OUTLINE OF OCCURRENCE OF GROUND WATER IN ALABAMA

By P. E. LaMoreaux

Introduction

This paper presents an outline of the geology of Alabama and contains information relative to the occurrence of ground water in the major physiographic divisions of the State. It was written at the request of Col. K. H. Shriver, Senior Planning Technician, Alabama State Planning Board. It is hoped that this report will result in a better understanding of the geology and hydrology as they affect the development of ground water for private, industrial, and municipal use in the State.

Alabama for the most part is richly blessed with this most important natural resource, an abundant ground-water supply. The water-bearing formations or aquifers in the State are being continually recharged by an average precipitation of 50 to 60 inches. These ground-water supplies, if used properly, should be adequate to meet most demands placed upon them. Excessiv use of ground water and especially waste should be discouraged. To use our water resources in an intelligent and conservative manner is a public respons bility to be borne by each individual.

History of Ground-Water Investigations in Alabama

The U. S. Geological Survey began in 1898 a study of the water resources of the State. In 1904 and 1905 two preliminary papers by the State Geologist, Dr. Eugene A. Smith, were published by the U. S. Geological Survey in Water-Supply Papers 102 and 114. _/ Three years later the Alabama Geological Survey

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_/ Smith, E. A., Section on Alabama, in Contributions to the hydrology of eastern United States, 1903: U. S. Geol. Survey Water-Supply Paper 102, pp. 276-331, 1904.

Smith, E. A., Section on Alabama, in Underground waters of eastern United States: U. S. Geol. Survey Water-Supply Paper 114, pp. 164-170, 1905.

published "The underground water resources of Alabama" by Dr. Smith._/ This

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_/ Smith, E. A., Underground water resources of Alabama: Alabama Geol. Survey Monograph 6, 388 pp., 1907.

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report contained all the ground-water data which had been accumulated up to that time.

This original work laid the foundation for more detailed ground-water studies to follow. In 1933 the Alabama Geological Survey issued Special Report 16, "Ground water in the Paleozoic rocks of northern Alabama" by W. D. Johnston, Jr. Since 1940 ground-water investigations in cooperation between the Alabama Geological Survey and the U. S. Geological Survey have been in progress. As part of that cooperative program, reconnaissance studies of ground water have been completed for the area in Alabama underlain by Cretaceous rocks, _/ for

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_/ Carlston, C. W., Fluoride in the ground water of the Cretaceous area of Alabama: Alabama Geol. Survey Bull. 52, 1942.

Carlston, C. W., Ground-water resources of the Cretaceous area of Alabama: Alabama Geol. Survey Special Rept. 18, 1944.

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the industrial and municipal supplies in the area in Alabama underlain by Tertiary rocks, _/ and for the salt-water encroachment problem in the Mobile

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_/ LaMoreaux, P. E., Fluoride in the ground water of the Tertiary area of Alabama: Alabama Geol. Survey Bull. 59, 1949.

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area, Alabama._/ At present detailed ground-water investigations are under

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_/ Peterson, Carl G. B., Ground-water investigations in the Mobile area, Alabama: Alabama Geol. Survey Bull. 58, 1947.

way in Mobile, Baldwin, Choctaw, and Wilcox Counties and in the Huntsville area, Alabama. Ground-water reports published by the Alabama Geological Survey are available upon request to that office.

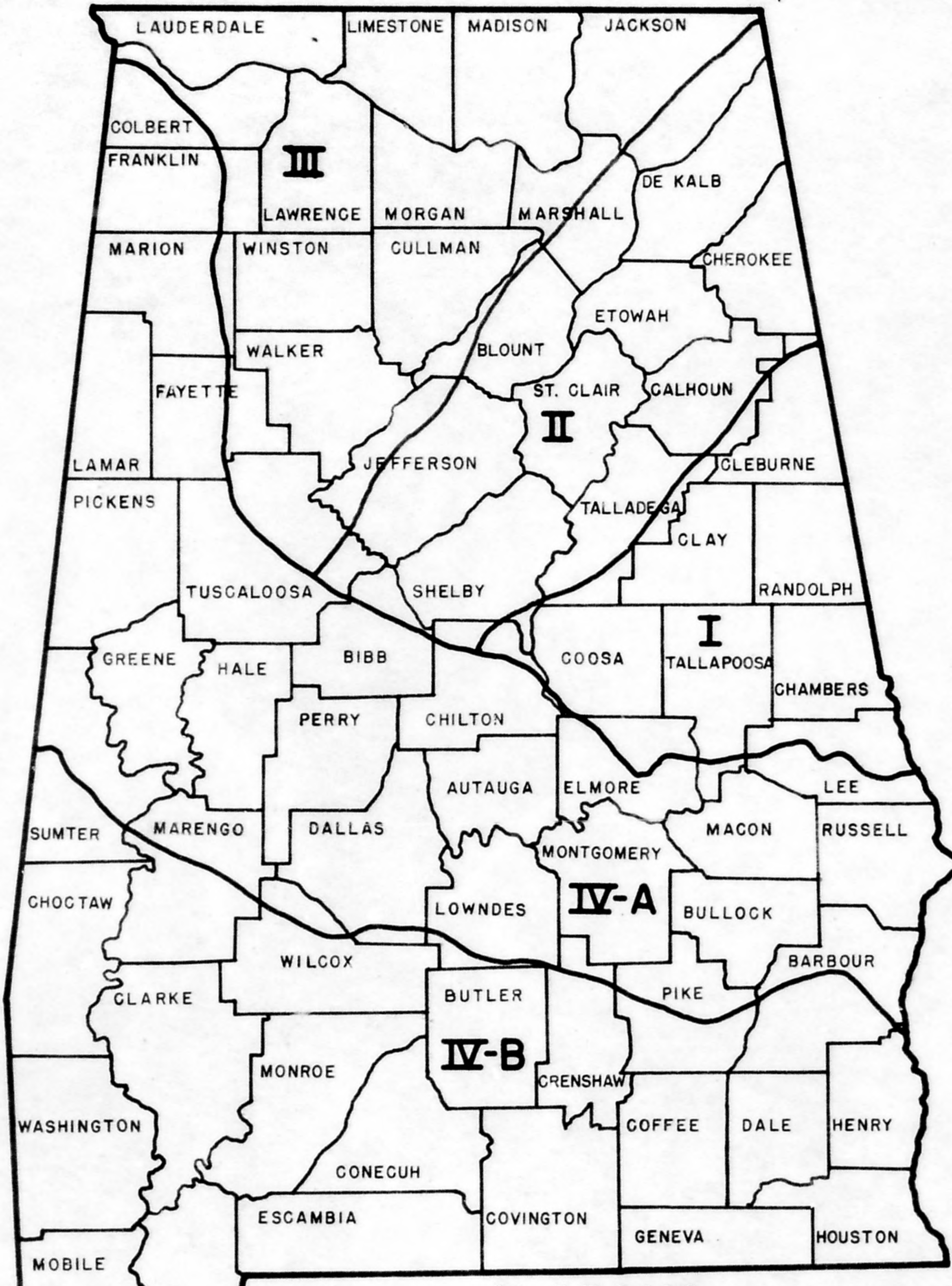
As part of the cooperative ground-water program started in 1940, periodic measurements of water levels are made in observation wells located at strategic points throughout the State. Observation wells are being measured at present at Tuscaloosa, Eutaw, Boligee, Aliceville, Carrollton, Reform, Vernon, Duncanville, Centerville, Maplesville, Stanton, Plantersville, Jones, Monroeville, Hurtsboro, Scottsboro, Tuskegee, Montgomery, Clanton, Selma, and Tuscumbia; and observations are made also at Huntsville Spring in Huntsville. It is hoped that this program will be enlarged somewhat to include additional locations, thereby giving an over-all picture of ground-water levels throughout the State.

Outline of Geology of Alabama

The State of Alabama includes parts of two major physiographic divisions, the Appalachian Highlands and the Coastal Plain. The boundary between these divisions is irregular and is known as the "Fall Line" of the Atlantic and Gulf Coast states. The Fall Line enters Alabama near Phoenix City, extends westward across to Wetumpka, Clanton, Centerville, and Tuscaloosa, then swings northwestward to the northwest corner of the State.

The Appalachian Highlands division in Alabama has three major provinces, the Piedmont province, the Appalachian Valley and Ridge province, and the Appalachian Plateau province (provinces I, II, and III, fig. 1).

The rock formations in the Piedmont province in east-central Alabama are metamorphic rocks, mainly crystalline schists and gneisses, injected by younger igneous rocks, and are mainly of pre-Cambrian age (province I, fig. 1). They are faulted and folded and have a complicated structure. These rocks are the oldest and among the most complex rocks in the State.



ALABAMA

PROVINCE

I – Piedmont.
II – Appalachian Ridge and Valley.
III – Appalachian Plateau.
IV – Coastal Plain.
A. Cretaceous Area.
B. Tertiary Area.

Fig. 1

The geologic formations of the Appalachian Ridge and Valley province and the Appalachian Plateau province are of Paleozoic age, ranging from Cambrian to Carboniferous. These rocks comprise a succession of formations consisting chiefly of shale, sandstone, limestone, and dolomite, aggregating many thousands of feet in thickness.

The provinces underlain by Paleozoic rocks are separated on the basis of their structure. The Appalachian Ridge and Valley province is characterized by mountain ridges and longitudinal valleys trending in a northeast-southwest direction (province II, fig. 1). The stratified rocks of this area are generally highly inclined as a result of folding and faulting. In the Appalachian Plateau province to the west the rocks show only minor deformation (province III, fig. 1). The rocks in this province are for the most part nearly horizontal, with only minor flexures or warps. If the surface irregularities brought about by erosion in this area are disregarded, the plateau may be described as a vast upland whose surface slopes gently and uniformly southward from an altitude of 1,600 to 2,000 feet in the northern part of the State to 500 feet at the margin of the Coastal Plain in Tuscaloosa County on the south. _/

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_/ Adams, G. I., Butts, Charles, Stephenson, L. W., and Cooke, C. W., The Geology of Alabama: Alabama Geol. Survey Special Rept. 14, p. 46, 1926.

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The rocks in the Alabama Coastal Plain area in the southern half of the State are divided into two major age groups, Cretaceous and Tertiary (fig. 1, province IV, A, B). The Cretaceous formations of Alabama, all of which belong to the Upper Cretaceous series, crop out in the northern part of the Coastal Plain province in a belt 70 to 75 miles wide. As can be seen in figure 1, part IV-A, the Upper Cretaceous beds crop out in a large crescent, extending across tho middle of the State and swinging northwestward into Mississippi. The Upper Cretaceous series consists primarily of chalk, clay, sand, and gravel and is divided at present in Alabama as follows:

Selma group
- Providence sand
- Prairie Bluff chalk
- Ripley formation
- Demopolis chalk and Cusseta sand
- Mooreville chalk and Blufftown formation

Eutaw formation
McShan formation
Tuscaloosa group

The Cretaceous formations dip southward toward the Gulf in eastern Alabama, and southwest toward the Mississippi Embayment in western Alabama at low angles, about 30 or 35 feet per mile.

The Tertiary formations crop out in the southern half of the Coastal Plain province or the southern quarter of Alabama (fig. 1, province IV, B). These beds lie unconformably on the Upper Cretaceous deposits, and have an approximate regional dip to the south and southwest of 25 or 30 feet per mile.

The Tertiary deposits of Alabama consist of alternating beds of clay, sand, gravel, marl and limestone, and on the basis of fossil content and lithologic character are divided in ascending order into the Clayton formation, Porters Creek clay, and Naheola formation, of the Paleocene series; the Nanafalia formation, Tuscahoma sand, Hatchetigbee formation, Tallahatta formation, Lisbon formation, Gosport sand, Jackson group, (including Moodys Branch formation, Ocala limestone, and Yazoo clay), of the Eocene series; the Red Bluff clay, Marianna limestone, Byram formation, and Chickasawhay limestone, of the Oligocene series; the Paynes Hammock sand, Catahoula sandstone, and undifferentiated upper Miocene deposits, of the Miocene series; and the Citronelle formation of the Pliocene series. _/ Above the Tertiary formations are terrace deposits of

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_/ MacNeil, F. Stearns, Correlation chart for the outcropping Tertiary formations of the eastern Gulf region: U. S. Geol. Survey, Oil and Gas Investigations series Chart 29, 1947.

Quaternary (Pleistocene age). In the vicinity of Dothan in southeastern Alabama the Tertiary and Quaternary deposits have an aggregate thickness of about 1,000 feet. In Baldwin and Mobile Counties in southwestern Alabama they are nearly 5,000 feet thick.

Outline of Water-Bearing Rock Systems in Alabama

Introduction

The occurrence of ground water in an area is determined largely by the local geology. A comprehensive study of geology includes a knowledge of the origin, character, distribution, and structure of the rock materials which underlie the earth's surface.

The term "rock" is used to refer to all earth material whether hard granite, clay, or loose sand. There are many kinds of rocks in the upper part of the earth's crust. These rocks contain open spaces. The rocks differ greatly in the number, size, shape, and arrangement of these open spaces, and hence differ in their water-bearing properties. The differences are due to the nature of the materials of which the rocks are composed and to the diversity of the geologic processes by which the rocks were produced or later changed.

As stated, the earth's crust is not solid throughout, but includes many interstices or void spaces. These voids may be divided into two classes, primary and secondary. Primary voids are the original openings in the rocks. They include the spaces between adjacent particles or grains. Sedimentary rocks like those in the Coastal Plain area of southern Alabama contain voids of this type. The Coastal Plain sand and gravel beds are some of the most important water bearers. Well-sorted gravel and sand have a large number of void spaces; therefore, they have a high porosity. In poorly sorted materials, however, the small particles occupy the spaces between the large ones, with the result that the porosity, and therefore the water-bearing capacity, are reduced. Secondary openings include joints and other fracture openings and solution cavities. Solution cavities are produced chiefly by water that penetrates existing voids, such as along joint and bedding planes, removing soluble material and carrying it away in solution. Solution plays a major role in limestone rocks, such as those in the Paleozoic area of northern Alabama, where large yields of ground water are obtained for industrial and municipal use from wells and springs.

In Alabama ground water is derived almost entirely from rainfall, supplemented by an occasional light snowfall in the winter months. The descent of water to the zone of saturation is determined by several factors: the rate of rainfall, the time of year, the porosity of the rocks and their permeability or ability to transmit water, the slope of the surface, the amount of vegetation, and the amount of water in the atmosphere.

Water after leaving the atmosphere in the form of rain or snow falls on the earth's surface. Some of the water runs off into creeks and rivers, some of it seeps into the soil and begins to seep downward below the land surface. Eventually some of this water percolates to the zone where all the void spaces are filled with water, and is then called ground water. Ground water may be defined as the water below the land surface that issues from springs, and issues or may be pumped from wells.

Piedmont province

The Piedmont province in east-central Alabama (fig. 1, province I) includes all or parts of Tallapoosa, Chambers, Lee, Elmore, Chilton, Shelby, Talladega, Clay, Randolph, and Cleburne Counties. In this area the metamorphic rocks, for the most part crystalline schists and gneisses injected by younger igneous rocks of pre-Cambrian age, crop out. The rocks are generally hard and dense and have a complicated structure, and in many instances the development of large ground-water supplies from them is difficult or impossible. Generally, only small yields are obtained from the rocks in this area. These rocks give rise to numerous small springs, but their flow fluctuates with the season and they may dry up in the summer. The wells in this area are of two types; shallow dug wells with large infiltration surfaces, receiving seepage from the weathered and decayed upper part of the complex rocks; and drilled wells, commonly 4 inches or more in diameter, ranging from less than 100 feet to generally not more than 250 feet in depth. The drilled wells obtain their supplies both from the weathered zone and from water-bearing fractures in the rocks. The development of water supplies in this area is a test-well proposition, requiring drilling until one or more water-bearing openings are intersected. Yields are low, generally less than 10 gallons a minute and rarely exceeding 50 gallons a minute.

Paleozoic provinces

The geologic formations of the Appalachian Ridge and Valley province and Appalachian Plateau province (provinces II and III, fig. 1) are of Paleozoic age, and comprise a succession of formations consisting chiefly of shale, sandstone, limestone, and dolomite, aggregating many thousands of feet in thickness. The rocks in the Appalachian Ridge and Valley province (fig. 1, II) are characterized by folding and faulting, and the stratified rocks of this area are generally highly inclined instead of flat lying. In contrast, the rocks in the Appalachian Plateau to the west show only minor deformation, (fig. 1, province III) and the rocks in this area are for the most part nearly horizontal, sloping gently to the southwest.

The Paleozoic rocks in the Appalachian Ridge and Valley and Appalachian

Plateau provinces are important sources of ground water in much of the northern part of the State. _/ Some of the more familiar water-bearing formations of

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_/ Johnston, W. D., Jr., Ground water in the Paleozoic rocks of northern Alabama: Alabama Geol. Survey Special Rept. 16, 1933.

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Paleozoic age in this area are the Conasauga formation, Ketona dolomite, Copper Ridge dolomite, Newala limestone, Fort Payne chert, Tuscumbia limestone, and Bangor limestone. Some of the less productive water-bearing beds of Paleozoic age are the Rome formation and the Athens, Chattanooga, and Floyd shales.

Many supplies in this area are derived from springs issuing from fractures or solution channels in limestone. Most of the large springs in northern Alabama that furnish domestic, industrial, and public supplies issue from relatively large openings in these rocks. Big Spring at Huntsville and Tuscumbia Spring at Tuscumbia are fine examples. The amount of water available from wells in this area is dependent on the number and kind of openings containing water intersected by a well. Although limestone in northern Alabama may contain solution channels or other fissures at great depths, generally these openings do not extend far below the water table. It is therefore generally not economical to drill to great depths in limestone in exploration for water. Generally, if adequate water is to be encouhtered it will be found within 200 or 250 feet of the surface. If water is not obtained by this depth a new location for a second well may be advisable. As a rule, this prodedure will be cheaper than to continue drilling to geater depths with only a slight chance of success. However, if the rocks in an area dip steeply, deep artesian circulation may exist, and the chances for obtaining water at depths greater than 250 feet may be relatively good.

One problem in connection with water from the Paleozoic formations is the quality. In many places it is found that water from the limestones or sandstones contains rather large amounts of mineral matter. This condition may be due to sluggish circulation of water in the formations at depths.

Coastal Plain province

The rocks in the Alabama Coastal Plain in the southern half of the State are divided into two major age groups, Cretaceous and Tertiary (fig. 1, province IV, A, B).

Cretaceous formations.- The Cretaceous rocks are present at or near the surface in a band approximately 70 to 75 miles wide extending in a northwest-southeast direction across the central part of the State. The Cretaceous formations consist mainly of beds of clay, chalk, sand, and gravel which dip gently to the south and southwest about 30 or 35 feet per mile.

The principal water-bearing beds of these deposits are the sands and gravels in the Tuscaloosa group, the Eutaw formation, and the Blufftown, Cusseta, Ripley and Providence formations of the Selma group. In western Alabama the most productive water-bearing beds are those in the upper part of the Tuscaloosa group, in the Tombigbee sand member and middle and lower sands of the Eutaw formation, and in the sand beds of the Ripley formation. In eastern Alabama the important water-bearing beds are the sands in the Tuscaloosa group, the Tombigbee sand member of the Eutaw formation, the Cusseta sand, the Ripley formation, and the Providence sand. _/

_/ Carlston, C. W., Ground-water resources of the Cretaceous area of Alabama: Alabama Geol. Survey Special Rept. 18, 1944.

Tertiary formations.- The Tertiary formations crop out in the southern half of the Coastal Plain or in the southern quarter of Alabama (fig. 1, province IV, B). These beds, mainly of limestone, marl, clay, sand, and gravel, lie unconformably on the older Upper Cretaceous deposits, and have an approximate regional dip to the south and southwest of 25 to 30 feet per mile. Nearly every formation of Tertiary age has sandy or limy beds or a basal channel sand that form potential sources of ground water. The wells studied in the Tertiary area tap water in all these water-bearing beds, but of major importance for the development of large municipal and industrial supplies are the water-bearing sands of the Nanafalia formation, the basal part of the Tuscahoma sand, the Lisbon formation, and the Gosport sand, solution channels in the Ocala limestone, and sands in the beds of Miocene age and the Citronelle formation.

Summary

The Coastal Plain province of Alabama has the most favorable geologic conditions in the State for the development of large quantities of ground water. In this area Mobile, Tuscaloosa, Eufaula, and Livingston are the only cities of any size that do not use ground water for municipal supply. Many industries such as paper, steel, cotton, and lumber mills, ice plants, bottling companies, and dairy projects use large quantities of ground water. The Hollingsworth-Whitney Paper mill in the Mobile area uses from 10 to 13 million gallons of ground water a day, and approximately the same amount is used for the Montgomery municipal supply.

The Paleozoic area in northern Alabama ranks second in the number of installations and development of ground-water supplies. In this area the development of ground water depends on local geologic conditions such as the presence of large springs or solution openings or fractures carrying ground water which may be intersected by a well. Examples of municipalities in this area using ground water are Anniston, 8 million gallons a day; and Huntsville, 4 million gallons a day. These supplies are taken from springs issuing from limestone rocks.

The crystalline rocks of the Piedmont area are least favorable for the development of large ground-water supplies. Most of the municipal supplies in the area are taken from surface streams. In this area few wells are capable of producing over 10 to 25 gallons a minute, although a few towns in the area do use water from a series of two or more wells or springs with fairly constant year-round yields. However, small wells yield limited amounts of ground water for small-scale developments such as domestic and farm supplies.

Alabama is fortunate in that it is in an area of moderate to heavy rainfall with an average of 50 to 60 inches per year. This large rainfall tends to recharge or replenish the ground-water reservoirs. As a result of the great amount of rainfall in Alabama and because we are still in the early stages of development of our water supplies, Alabama is for the most part still a non-critical area with respect to the lowering of the regional water table or depletion of local ground-water supplies. This is true in Alabama in general, although even at present there are certain localities where critical shortages are beginning to exist. For example, some of the wells in the old City of Montgomery well field originally flowed above the land surface. Now these wells have stopped flowing, owing to the effect of heavy pumping, and water levels have dropped to as much as 100 to 130 feet below the land surface. This problem has been corrected to some extent by the development of a new city well field. It is hoped that by careful planning of production and future drilling in the Montgomery area further depletion of this source will not take place. Another critical area in the State is in the vicinity of Mobile, where heavy pumping of air-conditioning wells has drawn down the fresh water and allowed contamination by the encroachment of salt water from Mobile Bay and River. Similar problems of depletion on a smaller scale are occurring at Selma, Dothan, and a few other localities in the State. Depletion is also taking place in certain areas of artesian flow where many flowing wells are allowed to flow unchecked, thereby drawing down the piezometric (artesian-pressure) surface.

The present observation-well program carried on in the State by the Ground Water Branch of the U. S. Geological Survey in cooperation with the Alabama Geological Survey shows the fluctuations of the water table. Only by accurate records can we know of an existing critical situation or the symptoms of a possible shortage. It must be stated again that excessive use of ground water and especially waste should be discouraged. Exact and reliable information should be collected on ground-water reservoirs of the entire area of the State. We must fully understand the conditions for the whole area and guard against depletion.