12	13	14	15	16	17	18	19	20
Date	5/4/84	5/4/84	4/30/84	5/1/84	5/1/84	5/10/84	5/7/84	4/30/84	4/30/84	5/1/84
Time	1300	1400	1115	0930	1330	1600	0830	0830	0900	1500
Flow (ft^3/s)[1]	1560	9560	4560	110	46	1340	260	1980	36700	160
Specific conductance (µmhos/cm)[2]	99	91	112	270	103	53	280	46	141	80
Temperature (°C)[3]	17.5	16.5	16	19.5	18	15	18	14	15	18.5
Dissolved oxygen (mg/L)[4]	7.6	9.5	8.9	9.0	8.1	10	8.8	9.4	11	8.1
Bicarbonate (mg/L)	34	34	40	150	32	10	89	18	26	33
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	28	28	33	130	26	8	73	14	22	27
pH	6.4	6.5	6.3	7.3	6.5	6.0	6.9	5.8	6.4	6.6
Silica (mg/L)	3.0	2.5	5.6	8.4	8.2	2.3	5.2	7.3	5.8	11
Calcium (mg/L)	12	11	14	55	10	3.8	32	2.9	11	13
Magnesium (mg/L)	2.8	3.0	4.0	2.1	2.9	2.8	9.3	2.0	5.9	1.2
Sodium (mg/L)	3.0	3.5	2.8	3.1	4.9	1.3	8.0	1.7	5.6	2.1
Potassium (mg/L)	2.0	1.3	1.6	1.1	1.5	0.9	4.0	0.9	1.6	1.0
Sulfate (mg/L)	12	12	9.7	6.8	8.6	13	43	8.4	31	1.8
Chloride (mg/L)	1.7	1.2	1.2	2.8	4.0	1.0	5.8	0.8	1.8	1.8
Fluoride (mg/L)	0.1	0.1	<0.1	0.1	<0.1	<0.1	0.3	ND[5]	<0.1	ND
Nitrate as N (mg/L)	0.27	0.23	0.32	0.05	0.05	0.11	1.49	0.09	0.51	0.01
Nitrite as N (mg/L)	0.01	0.01	0.01	0.01	0.1	ND	0.07	ND	0.01	0.01
Ammonia as N (mg/L)	0.05	ND	0.03	ND	0.02	ND	0.05	ND	0.04	0.02
Phosphorus as P (mg/L)	0.11	0.08	0.08	0.03	0.04	0.01	0.21	0.12	0.03	0.03
Arsenic (µg/L)[6]	2	2	2	1	3	ND	3	2	1	1
Cadmium (µg/L)	<1	<1	ND	<1	1	ND	<1	1	<1	<1
Chromium (µg/L)	1	ND	1	1	1	<1	2	1	1	1
Cobalt (µg/L)	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	230	180	200	420	1100	300	400	240	600	650
Lead (µg/L)	3	2	3	2	2	ND	2	1	2	2
Manganese (µg/L)	70	20	ND	10	60	80	70	60	150	80
Mercury (µg/L)	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND
Strontium (µg/L)	100	90	60	220	170	10	110	60	60	110
Zinc (µg/L)	30	10	10	10	<10	10	20	60	<10	10
Total dissolved solids (mg/L)	55	53	60	154	56	30	16	33	78	48
Total suspended solids (mg/L)	93	260	184	45	38	47	11	77	47	29

[1]ft^3/s - cubic feet per second.
[2]µmhos/cm - micromhos per centimeter.
[3]°C - degrees Centigrade.
[4]mg/L - milligrams per liter.
[5]ND - not detected.
[6]µg/L - micrograms per liter.

Table 6.--Chemical analyses of samples collected from selected streams in Alabama - Continued

Parameter	Site number									
	21	22	23	24	25	26	27	28	29	30
Date	5/2/84	5/8/84	5/22/84	5/8/84	5/8/84	5/21/84	5/10/84	5/9/84	5/8/84	7/13/84
Time	0930	1115	1530	1230	1325	1550	1100	1500	1500	0915
Flow (ft^3/s)[1]	134	4100	173	3500	7900	82	1050	6545	2.75	385
Specific conductance (µmhos/cm)[2]	26	181	63	185	83	240	36	180	320	40
Temperature (°C)[3]	20	11	16	13	14.5	19	18	17.5	15	23.5
Dissolved oxygen (mg/L)[4]	8.7	9.6	9.1	--	9.9	7.0	9.5	9.8	9.7	8.3
Bicarbonate (mg/L)	2	110	10	110	38	120	10	97	170	--
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	2	87	9	87	31	98	8	80	140	12
pH	5.2	6.9	6.2	6.6	6.5	6.9	6.1	7.3	6.5	6.8
Silica (mg/L)	2.6	1.8	1.6	1.7	1.4	2.0	1.3	1.4	4.0	5.4
Calcium (mg/L)	1.4	31	5.8	30	15	4.2	2.8	31	57	3.2
Magnesium (mg/L)	0.6	3.3	1.7	3.1	1.9	2.1	1.3	1.9	5.1	1.0
Sodium (mg/L)	2.4	0.7	1.6	0.7	1.0	2.0	1.0	1.9	2.3	2.1
Potassium (mg/L)	0.6	0.8	2.0	0.9	2.2	1.1	1.3	1.3	0.8	0.9
Sulfate (mg/L)	0.7	2.6	12	2.2	1.2	6.2	4.3	2.6	7.8	1.0
Chloride (mg/L)	3.4	0.2	2.6	0.5	1.6	3.4	1.4	3.7	3.6	2.9
Fluoride (mg/L)	0.2	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	0.1	<0.1
Nitrate as N (mg/L)	0.22	0.11	0.99	0.16	0.49	1.39	0.39	0.21	2.13	0.50
Nitrite as N (mg/L)	ND[5]	ND	0.01	0.01	0.01	0.01	0.01	0.01	ND	0.01
Ammonia as N (mg/L)	0.08	ND	ND	ND	0.02	ND	0.02	0.01	ND	--
Phosphorus as P (mg/L)	0.02	ND	ND	0.02	0.05	ND	0.01	ND	0.01	--
Arsenic (µg/L)[6]	1	1	ND	1	1	ND	<1	<1	ND	1
Cadmium (µg/L)	<1	ND	<1	ND	ND	<1	ND	ND	ND	2
Chromium (µg/L)	1	2	<1	1	1	2	<1	<1	1	<1
Cobalt (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (µg/L)	660	110	150	150	280	100	170	100	270	280
Lead (µg/L)	1	2	1	3	2	1	ND	ND	1	1
Manganese (µg/L)	10	10	20	10	20	50	90	ND	10	10
Mercury (µg/L)	ND	0.2	ND	ND	ND	ND	ND	2.25	ND	ND
Strontium (µg/L)	70	120	80	120	100	100	80	130	160	50
Zinc (µg/L)	<10	20	10	10	10	ND	10	10	10	<10
Total dissolved solids (mg/L)	14	95	37	94	45	124	20	93	174	26
Total suspended solids (mg/L)	9	71	20	167	177	15	70	210	--	--

[1] ft^3/s - cubic feet per second.
[2] µmhos/cm - micromhos per centimeter.
[3] °C - degrees Centigrade.
[4] mg/L - milligrams per liter.
[5] ND - not detected.
[6] µg/L - micrograms per liter.

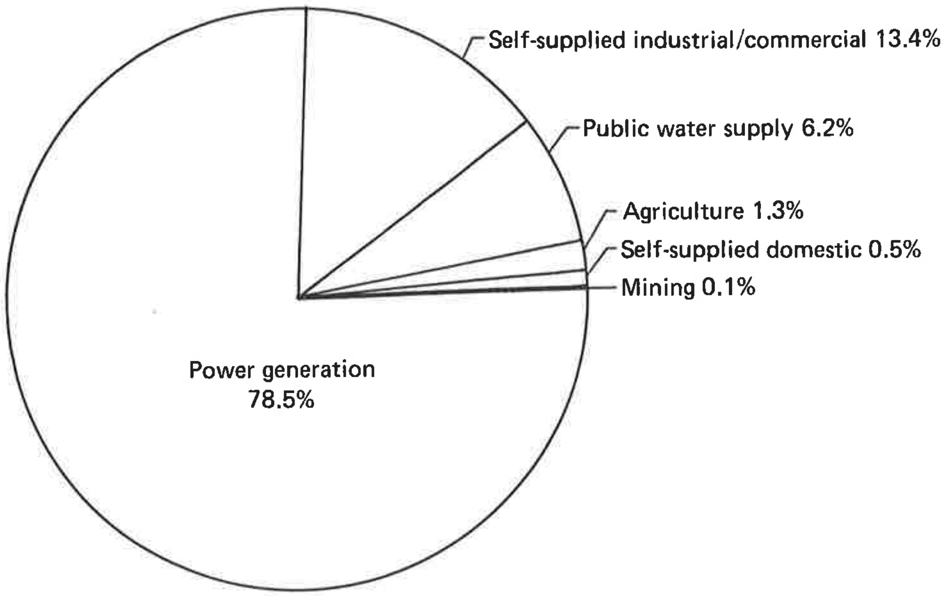
Table 6.--Chemical analyses of samples collected from selected streams in Alabama - Continued

Parameter	Site number										
	34	31	32	33	35	36	37	38	39	40	41
Date	7/12/84	5/3/84	5/10/84	8/2/84	7/13/84	7/30/84	7/10/84	4/30/84	5/14/84	7/12/84	7/11/84
Time	1330	1055	1443	1130	1215	1215	1245	1330	1100	0845	1445
Flow (ft^3/s)[1]	154	11	572	2750	3.0	57.8	132	4480	943	245	5.92
Specific conductance (µmhos/cm)[2]	28	42	23	53	340	247	22	24	79	60	200
Temperature (°C)[3]	29.5	20	14	23	29	23.5	26	18	20	28	35.5
Dissolved oxygen (mg/L)[4]	7.3	6.2	6.0	7.7	7.1	--	8.1	4.0	8.3	7.7	6.5
Bicarbonate (mg/L)	--	19	6	--	--	--	--	--	--	--	--
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0
Alkalinity as $CaCO_3$ (mg/L)	13	15	5	20	130	100	5	2	15	16	83
pH	6.4	6.2	6.0	6.8	7.0	7.3	6.4	4.9	6.1	6.9	7.4
Silica (mg/L)	12	2.2	2.4	5.0	2.4	7.4	7.4	1.6	2.0	9.4	6.4
Calcium (mg/L)	2.5	6.3	1.7	5.4	45	34	1.4	1.5	8.0	5.1	27
Magnesium (mg/L)	1.1	1.0	0.8	2.2	1.7	5.4	0.6	0.7	1.7	1.1	2.8
Sodium (mg/L)	2.4	1.4	1.0	0.8	6.3	3.7	1.1	1.0	2.3	2.5	6.1
Potassium (mg/L)	0.9	0.3	0.8	1.4	2.3	4.6	0.7	0.9	1.5	1.6	2.2
Sulfate (mg/L)	1.4	1.0	1.1	1.0	11	8.2	1.8	7.1	9.2	4.2	16
Chloride (mg/L)	1.2	2.3	0.8	0.4	9.7	3.2	1.0	1.0	3.3	1.6	5.0
Fluoride (mg/L)	<0.1	0.1	0.1	<0.1	0.2	<0.1	<0.1	ND[5]	ND	<0.1	0.2
Nitrate as N (mg/L)	0.02	0.02	0.16	0.16	ND	0.24	0.08	0.14	1.04	0.17	1.02
Nitrite as N (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	0.01	0.01	ND
Ammonia as N (mg/L)	--	0.02	ND	--	--	--	--	--	--	--	--
Phosphorus as P (mg/L)	--	0.02	ND	--	--	--	--	--	--	--	--
Arsenic (µg/L)[6]	1	<1	ND	1	5	3	1	ND	<1	1	2
Cadmium (µg/L)	1	<1	ND	<1	2	<1	2	2	1	1	2
Chromium (µg/L)	<1	1	<1	<1	1	1	<1	ND	ND	<1	1
Cobalt (µg/L)	ND	<1	ND	ND	ND	ND	1	ND	ND	<1	1
Iron (µg/L)	340	690	1500	50	80	20	100	110	100	350	50
Lead (µg/L)	ND	<1	ND	1	1	3	ND	1	1	<1	1
Manganese (µg/L)	20	30	20	10	110	10	80	60	50	30	90
Mercury (µg/L)	ND	ND	ND	0.3	0.1	0.2	0.2	0.15	<0.1	ND	0.1
Strontium (µg/L)	30	50	20	80	200	60	60	60	70	90	230
Zinc (µg/L)	ND	<10	20	ND	<10	ND	<10	10	20	<10	<10
Total dissolved solids (mg/L)	29	24	12	26	160	130	17	16	42	36	120
Total suspended solids (mg/L)	--	10	36	--	--	--	--	--	--	--	--

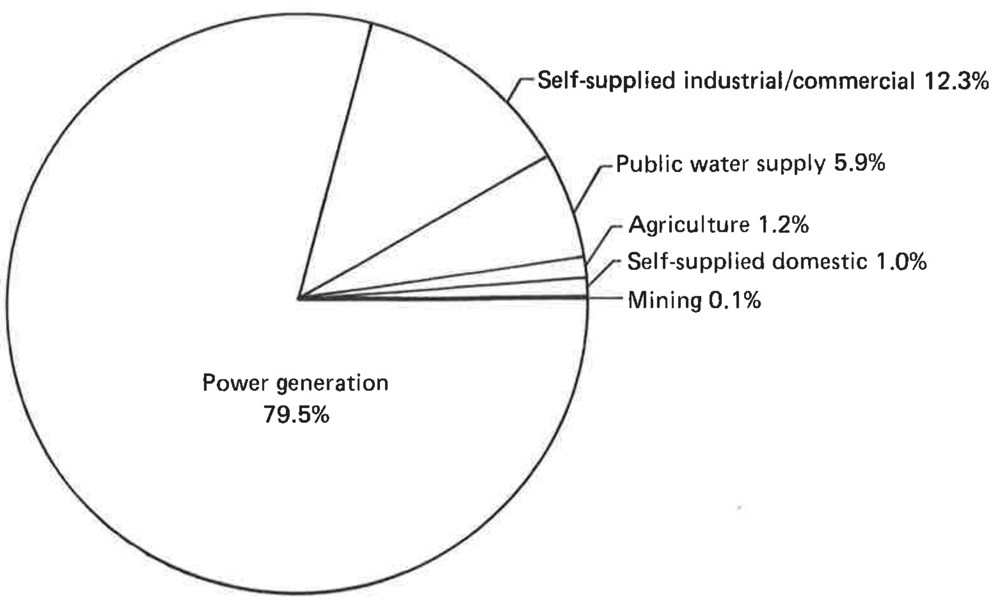
[1] ft^3/s - cubic feet per second.
[2] µmhos/cm - micromhos per centimeter.
[3] °C - degrees Centigrade.
[4] mg/L - milligrams per liter.
[5] ND - not detected.
[6] µg/L - micrograms per liter.

Table 6.--Chemical analyses of samples collected from selected streams in Alabama - Continued

Site number	Location	Site number	Location
1	Choctawhatchee River (02361000)	22	Crow Creek (03572110)
2	Blackwater River (02369800)	23	Town Creek (03572900)
3	Patsaliga Creek (02372250)	24	Paint Rock River (03574500)
4	Sepulga River (02373000)	25	Flint River (03575000)
5	Murder Creek (02374500)	26	Big Nance Creek (03586500)
6	Little River (02399200)	27	Bear Creek (03591800)
7	Big Canoe Creek (02401390)	28	Cedar Creek (03592200)
8	Tallapoosa River (02412000)	29	Huntsville Spring Branch (03575861)
9	Uphapee Creek (02419000)	30	Abbie Creek (02343300)
10	Mulberry Creek (02422500)	31	Panther Creek (02364570)
11	Shades Creek (02423630)	32	Clear Creek (02450825)
12	Cahaba River (02423647)	33	Terrapin Creek (02400100)
13	Cahaba River (02424000)	34	Hatchet Creek (02408540)
14	Cedar Creek (02425500)	35	Catoma Creek (02421000)
15	Turkey Creek (0242770)	36	Cahaba River (02423425)
16	Blackwater Creek (02453000)	37	Oakmulgee Creek (02424940)
17	Village Creek (02460500)	38	Buttahatchee River (02439000)
18	North River (02464000)	39	Mulberry Fork (02450180)
19	Black Warrior River (02465005)	40	Sucarnoochee River (02467500)
20	Satilpa Creek (02469800)	41	Chickasaw Bogue Creek (02468500)
21	Chickasaw Creek (02471001)		



1984
Withdrawal Use



1980
Withdrawal Use

Figure 12.--Total withdrawal water use, 1980 and 1984.

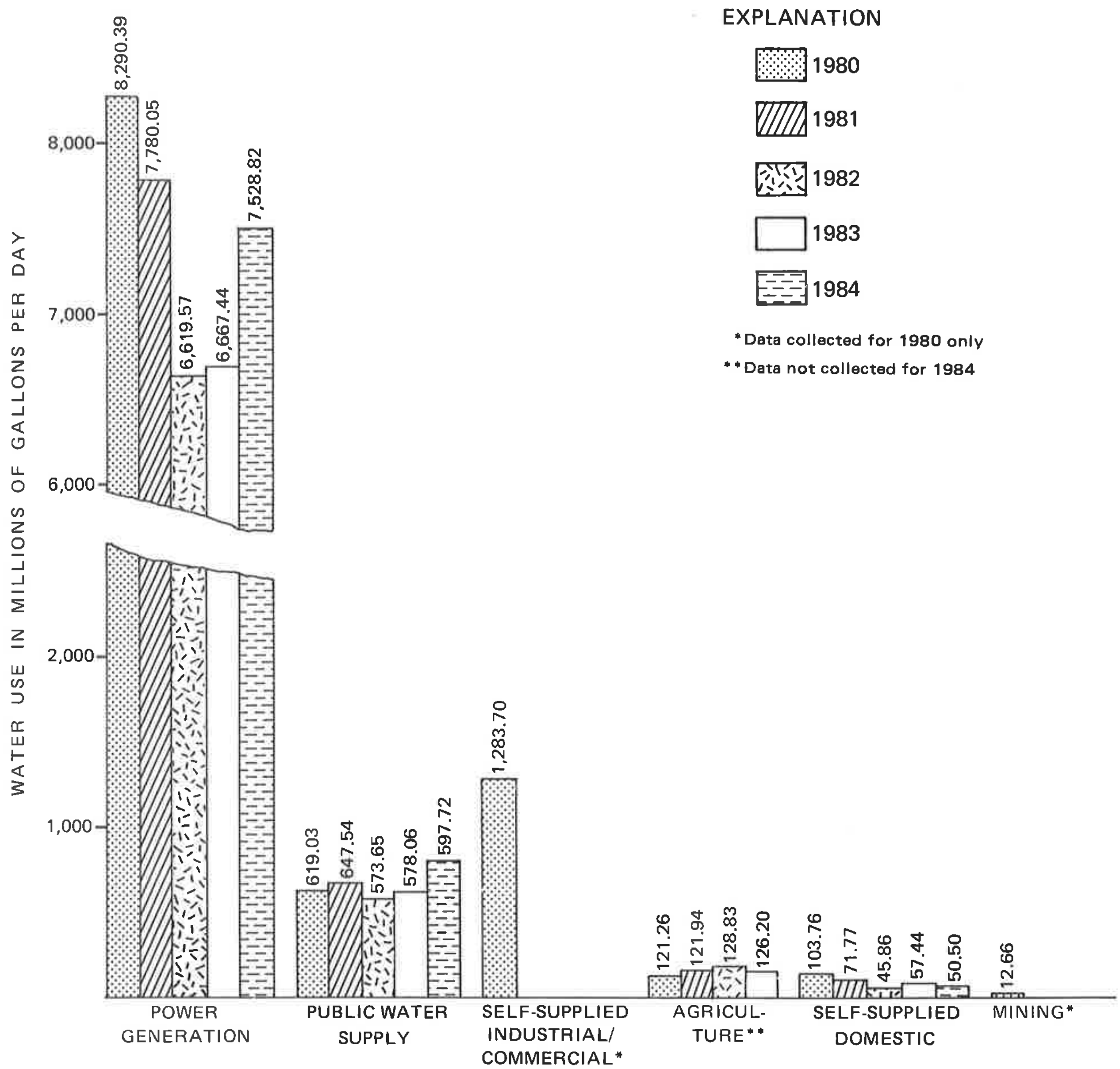


Figure 13.--Comparative withdrawal water use, 1980-84.

shows comparative amounts of withdrawal use in million gallons per day (mgd) for 1980 through 1984.

PUBLIC WATER SYSTEMS

Public water systems served an estimated 84 percent of the people of Alabama in 1984. Water use by public supply systems increased in 1984 due to an increase in the population served. The population-served values, as well as the water-use values, were obtained from records supplied by the Public Water Supply Department of the Alabama Department of Environmental Management. Withdrawal-use figures for public supply systems are usually accurate because withdrawals are measured; however, where individual system values were not available for 1984, a per capita use value of 110 gpd was used to estimate the system's withdrawal.

SELF-SUPPLIED INDUSTRIAL/COMMERCIAL

Information for self-supplied industrial/commercial use was not updated for 1984; therefore, use figures for this category in figure 13 are the same as for 1980.

AGRICULTURAL

Agricultural uses are divided into irrigation and nonirrigation uses. Nonirrigation use includes water for livestock operations and for catfish farming. Irrigation increased 340 percent from 1970 to 1982, indicating that farmers are using irrigation as a method of crop insurance, particularly during dry periods. Counties in south Alabama were the most intensively irrigated. Water-use values in figure 13 for agricultural use were based on 1982 irrigation water use and 1983 livestock water use.

SELF-SUPPLIED DOMESTIC

Water-use values for this category must be estimated. The number of people served by public water systems was subtracted from the total projected population for 1984 to determine the self-supplied domestic population. Projected 1984 population values were supplied by the Center for Business and Economic Research at the University of Alabama, Tuscaloosa, Alabama. Water-use figures were estimated using an average use of 75 gpd per person, which is considered a more realistic figure than the 110 gpd used prior to 1982. (Adjustment for this difference should be made when comparing 1982, 1983, and 1984 water use to that in previous years.) It is estimated that 16 percent of Alabama's population was self supplied during 1984.

POWER GENERATION

Water use by nuclear and fossil fuel power generation plants in Alabama accounted for 7,528.82 mgd, or more than 78 percent of the entire withdrawal water use. Water use for power generation declined from 1980 to 1982, primarily due to a decrease in water use at some of the larger plants in the state. Since 1982, however, water use for power generation has increased, but water use is still less than during 1980 and 1981.

MINING

The amount of water withdrawn for mining was not sufficient to constitute a major usage, at only 13 mgd (1980 estimate). Most of this water was used for washing coal, sand, and gravel. This water is usually recycled.

NONWITHDRAWAL USE

Nonwithdrawal or in-stream uses of water comprised 4 of the 10 categories inventoried. These are hydroelectric power generation, sewage treatment, navigation, and recreation/preservation. Water for these uses is not removed from its natural setting and is often used many times over as it moves downstream.

HYDROELECTRIC POWER GENERATION

The 21 hydroelectric power generating facilities operating in Alabama in 1984 used a reported 183,555 mgd of water to produce 10.2 million megawatt hours of electricity. There is virtually no consumptive use of water by hydroelectric generating plants; water used at one plant is often used in similar or other ways downstream.

SEWAGE TREATMENT

The total estimated discharge by sewage treatment facilities in Alabama was approximately 356 mgd (1980 estimate). The total discharge for 1984 was not determined. With the addition of new facilities since 1980, the total discharge value for 1984 will be higher. Discharge data from the Alabama Department of Environmental Management records, supplemented by discharge records from operators of sewage treatment facilities, were used to estimate the 1980 discharge value. Sewage treatment discharge data by county and hydrologic subregion are published by the Geological Survey of Alabama (Baker, 1983).

NAVIGATION

In 1984, there were 14 locks operating on 4 lock-and-dam navigation systems in Alabama. These locks have inside dimensions ranging from 84 X 100 feet to 110 X 600 feet. Water requirements for a single lockage range from a low of 9 million gallons (mg) at Oliver Lock on the Black Warrior River to 50 mg at Wilson Lock on the Tennessee River. The combined volume of all locks in Alabama is approximately 297 mg. Lockage is also a sequential use of water, in that the same water is used downstream.

RECREATION/PRESERVATION

Although recreation/preservation is not considered a major water-use category, it is important to the State's economy. Alabama has no natural large lakes, but many impoundments developed for navigation and hydroelectric power generation provide habitats for fish and wildlife and are used as recreational areas. They support a significant part of the State's economy by providing a basis for the tourist industry, sales of recreational equipment, and habitats and spawning areas for commercial game and fish.

Recreation/preservation use is usually estimated by the number of annual visits per facility. In 1980, the Tennessee Valley Authority estimated recreational use at its Guntersville, Wheeler, Wilson, and Pickwick Lakes and associated property at 16 million visits. Attendance at other State-operated parks and recreational areas was estimated at 7 million visits.

WATER PROBLEMS

FLOODING

Flooding is a major water-related problem. In many cases, it cannot be controlled in any way other than by construction of dams and flood-control impoundments. However, in many cases, permanent construction in the path of a flood can be avoided. Very few people have an adequate idea of the area that floodwaters can cover in a short period of time. Although flat, open flood plains appear to be attractive, easily developed sites for building, these areas are particularly susceptible to flooding.

The U.S. Geological Survey has published flood-prone area maps for most areas in Alabama (pl. 5). Comparison of building-site maps and flood-prone area maps, delineating areas of danger from floods, should be a prerequisite to any construction near rivers.

WATER SHORTAGES

Water shortages may occur naturally as droughts or as a result of overuse or improper development of ground- or surface-water resources. Wherever they occur, the effects may be long term and costly to water users and detrimental to the environment.

DROUGHTS

In recent years, Alabama has experienced three major droughts of record: in 1954, 1968, and 1980-81. The 1954 drought affected the entire state; rainfall averaged more than 20 inches below normal, and streamflows reached 30-year lows. The 1968 and 1980-81 droughts had less rainfall deficit, but several factors caused severe local effects in some areas. The 1968 drought was concentrated mainly in the southeastern counties of the state, where rainfall was 15 to 20 inches below normal. This drought lasted longer in the affected area than the drought of 1954. The drought of 1980-81 differed in several respects from the 1954 and 1968 droughts. Rainfall in the southern part of the state was only 8 to 14 inches below normal; however, 1980 was preceded by drier than normal weather, and about 50 percent of the rainfall deficit occurred in June or July of 1981, a period of high irrigation withdrawal. Irrigated acreage in the affected area was much greater than in 1954, as was the population. The decline in rainfall was so gradual during 1980 that many water managers did not decrease withdrawals until the drought was fairly well advanced, thereby further affecting ground- and surface-water supplies.

There are recognizable conditions that may indicate the beginning of a drought. These indicators include lower than normal precipitation over an extended period of time, decreased streamflows, ground water level declines, and continuous decreases in lake or impoundment levels.

The Palmer Drought Severity Index (Palmer, 1965), used by the National Weather Service, uses precipitation and temperature data to develop a graph of the variations in soil moisture over a given period of time. Positive numbers indicate moisture excesses; zero to slightly above zero is the moisture norm; and negative numbers indicate moisture deficiencies.

Figure 14 shows the Palmer Drought Severity Index for Alabama from 1884 to 1983. The index for the drought of 1954 was very low, as shown by the sharp negative peak for that year; however, because the droughts in 1968 and 1980-81 were only locally severe, the statewide index figures indicate less moisture deficiency overall.

Low streamflows for extended periods may be better indicators of drought conditions in a given area than either meteorological parameters or short-term low-flow values such as the 7-day Q_2 and Q_{10} values. The 30-day low-flow values are useful because the period is long enough to reflect developing droughts rather than temporary streamflow shortages, and because published monthly mean streamflow values are readily available. Figure 15 shows graphs of streamflow in two streams located in the area most affected by the 1980-81 drought. Note that the 30-day low streamflow values indicate drought conditions occurred in this area in 1954, 1968, and 1980-81.

The National Weather Service has developed a new numerical model referred to as the Extended Streamflow Prediction (ESP) model, which can be utilized as a drought analysis tool. This model is part of the National Weather Service River Forecast System, which was released for application throughout the United States in the fall of 1984.

The ESP Model can be used as a long-range prediction tool that develops probabilistic forecasts of streamflow parameters and reservoir stages for any period in the future. The model uses current hydrologic and meteorological data along with historical data to simulate future streamflow conditions.

If the temperature, precipitation, and streamflow of an area are closely monitored, it is possible that a combination of the several data plots mentioned above could be used to assess conditions that are precursors to droughts, and water-management plans could be implemented.

WATER-LEVEL DECLINES

Water shortages induced or enhanced by man's activities are, in contrast, usually only locally severe. The most common is the decline in ground-water levels caused by overpumping. Several cities in Alabama, especially in the southern part of the state, derive their water supplies from wells. Increased pumpage to keep pace with demand from an increasing population has caused water-level declines in the immediate vicinity of these cities.

Water levels in wells in the pumping centers of Dothan and Fort Rucker have been declining for several years. Potentiometric maps made by the U.S. Geological Survey in the Fort Rucker area in

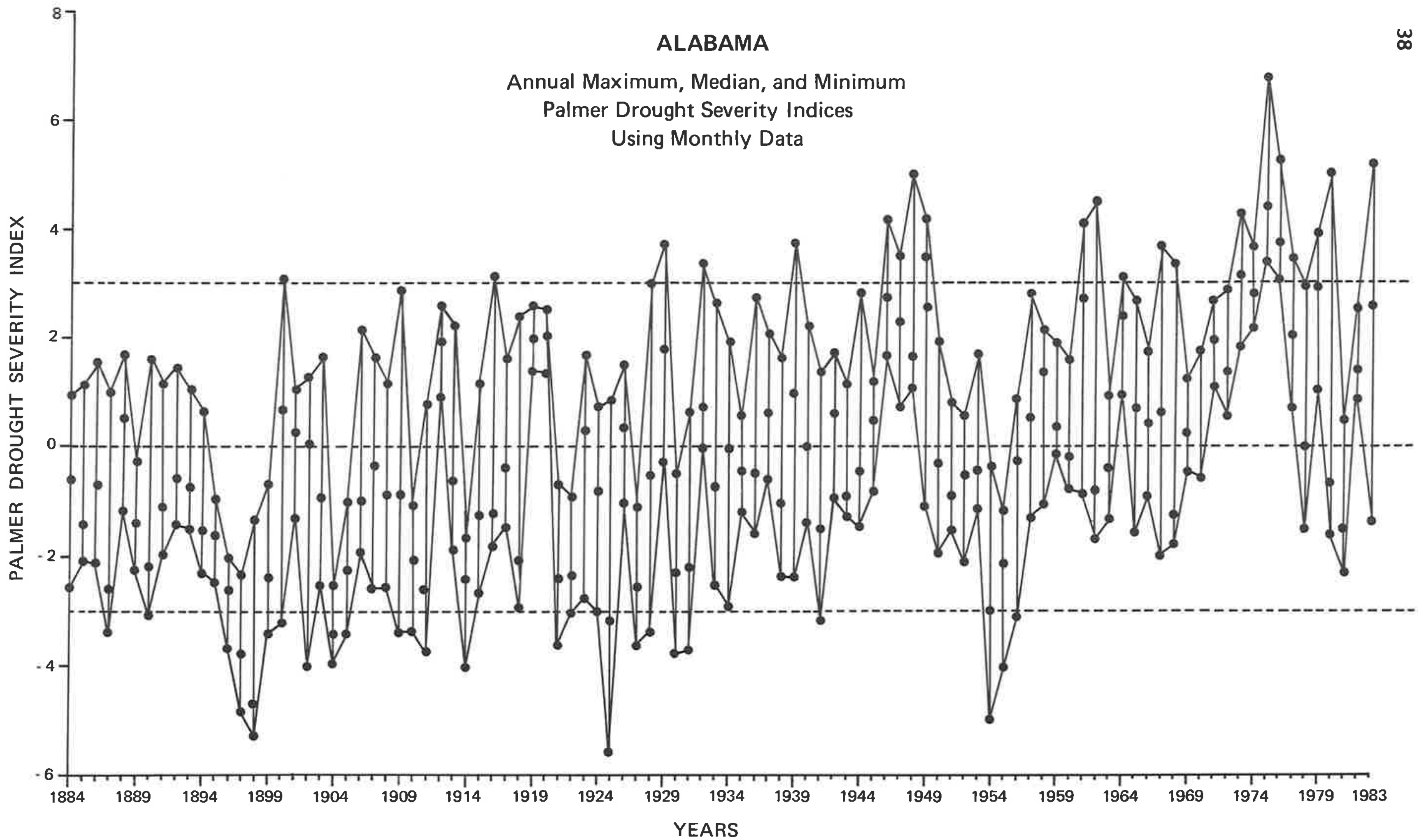
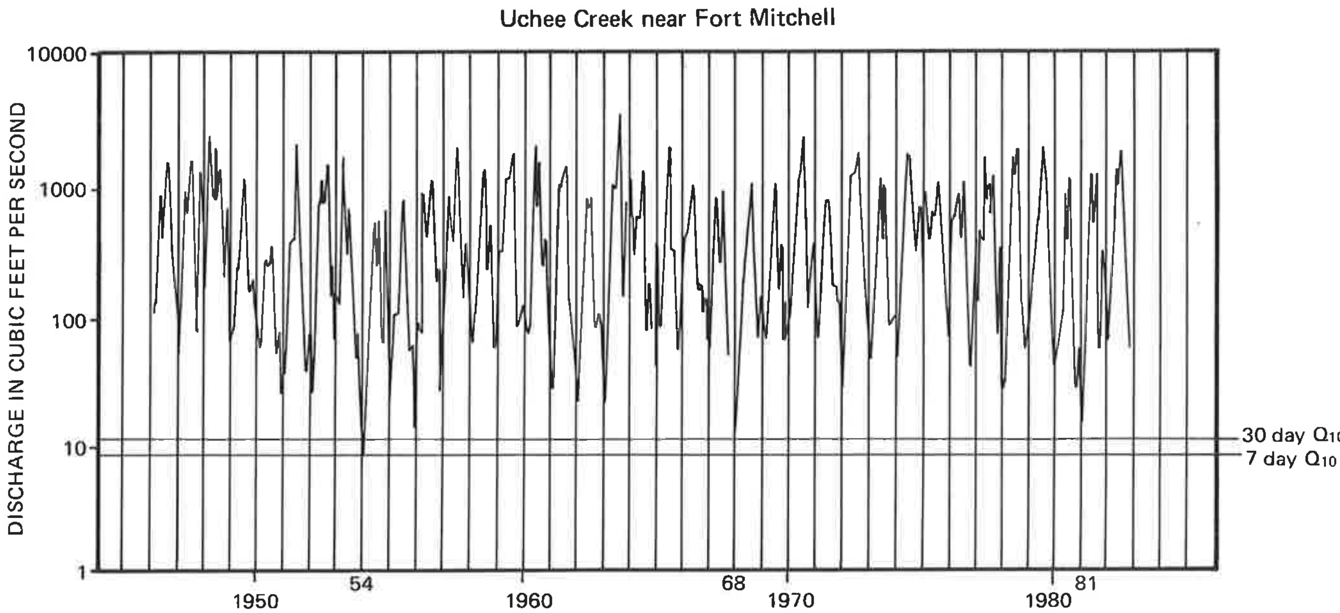


Figure 14.--Palmer Drought Severity Indices for Alabama, 1884-1983 (modified from Karl and others, 1983).



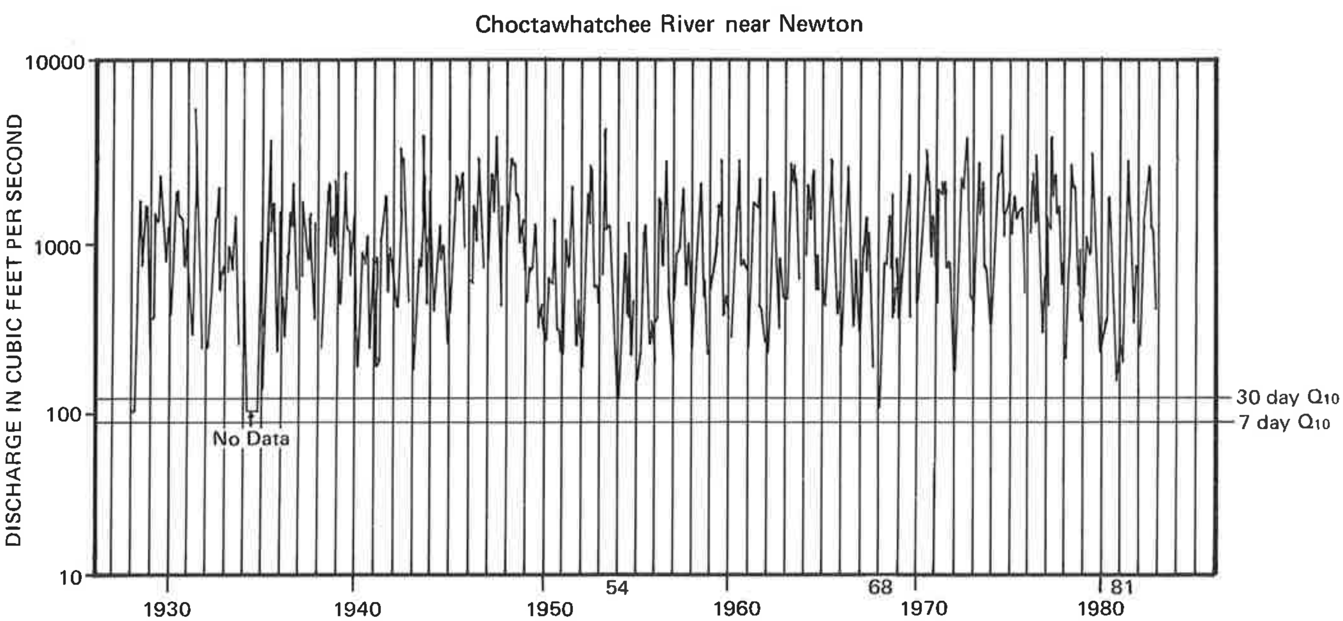


Figure 15.--Monthly mean discharges for two streams in southeast Alabama, showing low 30-day Q_{10} for drought years 1954, 1968, and 1980-81.

1982 (Scott and others, 1984), and jointly by the Geological Survey of Alabama and the U.S. Geological Survey in southeastern Alabama in 1983 (Moffett and others, 1985) delineated cones of depression in the potentiometric surface around each of these pumping centers (fig. 16).

At Fort Rucker, installation of new, more widely spaced wells combined with reduced pumping of older, more closely spaced wells, has resulted in a temporary recovery of water levels in the area. Water levels in wells at Dothan, however, have continued to decline.

WATER-QUALITY PROBLEMS

Naturally occurring conditions such as excessive chloride, iron, and hardness are the most common water-quality problems affecting ground-water supplies. High chloride content makes water unfit for most uses. Excessive hardness inhibits the action of cleaning agents, causes scum in bathtubs, scale in hot water tanks and lines, and problems in processing of food, beverages, and rubber. Excessive iron in water causes staining of plumbing fixtures and laundry, objectionable taste, and may form scale or sludge in pipes, pumps, and water heaters. Some aquifers produce water with a sulfurous ("rotten egg") odor and taste. Naturally occurring trace metals such as arsenic have been detected in water in Alabama.

A potential water-quality problem in coastal areas is salt-water encroachment. Excessive pumpage of ground water in areas where the salt-water/fresh-water interface is very close to the surface may draw salt water into fresh-water aquifers, effectively destroying them for many years. When the fresh-water aquifer becomes contaminated with salt water, surface-water supplies may have to be used.

Streams draining undeveloped areas generally contain water of good quality, but streams draining areas of municipal and industrial development may contain water of poor quality. Major sources of stream pollution include industrial waste discharges, discharges from wastewater treatment plants, and nonpoint discharge from urban areas, mining operations, and agricultural areas.

RESEARCH INVESTIGATIONS

Several research projects were initiated or completed by the Geological Survey of Alabama's Water Resources Division in 1984. These studies, along with ongoing annual and semiannual water-resources programs to measure ground-water levels, monitor water quality, and measure surface-water discharge, provide water-resources data useful for many different applications.

OIL-FIELD MONITORING PROGRAM

In 1984, a program to monitor water quality in selected streams in the oil- and gas-field areas of Alabama was initiated by the State Oil and Gas Board and implemented by the Water Resources Division of the Geological Survey of Alabama. The purpose of the project is to detect spills and unauthorized discharges of brines from oil and gas exploration and production. Ten continuous-record "minimonitor" recorders were installed on streams draining oil- and gas-field areas. These recorders detect the presence of mineralized water in streams by measuring the water's specific conductance. Hourly specific conductance and temperature readings are recorded on punch tapes, and the tapes are collected at regular intervals by Geological Survey of Alabama and Oil and Gas Board personnel.

These stations have proved effective in detecting accidental pipeline breaks, overflow from tank batteries, and other unauthorized discharges into surface-water systems. In 1984, about 12 suspected spills were detected by the minimonitors. The locations of minimonitor sites are shown in plate 4.

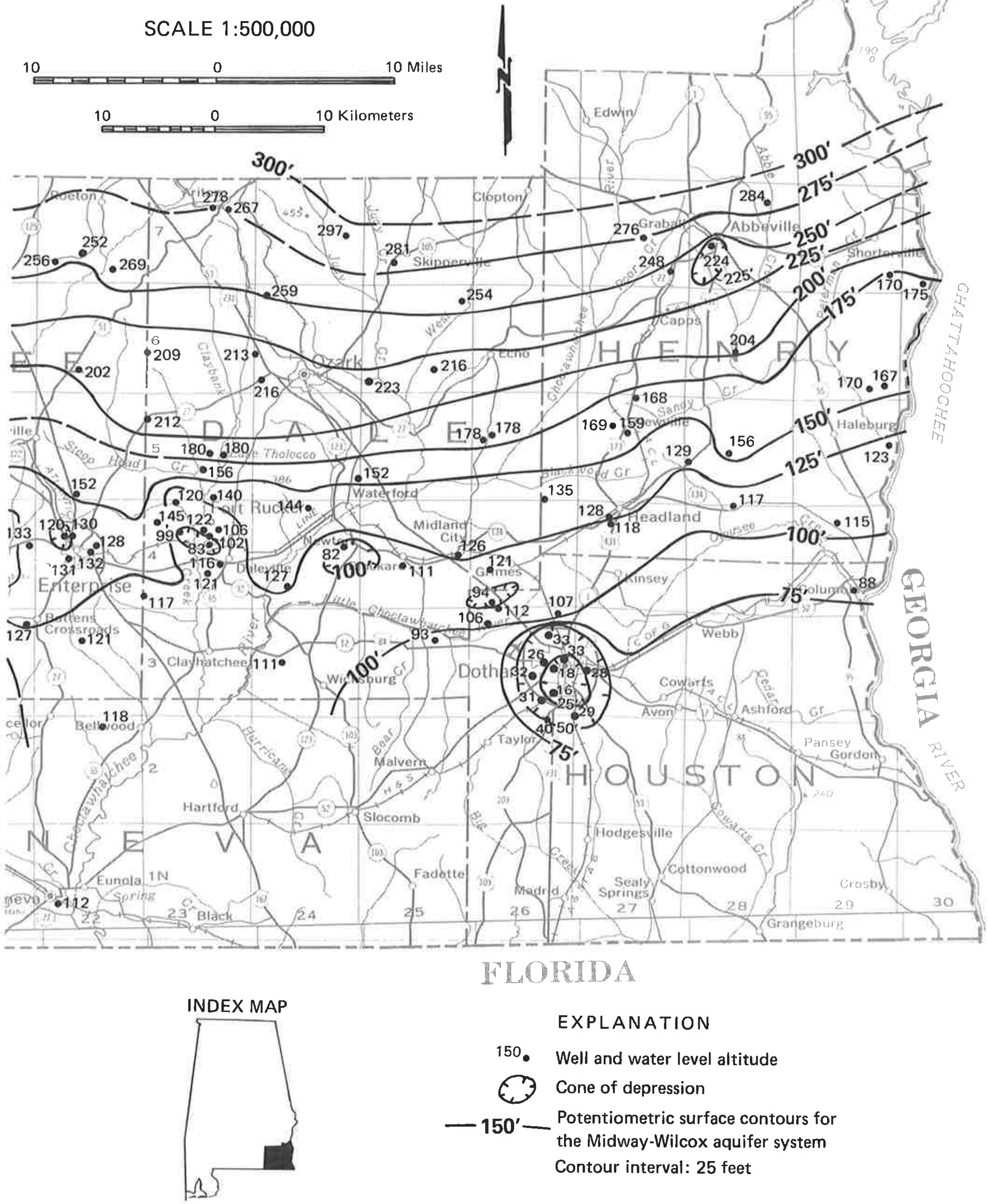


Figure 16.--Cones of depression from pumpage of ground water around major pumping centers, southeast Alabama (modified from Moffett and others, 1985).

RECONNAISSANCE OF GROUND-WATER CONDITIONS IN SOUTHEAST ALABAMA

In most of southeast Alabama, ground water is the primary source of municipal supply. Water demand by a growing population has resulted in increased pumpage from aquifers supplying the larger cities, and ground-water levels have begun to decline in some areas.

A hydrogeologic study of a six-county area in southeast Alabama was conducted in 1983 by the Geological Survey of Alabama and the U.S. Geological Survey. Results of the study confirmed a suspected decline in the potentiometric surface of aquifers in areas surrounding some of the major cities.

Background research for the study also disclosed the presence of at least three separate aquifer systems: a shallow aquifer, in which most domestic and irrigation wells are completed; an intermediate aquifer, supplying most of the Dothan city wells; and a deep aquifer that has not been developed in the area.

Results of the reconnaissance study have been published by the Geological Survey of Alabama in Circular 123, "Reconnaissance of Ground-Water Conditions in Southeast Alabama".

SALT WATER ENCROACHMENT STUDY, SOUTH BALDWIN COUNTY

Ground water is used extensively in south Baldwin County for municipal and domestic supply, industrial needs, and irrigation. In some areas, especially near the coast, high chloride concentrations have begun to appear in wells. The Geological Survey of Alabama conducted a study in this area in 1984 to determine the extent of salt-water encroachment, and to describe the hydrogeology and water chemistry of the fresh-water aquifer zones. Three hundred and twenty wells and test holes were inventoried. Water samples were collected from many of these wells and from surface-water bodies for chemical analysis. Electric logs from gas-test holes and water-use values were also examined for comparison.

Three places were found to be affected by salt-water contamination, all in coastal areas near the Gulf of Mexico. Results of this study will be published in 1985 by the Geological Survey of Alabama.

DROUGHT-RELATED IMPACTS ON WATER USES IN NORTH ALABAMA

A cooperative study between the Geological Survey of Alabama and the Tennessee Valley Authority was initiated in 1984 to analyze present and projected water use and identify and describe drought-related impacts on water uses in the fifteen Alabama counties in the Tennessee River Basin.

This study is intended to provide decisionmakers with data for use in dealing with water-supply shortages when they occur, and for use in implementing water-management plans for the Tennessee Valley area and the state. The report is scheduled to be published in October 1985. Interim data are available from the Water Resources Division, Geological Survey of Alabama.

SELECTED REFERENCES

Alabama Department of Environmental Management, 1982, Regulations governing public water supplies: Alabama Department Of Environmental Management open-file report, 100 p.

Alabama Digest, 1985, Waters and water courses: West's Alabama Digest, v. 19, p. 82

Baker, R. M., 1983, Use of water in Alabama, 1982: Alabama Geological Survey Information Series 59C, 49 p.

Bingham, R. H., and Moore, J. D., Summary of streamflow in Jefferson County, Alabama: Alabama Geological Survey Atlas 16, 21 p.

Bird, J. C., 1985, Groundwater protection: emerging issues and policy challenges: Environmental and Energy Study Institute, Washington, D.C., 42 p.

Chandler, R. V., and Moore, J. D., 1983, Fresh ground-water resources of the Dauphin Island area, Alabama: Alabama Geological Survey Circular 109, 89 p.

Cohen, Harry, 1972, Water laws in Alabama--a comparative survey: Alabama Law Review, v. 24, p. 453-489.

Geological Survey of Alabama, 1981, Geology and natural resource factors related to planning and government in the Jefferson County-Birmingham area: Alabama Geological Survey Atlas 17, 74 p.

Griggs, J. H., 1978, Water laws of Alabama: Alabama Geological Survey Bulletin 89.

Karl, T. R., Metcalf, L. K., Nicodemus, M. L., and Quayle, R. G., 1983, Statewide average climatic history, Alabama 1884-1982: National Climatic Data Center Historical Climatology Series 6-1, 35 p.

Lineback, N. G., Peirce, L. B., and Turnage, N. E., 1974, The map abstract of water resources: University of Alabama Press, Map Abstract No. 2, 105 p.

Moffett, T. B., Baker, R. M., and Richter, K. E., 1985, Reconnaissance of ground-water conditions in southeast Alabama: Geological Survey of Alabama Circular 123, 78 p.

Moore, J. D., 1984, Ground-water levels in Alabama: 1981 water year: Alabama Geological Survey Circular 112A, 222 p.

______1984, Ground-water levels in Alabama: 1982 water year: Alabama Geological Survey Circular 112B, 189 p.

Moore, J. D., and others, 1978, Water-supply problems in Alabama: Alabama Geological Survey open-file report, 114 p. (In cooperation with Alabama Development Office, ADO-WRC-III-1.)

Moore, J. D., and Moser, P. H., 1985, Ground-water levels in Alabama: 1983 Water Year: Geological Survey of Alabama Circular 112C, 201 p.

Newton, J. G., 1976, Early detection and correction of sinkhole problems in Alabama, with a preliminary evaluation of remote sensing applications: Alabama Highway Department HPR Report No. 76, 83 p.

Palmer, W. C., 1965, Meteorological drought: Washington, D. C., U.S. Weather Bureau Research Paper No. 45, p. 1-33.

Peirce, L. B., 1967, 7-day low flows and flow duration of Alabama streams: Alabama Geological Survey Bulletin 87-A, 113 p.

Richter, K. E., Moffett, T. B., and Gillett, Blakeney, 1985, Surface water report: 1982 Water Year: Geological Survey of Alabama Circular 116B, 114 p.

Rollins, H. C., Sedberry, F. C., Ming, E. G., and Tucker, J. W., 1984, Water resources Data, Alabama--Water Year 1983: U.S. Geological Survey Water Data Report AL-83-1, 458 p.

Scott, J. C., Law, L. R., and Cobb, R. H., 1984, Hydrology of the Tertiary-Cretaceous aquifer system in the vicinity of Fort Rucker Aviation Center, Alabama: U.S. Geological Survey Water Resources Investigations Report 84-4118, 221 p.

U.S. Department of Commerce, 1984, Alabama, 1983: National Climatic Data Center Climatological Data Annual Summary, vol. 89, no. 13, 22 p.

U.S. Environmental Protection Agency, 1979, Methods for chemical analysis of water and wastes: Environmental Monitoring Support Lab, EPA 600/4-79-020, unpaged.

U.S. Environmental Protection Agency, 1983, National revised primary drinking water regulations: Federal Register, v. 48, no. 194, p. 45502-45521.

U.S. Geological Survey, 1973, Map of flood-prone areas, Sipsey quadrangle, Alabama: U.S. Geological Survey Flood-Prone Area Map 188A.

______1974, Hydrologic unit map, 1974, State of Alabama: Reston, Va., U.S. Geological Survey.

______1983, National water summary 1983--hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

GLOSSARY

ACRE-FOOT - A unit of measurement of water volume that represents the quantity of water required to cover 1 acre to a depth of 1 foot.

AQUICLUDE - Relatively impermeable rock that acts as the upper or lower boundary of an aquifer. It can slowly absorb water but does not readily transmit water to wells or springs.

AQUIFER - A formation, part of a formation, or a group of formations that is saturated and will yield water to wells and springs.

ARTESIAN WATER - Ground water that is in an aquifer confined by an impermeable bed or beds and under sufficient pressure to cause the water levels in wells to rise above the base of the overlying confining bed.

ARTESIAN WELL - Well deriving water from an artesian or confined water body.

AVERAGE DISCHARGE - The arithmetic average of the average annual discharges for all complete water years of record.

BASE FLOW - The sustained flow of a stream during fair weather conditions. Generally the base flow is composed of effluent ground water.

BASIC HYDROLOGIC DATA - Data collected during inventories of water and related land features, and records on water-related processes. The data include records of precipitation, streamflow, ground-water levels, and water quality.

CONDENSATION - The process by which a substance changes from the vapor state into the liquid or solid state.

CONE OF DEPRESSION - The depression in the water level or potentiometric surface of ground water caused by pumping a well or pit. The greatest amount of depression occurs near the discharge well or pit. The cone defines the area of influence of pumpage.

CONFINED WATER - Ground water occurring under pressure greater than atmospheric pressure. The boundary of the upper surface of the water is an impermeable bed or a bed with a permeability significantly less than the permeability of the bed in which the water occurs.

CONFINING BED - A relatively impermeable bed adjacent to and confining water in an aquifer.

DAILY DISCHARGE - The volume of water flowing past a point within a 24-hour period. Daily discharge is normally reported as the mean discharge for 24 hours.

DAILY GAGE HEIGHT - Gage height is the mean gage height for 24 hours or the value that occurs at a specified time during the day.

DEPLETION - The removal of ground water from an aquifer at a rate greater than that of recharge.

DISCHARGE - The volume of water passing a specified point within a specified period of time. Discharge is commonly reported in cubic feet per second (ft^3/s).

DRAINAGE BASIN - The area around a surface-water drainage system that contributes runoff from precipitation to the system.

DRAINAGE DIVIDE - The boundary or rim separating two drainage basins.

DRAWDOWN - The amount of decline in the water level or the reduction in pressure in a well caused by ground-water discharge.

EVAPORATION - The process by which a substance passes from a liquid or solid state to a vapor state.

EVAPOTRANSPIRATION - The combined processes by which water is lost from the land area by evaporation from water surfaces and moist soil and by transpiration of plants.

ft^3/s (cubic feet per second) - The volume of water flowing at a velocity of 1 foot per second through a cross section with an area of 1 square foot.

FRESH WATER - Water with a low salinity or with a low dissolved-solids content.

GAGE HEIGHT OR STAGE - The height of a water surface above an arbitrarily established datum plane. Gage height and stage are synonymous terms.

GROUND WATER - The part of subsurface water that is in the zone of saturation. However, the term is used by some to refer to all water beneath the surface.

GROUND-WATER DISCHARGE - The removal of water by any means from the zone of saturation.

GROUND-WATER RECHARGE - The process by which water is added to the zone of saturation.

HARDNESS - The property of water that prevents lathering of soaps and causes the formation of insoluble residues when soap is used. It causes scale to form in vessels in which water has evaporated. It is due to the presence of some cations, primarily calcium and magnesium.

HEAD - The pressure of a fluid on an area at a given point caused by the height of the fluid surface above that point.

HYDROGRAPH - A graph which shows the change in ground-water level or other characteristics of water with time.

HYDROLOGIC BUDGET - An accounting of the inflow to, outflow from, and storage in a hydrologic unit such as an aquifer, drainage basin, or reservoir.

HYDROLOGIC CYCLE - A term to denote the sequence of events in the circulation of water from the sea, through the atmosphere, to the land, and back to the sea.

HYDROLOGY - The science that deals with the properties, circulation, and distribution of water on and under the earth's surface and in the atmosphere.

HYDROSTATIC HEAD - The height of a vertical column of water with a unit cross-sectional area having a weight equal to the hydrostatic pressure at a point.

HYDROSTATIC LEVEL - The level to which water will rise in a well under a full pressure head. This level defines the potentiometric surface. Same as STATIC LEVEL.

HYDROSTATIC PRESSURE - The pressure caused by the weight of the ground water at higher levels in the zone of saturation.

INFILTRATION - The movement of water into soils or into interstices or cracks in rocks.

INFILTRATION RATE - The rate at which soils or interstices in rocks under specified conditions can absorb water. It is expressed as depth of water per unit of time.

IMPERMEABLE - A term used in describing a substance that does not allow the transmittal of fluids under pressure.

MAXIMUM DISCHARGE - The instantaneous maximum streamflow. These values are commonly determined from records of surface-water elevation (stage, gage height) and the use of streamflow rating charts.

MAXIMUM GAGE HEIGHT - The maximum instantaneous gage height (stage).

MOISTURE - Water that is diffused in the atmosphere or in the ground.

PERCHED AQUIFER - An aquifer containing perched ground water.

PERCHED GROUND WATER - Ground water that is separated from an underlying main body of ground water by an unsaturated zone.

PERCHED WATER TABLE - The water table of a body of perched ground water. See PERCHED GROUND WATER.

PERCOLATION - The movement of water, generally downward, by the force of gravity or under hydrostatic pressure, through the interstices of rocks or soils, but not through large openings such as caves.

PERMEABILITY - The ability of a porous rock or soil to transmit fluids without impairment of the structure of the rock or soil.

POROSITY - The property of a rock or soil of containing interstices. It is expressed as the ratio (as a percentage) of the volume of the interstices to the total volume of the rocks.

POTABLE WATER - Water that is safe and palatable for human consumption.

POTENTIOMETRIC MAP - A map showing the elevation of the potentiometric surface of an aquifer.

POTENTIOMETRIC SURFACE - The imaginary surface representing the static head of ground water in an aquifer. It is defined by the level to which water will rise in wells.

RECHARGE - The process by which water is added to the zone of saturation.

RECHARGE AREA - The area where water enters the soil and moves downward to the zone of saturation.

SALINITY - The quantity of dissolved salts in water measured by weight in parts per thousand with the qualifications that all carbonate has been converted to oxide, all bromide and iodide have been converted to chloride, and all organic matter has been oxidized.

SALT-WATER ENCROACHMENT - The displacement of fresh water in an aquifer by salt water because of the greater density of salt water. The encroachment occurs when the total head of the salt water exceeds that of the fresh water.

7-day Q_2 LOW FLOW - The lowest mean discharge during 7 consecutive days of a year that will be expected to occur once every 2 years.

7-day Q_{10} LOW FLOW - The lowest mean discharge during 7 consecutive days of a year that will be expected to occur once every 10 years.

SOIL MOISTURE - Water in the upper part of the zone of aeration, which is just beneath the land surface.

SPECIFIC CAPACITY - The rate of discharge of water from a well per unit of drawdown. It is generally expressed in gallons per minute per foot of drawdown.

SPECIFIC DISCHARGE - The rate of discharge of ground water through a unit cross-sectional area of the aquifer measured perpendicular to the direction of flow.

SPECIFIC YIELD - The ratio of the volume of water that a saturated soil or rock will yield by gravity to the volume of the rock or soil.

SPRING - A place where ground water flows naturally from a soil or rock onto the land surface or into a surface-water body.

STAGE - See GAGE HEIGHT.

STATIC HEAD - The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point. It is the sum of the elevation head and the pressure head.

STATIC LEVEL - See HYDROSTATIC LEVEL. Also, static level refers to the water level in a well that is not affected by ground-water withdrawal.

SUBSURFACE WATER - All water occurring below the surface of the earth and within bodies of surface waters.

TRANSPIRATION - The process by which water is absorbed by roots of plants and then evaporated into the atmosphere at the surfaces of the plants.

UNCONFINED WATER - Ground water that is not confined under pressure by relatively impermeable rocks. It has a free-water surface.

UNSATURATED ZONE - The zone between the land surface and the water table. The water is under pressure less than atmospheric pressure.

WATER TABLE - The surface of a ground-water body that has a pressure equal to atmospheric pressure. It is the surface that separates the zone of saturation and the zone of aeration. It is defined by the level that water will stand in a well completed in an unconfined aquifer.

WATER YEAR - October 1 to September 30.

WELL - A pit, hole, or tunnel constructed in the ground for the purpose of obtaining water from soils or rocks.

APPENDIX 1

WELL FORMS

REPORT OF DRILLED WELL

DRILLING CONTRACTOR | License Number | Address | Zip Code | Date

PROPERTY OWNER | Address (mailing) | Zip Code

WELL LOCATION | County | Section | ¼ Section | Township | Range ---or:

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR: ☐ Private supply ☐ Public supply ☐ Industrial supply ☐ Test well ☐ Irrigation Other: ______

Estimated starting date

Drilling method (check) Cable tool Rotary Jetted Bored Other: ______

Diameter of well

Estimated depth

SIGNATURE of Drilling Contractor

Total Depth ______ Completion Date ______

Inter-val	Description of cuttings	Inter-val	Description of cuttings

Completion date: report depths below ground level

Pump
Type: ☐ Turb. ☐ Subm. ☐ Jet ☐ Cyl.; Other: ______
Intake depth ______ H.P. ______ Yield ______ gpm

Capacity
Tested by: ☐ pumping ☐ air lift ☐ bailer ☐ none
Measured Static Water Level ______ ft.
Measured pumping level ______ ft. after
______ hrs. pumping ______ gpm
Development time prior to testing ______ hrs.

Finish
☐ Open hole ☐ Screened ☐ Slotted pipe ☐ Gravel pk.
Interval(s) screened: ______ to ______ ft;
______ to ______ ; ______ to ______ ft.
Packer(s) set at ______ and ______ ft.
Screen: diam. ______ ; Size openings ______

Casing

Interval cased	Diam. (Inches)	*Type pipe	*Type couplings	Interval grouted

*Couplings: Threaded & Coupled (T&C) Welded (W)
Threaded & coupled & welded (TC&W)

Other: ______

*Pipe: Black; PVC; Galv.; Other: ______

Quality
Water analysis obtained? (check) ☐ No ☐ Bacteriological ☐ Chemical

Analysis by: ☐ Ala Geol. Surv. ☐ U.S. Geol. Surv. ☐ Ala Health Dept. ☐ Private lab.

Signed:

*For deeper well please attach continuation sheet.

ADEM Form 60 1/83

NOTIFICATION OF INTENT TO DRILL A WATER WELL

DRILLING CONTRACTOR — License Number — Address — Zip Code — Date

PROPERTY OWNER — Address (mailing) — Zip Code

WELL LOCATION — County — Section — ¼ Section — Township — Range ———or:

Distance and direction from nearest town, community, road junction or other reference point

WELL WILL BE USED FOR:

- ☐ Private supply
- ☐ Public supply
- ☐ Industrial supply
- ☐ Test well
- ☐ Irrigation
- Other: ____________________

Estimated starting date

Drilling method: (check)
- Cable tool
- Rotary
- Jetted
- Bored
- Other: ____________________

Diameter of well

Estimated depth

ADEM Form 60 1/83

____
SIGNATURE of Drilling Contractor

(Tear here for mailing.)

FIRST
CLASS
POSTAGE

SANITARIAN

____________________County Health Department

____________________, Alabama

APPENDIX 2

STATE OF ALABAMA

LICENSED WATER WELL DRILLERS

AS OF DECEMBER 4, 1984

Pursuant to the provisions of Act No. 1516 (1971 Regular Session, Legislature of Alabama), the following have been granted a license to drill water wells within the State of Alabama by the Alabama Department of Environmental Management.

A-1 Drilling Service, Inc.
Route 2, Box 366
Laurel, MS 39440
Washington/Mobile
601/428-1435
(Wilbur Baughman)

Abernathy Well Drilling
P.O. Box 5344
Rome, GA 30161
Cherokee/Calhoun
404/291-2065
(J. L. Abernathy)

Acme Drilling Co.
P.O. Box 88
River Falls, AL 36476
Covington County
205/222-7452
(Marvin Haveard)

Marvin Adams
Rt. 9, Box 325
Athens, AL 35611
Limestone County
205/232-2855

Adams-Massey Co.
309 N. Park St.
Carrollton, GA 30117
Carroll County (GA)
404/832-3132
(Winnie A. Massey)

Allsup Drilling, Inc.
Rt. 3, Box 863
Macon, MS 39341
Pickens/Sumter
601/726-4330
(H. B. or Dorothea Allsup)

Alms Pump Service, Inc.
201 E. Michigan Rd.
Foley, AL 36535
Baldwin County
205/943-1249
(Leon Alms)

Alsay Inc.
P.O. Box 6650
Lake Worth, FL 33466
305/967-6620

American Drilling Co. of AL
P. O. Box 907
Alabaster, AL 35007
Shelby County
205/663-0139
(Samuel H. Ramsey)

G. H. Anderson
1113 N. Main Ave.
Sylacauga, AL 35150
Talladega County
205/245-4186

Anderson Drilling Co.
113 Broad St.
Grove Hill, AL 36451
Clarke/Monroe
205/275-8276
(Joe Anderson)

Delma Baird
Rt. 2, Box 73
Arley, AL 35541
Winston County
205/384-4923

Ballard Well Drilling
Hwy. 22 E.
Alexander City, AL 35010
Tallapoosa County
205/234-6850
(Donald C. Ballard)

Bay Hardware
P.O. Box 357
Grand Bay, AL 36541
Mobile County
205/865-6711
(R. M. Duck)

James E. Bearden
5312 Hwy. 280 S.
Birmingham, AL 35243
Shelby County
205/991-5467

Mack H. Beasley Water
Well Service
Rt. 3, Box 981
Jay, FL 32565
Santa Rosa Co (FL)
904/675-6577

Black Belt Drilling Co.
Rt. 1, Box 311
Forkland, AL 36740
Greene County
205/289-0399
(James W. Bird)

Wayne M. Blair
103 Salter St.
Evergreen, AL 36401
Conecuh County
205/578-2352

Ralph Bland Drilling
Rt. 2, Box 94B
Empire, AL 35063
Walker County
205/648-5292
(Ralph Bland)

Bruce Bond
Rt. 3, Box 286
Andalusia, AL 36420
Covington County
205/493-3785

Herbert Boring
Route 3
Blountsville, AL 35031
Blount County
205/466-7451

Alvin Bradley
1501 N. Kirk St.
Pensacola, FL 32505
Baldwin/Mobile
904/432-2496

Brady Well & Pump Works
Rt. 3, Box 99
Selma, AL 36701
Dallas County
205/874-6801
(R. A. Brady, Jr.)

Branton Bros. Well Drilling
Rt. 8, Box 200
Dothan, AL 36301
Houston County
205/677-5489
(Terry Branton)

Loyd Lee Busha
Rt. 3, Box 65
Boaz, AL 35957
Etowah County
205/593-8576

C & C Drilling Co.
Rt. 5, Box 417
Jasper, AL 35501
Walker County
205/387-7006
(James E.Chamness)

Campbell Well Drilling
111 W. Pine St.
Scottsboro, AL 35768
Jackson County
205/547-2352 or 547-2189
(Kermit Campbell)

Carloss Well Supply Co.
P.O. Box 2079
111 N. Parkway
Memphis, TN 38103
901/526-1141

Carr's Well Service
Rt. 1, Box 150
Buckatunna, MS 39322
Washington County
601/648-2537

Champion Drilling Co., Inc.
P. O. Box 565
Thomasville, AL 36784
Clarke County
205/636-2374 or 636-4605
(Marcus Champion)

Champion Well & Pump Serv.
1805 North 4th St.
Lanett, AL 36863
Chambers/Randolph
205/644-2424
(William B. Champion)

Clardy Well Drilling
223 Hartley Dr.
Columbus, MS 39701
Lamar/Pickens
601/328-3168
(W. B. Clardy)

Coast Water Well Service
6601 Baker Road
Ocean Springs, MS 39564
Mobile/Baldwin
601/875-0260
(H. O. Ridgdell)

Coffey Well Service
Rt. 3, Box 458
Jay, FL 32565
Santa Rosa County (FL)
904/675-6676
(George Coffey)

Joel A. Coley
Rt. 1, Box 50
Forkland, AL 36740
Greene County
205/289-1868

D. L. Drilling Co.
Rt. 1, Box 300
Eufaula, AL 36027
Barbour County
205/687-5634
(D. L. Sparkman)

John H. Davis
Rt. 1, Box 365
Loxley, AL 36551
Baldwin County
205/947-7505 or 947-5090

Dawes Well Service
Rt. 2, Box 279
Mobile, AL 36609
Mobile County
205/666-3733
(H. R. Porter)

Densmore Drill. Co.
3029 Nixon Road
Bessemer, AL 35020
Jefferson County
205/428-7241
(William V. Densmore)

Dixie Drilling Corp.
1940 Pinson Valley Parkway
Birmingham, AL 35217
Walker County
205/849-5411
(Russell Borin)

Dixie Well Boring Co.
Route 2, Whitesville Rd.
LaGrange, GA 30240
Lee, Macon, Russell
404/884-5756
(Arthur Watson)

Hawley Dodson & Son
P.O. Box 585
Fayetteville, TN 37334
Madison/Etowah
615/433-4201
(Hawley/Charles Dodson)

Thomas Clayton Duncan
Rt. 3, Box 482
Jasper, AL 35501
Walker County
205/387-2318

English Well Drilling Co.
P.O. Box 367
Elba, AL 36323
Coffee County
205/897-2428
(Foy W. English)

Fairpark Equipment Co.
Rt. 4, Box 14
Talladega, AL 35160
Talladega County
205/362-7019
(William W. Gilbert)

Doc Faison Well Drilling
P.O. Box 597
Bonifay, FL 32425
904/547-3639
(John R.White)

Billy Feltman
Rt. 1, Box 232
Carbon Hill, AL 35549
Walker County
205/622-3563

Finch Well Co.
Box 230, Ave. D
Mobile, AL 36608
Mobile County
205/633-4006
(Willis E. Finch)

Flo Drill. & Pump Co.
Rt. 5, Box 90
Brewton, AL 36426
Escambia County
205/867-4976
(Travis Lambeth)

French Well Drilling Co.
205 S. 9th St.
Gadsden, AL 35901
Etowah County
205/547-8375
(W. C.French)

Fryfogle Water Well Serv.
Rt. 8, Box 3
Lucedale, MS 39452
601/947-3262
(Anthony & Pal Fryfogle)

J. R. Goodwin
1131 Cedar Springs Rd
Weaver, AL 36277
Talladega County
205/820-2258

Gothard & Son Contractors
Rt. 2, Box 400-A
Montgomery, AL 36108
Montgomery County
205/263-9949
(G. S. Gothard)

Graves Well Drilling
P.O. Box 225
Sylacauga, AL 35150
Talladega County
205/249-4371
(Stan Graves)

I. D. Griffin Water Well
607 S. Commerce St.
Geneva, AL 36340
Geneva County
205/684-2475

Griffin Well Co.
Rt. 1, Box 148-A
Wilmer, AL 36587
Mobile County
205/649-2888
(J. R. Griffin)

Tom Griffith Water Well &
Conductor Service
320 Mason Ave.
Columbia, MS 39429
Baldwin/Escambia
601/736-2646
(Tom Griffith)

Griner Drilling Service
P.O. Drawer 825
Columbia, MS 39429
Escambia, Mobile, Clarke
601/736-6347
(Charles H. Griner)

Hacoda Drilling Co.
Rt. 2, Box 10
Florala, AL 36442
Covington County
205/858-6294
(Vernon Robbins)

Hammett Drilling Co.
Rt. 2, Box 203
Andalusia, AL 36420
Covington County
205/222-3562
(Marvin Hammett)

Hancock & Chestnutt Drilling
Rt. 6, Box 317
Ft. Payne, AL 35967
DeKalb County
205/523-3386
(Ted Chestnut)

Hanners & Davis Well Drilling
Rt. 2, Box 227
Lineville, AL 36266
Clay County
205/396-5382
(James L. Hanners)

D & H Havens Well Co.
Rt. 1, Box 209
Semmes, AL 36575
Mobile/Baldwin
205/649-6912 or 649-1793
(Henry Havens)

Heart of Dixie Well
Drilling
Rt. 2, Box 52-A
Alpine, AL 35014
Talladega County
205/268-9791
(Guy Smith)

Helms Brothers Well
Boring
Rt. 2, Box 535
Villa Rica, GA 30180
Paulding County (GA)
404/459-3807
(John C. Helms)

Helms Well Pump, Inc.
1805 S. Highway 100
Bowdon, GA 30108
Cleburne/Randolph
404/258-7749
(Donald L. Helms)

Ray Hendon
Rt. 9, Box 239
Jasper, AL 35501
Walker/Winston
205/387-1377

Herndon Well & Supply
P.O. Box 37
Shannon, MS 38868
Lee County (MS)
601/767-9777
(Robert E. Herndon)

Walter C. Hicks
Rt. 1, Box 238
Mount Hope, AL 35651
Lawrence County
205/974-6283

Holland Well Co.
P.O. Box 7363
Mobile, AL 36607
Mobile County
205/473-5752
(Sanford A. Holland)

A. D. & Hayward Hughes
Well Drilling
Rt. 1, Box 320
Chancellor, AL 36316
Coffee County
205/347-2989 or 347-8762

J. D. Hughes Well Drill.
Rt. 1, Box 320
Enterprise, AL 36330
Coffee County
205/347-9757

J. R. Hughes
Rt. 2, Box 36
New Brockton, AL 36351
Coffee County
205/347-7303 or 894-2380

Hughes Water Well Co.
3205 Cromwell Dr.
Dothan, AL 36301
Houston County
205/794-3764
(Bobby Hughes)

Hughes Water Well Drilling
Rt. 1, Box 310
Geneva, AL 36340
Geneva County
205/684-9814
(Ruben Hughes)

Hughes Well Drilling
Rt. 1, Box 331
Chancellor, AL 36316
Coffee County
205/347-9758 or 347-1147
(Edgar or Jerry Hughes)

William O. Humphrey
Rt. 3, Box 263
Boaz, AL 35957
Etowah County
205/593-8801

Hurst Well Drilling
Rt. 3, Box 102-A
Lineville, AL 36266
Clay County
205/488-5547
(Pat Hurst)

Jackson Drilling Co.
Rt. 2, Box 385
Haleyville, AL 35565
Marion/Winston
205/486-5452
(O'Neal Jackson)

Charles G. Kitchens Well
Drilling
Rt. 1, Box 349
Parrish, AL 35580
Walker County
205/686-7811
(Charles G. Kitchens)

Knox Drilling Co.
P.O. Box 83
Haleyville, AL 35565
Marion County
205/486-3128
(Albert D. Knox)

Layne Central Co.
3720 N. Palafox St.
Pensacola, FL 32505
Escambia County (FL)
904/432-5101
(Alan Symons or Pat Scott)

James D. Lemley
Rt. 1, Box 594
Woodville, AL 35776
Marshall County
205/728-2526

Lineberry Drilling Co.
Rt. 2, Box 41
Clifton, TN 38425
Wayne County
615/676-3464
(Wayne Lineberry)

McCormack Drilling Co.
Rt. 2, Box 103-A
Leighton, AL 35646
Colbert County
205/446-5625
(Hubert McCormack)

McDonald & Hill, Inc.
P.O. Box 1510
1020 Grand Ave.
Meridian, MS 39301
Lauderdale County (MS)
601/693-3401
(Robert E. Hill)

Michael Drilling Co.
Rt. 4, Box 220
Rogersville, AL 35652
Lauderdale County
205/247-5531
(James Michael)

Mid-South Drilling Co.
Rt. 1, Box 36-F
Carrollton, AL 35447
Pickens County
205/367-8496
(Louis Reece)

Miller Drilling Co.
P.O. Box 706
Lawrenceburg, TN 38464
Lawrence County (TN)
615/762-7548
(G. E. Miller)

Odom Well Drilling
Rt. 4, Box 81
Jacksonville, AL 36265
Calhoun County
205/820-2590
(Charles Odom)

Owens Drilling Co.
Rt. 2, Box 230
Fort Payne, AL 35967
DeKalb County
205/657-3395
(Johnny R.Owens)

Robert Peek
Route 2
Pisgah, AL 35765
Jackson County
205/451-3548

Jim V. Peel
Rt. 1, Box 365
Maylene, AL 35114
Shelby County
205/426-3606

Pope Testing Lab, Inc.
2463 Eslavia Creek Pkwy.
Mobile, AL 36606
Mobile County
205/471-3458
(William Pope)

Porter Drilling & Supply
Rt. 1, Box 106
Waynesboro, MS 39367
Wayne County (MS)
601/735-4530

Powell Drilling Co.
P.O. Box 155
Rutledge, AL 35071
Crenshaw County
205/335-5365
(Alton E. Powell)

Vertice Allen Powell
P.O. Box 87
Uriah, AL 36480
Monroe County
205/862-2500

J. M. Presley
Rt. 4, Box 165
Enterprise, AL 36330
Coffee County
205/347-2829

W. Presnall, Inc.
Rt. 1, Box 418
Grove Hill, AL 36451
Clarke County
205/246-4055
(Willie Presnall)

Cecil Radford & Son
Rt. 2, Box 87
Selma, AL 36701
Dallas County
205/872-1651
(Johnnie Radford)

Rafter 5 Service Co.
P.O. Box 114
Aliceville, AL 35442
Pickens County
205/373-8428
(Charles A. Shaul)

W. H. Richey
Route 7
Russellville, AL 35653
Colbert/Franklin
205/332-0688

Marvin S. Ridgeway
Rt. 2, Box 342
Millport, AL 35576
Lamar County
205/662-4278

J. D. Roberts
Rt. 2, Box 179
Hope Hull, AL 36043
Lowndes County
205/288-5613

Thomas Rossi
Rt. 1, Box 331-A
Sulligent, AL 35586
Lamar County
205/698-8757

Rowe Drilling Co.
P.O. Box 1363
Tallahassee, FL 32302
Leon County
904/576-1271
(H. Lamar Rowe)

Rutherford Well Boring
P.O. Box 903
Clanton, AL 35045
Chilton County
205/755-2525
(Talmadge Rutherford)

Johnny M. Sanford
Rt. 5, Box 609-A
Anniston, AL 36201
Cleburne County
205/831-8753

Selvage Drilling Co.
Rt. 3, Box 278
Scottsboro, AL 35768
(Jackson, Marshall)
205/728-4388
(M. C.Selvage)

Shumock Well Co.
Rt. 1, Box 79
Wilmer, AL 36587
Mobile County
205/649-4559
(C. E. Shumock)

Simmons Well Drilling
Rt. 3, Box 105
Boaz, AL 35957
Etowah County
205/593-3435
(Marvin Simmons)

Donald Smith Co.
Rt. 3, Box 1
Headland, AL 36345
Henry County
205/693-2969

William E. Smitherman
Rt. 2, Box 167
Maplesville, AL 36750
Chilton County
205/366-2637

H. T. Sparks
Rt. 2, Box 23
Hollypond, AL 35083
Cullman County
205/796-5182

Stacon Corporation
P. O. Box 5767
Orange, CA 92667
714/639-9531
(A. W. Macomber)

Terry Drilling Co., Inc.
Rt. 8, Box 28
Meridian, MS 39301
Lauderdale County (MS)
601/482-6412 or 482-0361
(Norman Terry)

Thomason Well Drilling, Inc.
713 Edge St.
Ft. Walton Beach, FL 32548
Okaloosa County (FL)
904/862-4613
(J. E. Thomason)

Tri State Drilling Service
504 Dusy St.
Dothan, AL 36301
Houston County
205/792-3605
(Jack C.Walker)

Uriah Drilling Co.
P. O. Box 116
Uriah, AL 36480
Monroe County
205/862-2258
(Tony Powell)

Virginia Supply & Well Co.
P.O. Box 14145
Atlanta, GA 30376
Fulton County (GA)
404/875-0441
(W. A. Martin)

Weldon Drilling Co.
Rt. 1, Box 330
Tallassee, AL 36078
Elmore County
205/541-3615
(Larry Weldon)

Western Well & Pump, Inc.
207 N. Franklin
Colby, KS 67701
913/462-6708
(Roy F.Senior, Jr.)

E. C. White
Rt. 1, Box 15
Perdido, AL 36562
Baldwin County
205/937-9384

White Well Company
4607 Dauphin Island Pkwy
Mobile, AL 36605
(Mobile County)
205/479-8718
(Stanley White)

Windham Pump & Supply
5800 Muldoon Rd.
Pensacola, FL 32506
Escambia County (FL)
904/455-2281
(Drayton Windham)

Wright Test Drilling Inc.
6245 Howells Ferry Rd
Mobile, AL 36608
Mobile County
205/343-7486
(Paul Wright)

APPENDIX 3

FEDERAL AND STATE AGENCIES RESPONSIBLE

FOR WATER REGULATION IN ALABAMA

FEDERAL

U.S. Environmental Protection Agency
345 Courtland Street, N.E.
Atlanta, Georgia 30365

STATE

Alabama Department of Conservation and Natural Resources
64 North Union Street
Montgomery, Alabama 36104

Alabama Department of Environmental Management
1751 Federal Drive
Montgomery, Alabama 36130

Alabama Surface Mine Reclamation Commission
P.O. Box 1027
Jasper, Alabama 35501

State Oil and Gas Board
P. O. Box O, University Station
420 Hackberry Lane
Tuscaloosa, Alabama 35486