VAST RESERVOIRS OF WATER underlie the Eighth Federal Reserve District and demand for water is growing rapidly on the part of both industry and agriculture.

Particularly abundant ground-water supplies are associated with major river basins such as the Ohio at Louisville and the Missouri-Mississippi at St. Louis. Another large supply is found in the Gulf Coastal Plain at Memphis and underlying most of the southern portion of the district. Other underground water resources are broadly distributed, but surface supplies appear to afford the best water source for much of northern Missouri, southern Illinois and southern Indiana.

In conclusion, the physical quantity of water appears sufficient for needs over many decades in major district cities and to meet further farm irrigation demands. But only a small part of the water resource potential is being realized today.
Ground-water Resources of the Eighth District

Vast reservoirs of water underlie the Eighth Federal Reserve District. In some areas they have been heavily drawn upon; in others the reserve has been barely tapped. What is the nature and extent of this district underground water supply? Does it offer great potentialities for agriculture and industry? Or is it merely a supplemental source of supply that is relatively unimportant?

Considerable mystery about the origin of ground water has persisted, and colorful theories died hard. In 1717 Athanasius Kircher in his "Mundus Subterraneous" attributed springs to caverns of fire and water fed respectively by a fiery mass in the center of the earth and the waters of the sea. Even today water diviners practice their art with a bent twig, suggesting that there is something supernatural about underground water, although experiments have demonstrated that water-divining is useless even in "finding" water that is already known to exist.

Geologists have done much to dispel the mystery associated with this hidden resource. They classify subsurface-water resources under two major headings from the standpoint of use. The first category is subsurface water held in the upper layers of the crust of the earth, usually on a more or less temporary basis. This water, discussed in a previous article in connection with rainfall, is the source of most soil moisture and is not part of what is ordinarily considered the ground-water supply. The second category designates what is ordinarily meant by "ground water;" it is found considerably deeper beneath the surface, though usually not over a depth of 2,500 feet, in the pores and fissures of the rocks, including clay, sands, and gravels. It is the main source of supply for wells, artesian water, and springs. Other categories of subsurface water are subsurface ice, mineral water in rocks at great depths, and water in the zone of rock flowage deep down in the earth, which may be the source of hot springs and geysers and the steams escaping with volcanic eruptions.

Editor’s Note

This article on the ground-water supply of the Eighth District is the third of a series by this bank in which water resources have been considered. Prior articles, appearing in the April 1954 and May 1955 issues of the Review, dealt with climate and with atmospheric water supply. They pointed out that, while the district is far more humid than much of the rest of the world, when evaporation is taken into account there are some areas of moisture deficiency. The current article emphasizes ground water but includes some discussion of surface waters.

Were the district’s underground waters gathered together in some vast subterranean cavern, the problems of estimating their utility and productivity would be greatly simplified. Unfortunately for purposes of measurement, this is not so. On the contrary, ground water is found separately in many different kinds of rock formations. Some yield generously; others not at all. Consider sandstones, for example, which are an important water-bearing rock. For some of these sandstones, it is possible to determine with fair accuracy the extent of the rock strata and the water capacity per cubic foot. But even in such a case the yield at any given point and depth may not reach expectations. More than likely the rock bed is fractured at various points, and if the fracturing is accompanied by displacement, it may be necessary to drill hundreds of feet deeper to obtain water (figure 1). In point of fact, the productivity of the water in some areas may not be worth the expense of drilling to it.

Some limestones are another important series of water-bearing rocks in the Eighth District, but they are usually a much more erratic source of water than sandstone (figure 2). One driller may strike a concentration point for water seeping between the rock spaces so that his well flows generously. But his neighbor, sinking a well only a short distance away, may get only a trickle because the drill happened to miss suitable structure. Other limestones are so cemented by clays that they are poor water bearers. Clays, on the other hand, hold vast quantities of water, but yield it so niggardly that they too are generally considered a poor water source. Besides, compacted clay may form a “roof” over water-bearing rocks, preventing the latter from being used until the clay is pierced. Granites, known for their hardness and thus excellent building properties, are an unlikely source of water, yet even they may provide enough water for domestic use if the well successfully taps a “crossroads” of jointing and fracturing (figure 3). No wonder then that experienced geologists are often reluctant to forecast before they drill. Water, like oil, is where you find it.

In addition to sandstones and limestones, stream and glacial sands and gravels are other leading holders of the district’s ground-water supply. Water-retaining sands and gravels resulting from continental glaciation are often closely linked with these major stream deposits, but others, left as irregularly shaped lenses, are not necessarily so. It would seem that at least the deposits along streams could be readily identified and the extent of their water-holding capacity measured. But much remains to be learned about these deposits even in industrial areas. The United States Geological Survey has completed only recently, in manuscript form, the first extensive study of them along the lower Ohio River. And a new study on the “American Bottoms,” the area opposite St. Louis, has just been published by the Illinois State Geological Survey.²

To the vagaries of occurrence noted above must be added the fact that ground-water supplies undergo varying rates of recharge and withdrawal. Such changes in the supply may be the result of both natural and man-made causes. A drop in the water table is not always an indication that a ground-water supply is being impaired, for some water-bearing rocks are capable of rapid recharge with good quality water. However, any assessment of the ground-water supply should take its fluctuating nature into account.

Is it possible, then, to measure this variable, imperfectly known resource? In terms of a precise figure, the answer is “No.” But even if an aggregate could be reliably computed, it would have little practical significance, for ground-water availability varies greatly from place to place. And in the Eighth District the total supply is not economically available everywhere. Hence, the most meaningful analysis is one in terms of smaller areas.

...and demand for water is growing rapidly...

Despite problems of measuring the ground-water reservoir, it appears that the need for more water will be increasingly met from ground water because of its many likely advantages. Harold E. Thomas has cited four principal reasons why ground rather than surface waters have frequently been selected as a source of supply:

1. Ground water can often be reached more conveniently than surface water.
2. Ground water may be available in areas where surface waters have already been appropriated for use.
3. The yield from wells and springs generally fluctuates less than streamflow in alternating wet and dry periods.
4. Ground water is more uniform in temperature and soluble mineral load than surface water and is ordinarily free of turbidity and bacterial pollution.

That use of water in the United States has recently grown by leaps and bounds hardly needs arguing in view of the wide publicity given to this fact by both Government and press. The President’s Materials Policy Commission estimated that water requirements in this country would increase from 185 billion gallons daily in 1950 to 350 billion gallons daily by 1975. An even higher estimate of future requirements has recently been published by the United States Department of Commerce (figure 4). By 1955 residential, industrial, public, and commercial demand, including allowance for loss, had grown to an estimated national average of 143 gallons per person per day from an average of 95 gallons in 1900 and 138 gallons in 1950.4

...on the part of both industry...

The extent of the expansion of industrial water demand for any one small area is particularly difficult to estimate. Who, ten years ago, could have forecast for the Paducah area a potential demand for 23 million gallons of water per day by a single Government plant? In this case, as for most industrial plants, the water is largely returned to the river where it may be re-used for other purposes. An outstanding example of such multiple use is Ohio’s Mahoning River, where it is estimated that every gallon of the average flow of 500 million gallons daily is drawn into use from three to 15 times. Moreover, an individual plant may re-cycle the water it uses many times, thus greatly reducing initial requirements.5

...and agriculture...

Farmers have also begun to draw more heavily on ground-water supplies. In the states east of the Mississippi River, excluding Florida, the number of farms reporting irrigation increased more than three times between 1950 and 1954, and in these 25 states there are now more than one-half million acres of irrigated land. In Arkansas irrigation of rice land expanded from 411,000 acres in 1949 to 667,000 acres in 1954.

It appears that more and more use of supplemental irrigation will be made for such crops as corn, cotton, and soybeans, and even for pastures. But there are many immeasurables.

For one thing, water requirements for supplemental irrigation vary greatly. Mississippi Circular 180 notes that from 12 to 15 inches of irrigation water is required to keep perennial summer pasture productive throughout an average season.6 A study made in Kentucky suggests that an average of 6 acre-inches of water is required for each acre to be irrigated.7

Costs of irrigation also show wide differences from one farm to another. For example, in Kentucky in 1950 sixteen farmers made investments of from $875 to $9,000 for portable irrigation systems, the annual fixed costs for the systems ranging between $94 and $856.

5 For detailed information on industrial water use based on a survey of over 3,000 plants, see Water in Industry, National Association of Manufacturers and The Conservation Foundation, New York, December 1950.
6 Crop Response to Irrigation in Mississippi, Mississippi State College Agricultural Experiment Station, State College, Mississippi, 1955. p. 12.
7 For this and other cases used in the following paragraph see: Tharp, Max M., and Crickman, C. W., "Supplemental Irrigation in Humid Regions," Water, Yearbook of Agriculture, 1955, United States Department of Agriculture, pp. 255-256.

![FIGURE 4](http://fraser.stlouisfed.org/)

**Water Use in the United States, 1920 — 1975**

**Source:** United States Department of Commerce Business and Defense Administration.
The fixed costs per acre-inch varied from only 66 cents for a system used at near-capacity to $25.82 for a system that was little used. Variable costs per acre-inch of water applied did not show so great a range, but differences in labor costs account for a considerable spread in variable costs throughout the district. Some studies have indicated the profitability of supplemental irrigation in certain places, but final conclusions cannot be reached until data are obtained which cover a series of years.

Particularly abundant supplies are associated with major river basins such as the Ohio, ... .

It seems clear that there will be more and more call upon the water resources of the Eighth District. Although no total estimate of potential is feasible, a more detailed examination of district territory will indicate which smaller areas have the greatest possibilities of expansion for future needs. While the emphasis will be on ground water, surface water relationships are included where necessary for comparative purposes.

The major river basins of the Eighth District have an exceptionally abundant supply of ground water. According to the Geological Survey study noted earlier, the lower Ohio River Valley in Kentucky has more than a trillion gallons of water stored in its sand and gravel fill. This ground-water reservoir ranking as one of the most important in the United States in terms of present use and future potentialities. Because water moves from the river into the alluvium, the supply is virtually inexhaustible as long as water flows in the river.

... at Louisville, ... 

This ability of ground-water reservoirs near rivers to refill so rapidly that they afford a continuing source of supply, provided they are not overdrawn, is illustrated by the geologic structure at Louisville (figure 5). The river basin is largely filled with glacial gravels overlain by a blanket of silt, soil, and clay. Underneath and on both sides of the basin are rock layers of limestone and shale. The most productive wells in the area have been drilled into the glacial gravels, although a few have been drilled deep enough to penetrate the underlying limestone. The shale holds little water, even acting as a barrier against the recharging of water into the gravels.

Use of water from this basin has shown that in most cases both rainfall and Ohio River water very rapidly replace water drawn from wells. Where natural recharging is insufficient, artificial recharging and conservation methods have proved successful. A ground-water shortage developed in the central industrial area in 1943, but various techniques, including artificial recharge of city water (river sources), re-use of water, use of city water in place of ground water, use of cooling towers, and changes in plant equipment so improved matters that since 1946 pumpage in this sector of the basin has been in close balance with natural recharge. Furthermore, city water has been stored in the ground during the
winter to supply cold water in summer, and used warm water has been recharged into the ground water supply.

The potential supply of ground water in the area, including not only the central industrial area discussed above but all other reservoirs as well, was more than ten times use in 1952. Besides, the flow of the Ohio River is so large that it overshadows the ground-water supply. A study of water use in 1952 indicated that the estimated potential supply (based on minimum daily flow for 20 years) was more than four times use. Moreover, since most of the water used at Louisville is returned to the river and is available for re-use downstream, the magnitude of potential use is greatly understated. Total use will probably be largely controlled by temperature and pollution with chemical wastes rather than by flow rates, according to the Geological Survey.

The flood plains of the Missouri, Mississippi, and some of their major tributaries also have large quantities of ground water. At St. Louis, for example, the supply is particularly abundant. Part of the river flood plain, known as the “American Bottoms,” is an elliptic area of about 175 square miles comprising the Mississippi River Valley to the east of St. Louis. A Chamber of Commerce study has estimated that the potential water supply here is about 1.2 billion gallons daily, or six times what is presently needed to meet the daily average requirements of communities in the area. The study of the Illinois Geological Survey previously noted shows, however, that there are great differences in the potential from place to place, ranging from unfavorable to excellent. Even this generally abundant supply, moreover, is dwarfed by the surface-water supply of the Mississippi which, after being joined by the Missouri and Illinois, has channelled from a minimum of 21 billion to a maximum of over 400 billion gallons of water past St. Louis daily (according to mean monthly flow figures for the years 1940-1950). Ground-water supplies further upstream between the Missouri and the Mississippi and along the south bank of the Missouri also have promising possibilities, though not as much is known about their capacity.

The Coastal Plain of the United States, which in its entirety includes both the Atlantic and Gulf-fronting lowlands, and the lower Mississippi Basin, has been described by a leading expert as “probably the region the most abundantly endowed with water of all those in the United States.” As shown by the map (figure 6), this region includes a considerable portion of the Eighth District.

The rock strata in the district section were laid down in the body of water that was once an arm of the Gulf of Mexico. They are thus very recent in terms of geologic age and less compacted than the rocks underlying the other two major ground-water regions of the Eighth District which will be considered next (map, figure 7). The rock beds in the Coastal Plain Region are also more uniform in water-bearing characteristics and are of generally much greater capacity than those in other major regions of the district. They form long, continuous, inclined strata that are often ideally constituted so as to, first, catch surface water and, second, retain it as ground water. In addition, the generally abundant rainfall of the region constantly recharges the underground water supply.

Memphis benefits greatly from the exceptional ground-water supply of this region. So plentiful and pure is the ground water there that the vast surface supply of the Mississippi has not even been drawn upon for municipal use. Of the 22 cities in the United States with a 1950 population between 250,000 and 500,000, only San Antonio and Memphis obtained their municipal supplies from

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ground water. Houston was the only one of 18 cities of
more than 500,000 inhabitants that depended on wells
for all its public supplies.\(^1\)

Deep wells drilled in the Memphis area pass first
through the topsoil, then through a mixture of sand and
gavel. At a depth of about 100 feet hard clay is en-
countered, which, varying from 100 to 250 feet in thick-
ness, seals off surface water from above. Below this clay
blanket are three U-shaped layers of water-bearing sands.
These layers extend from the Ozarks on the west to the
Tennessee River on the east. The first is reached at a
depth of about 500 feet and the second at about 1,400
feet. The third at about 2,600 feet extends all the way
to bedrock. These sands are constantly being recharged
by rainfall, which enters the sands where their margins
are at surface, particularly in the east, and the supply
will probably continue as long as the rainfall continues.
Today the city of Memphis is drawing around 210,000,000
gallons of water daily from this vast underground reservoir.
The water is so pure that the only treatment the city gives
it is aeration to remove carbon dioxide gases and filtration
to remove traces of iron.\(^2\)

... and underlying most of the southern portion
of the district.

Other sections of the district's Coastal Plain include
western Tennessee, northern Mississippi, the Jackson
Purchase area of Kentucky, eastern Arkansas and the Mis-
souri Bootheel (map, figure 7).

The situation at Memphis in western Tennessee has just
been noted. For the balance of the area the Geological
Survey reports that except for the presence of iron the
water is of good quality for all purposes and that "large
quantities of ground water can be developed throughout
the area."\(^3\)

The Geological Survey further reports that the alluvial
deposits underlying the Yazoo Delta in the State of Mis-
sissippi to depths of 125 to 200 feet contain vast quanti-
ties of water which may be regarded as practically inex-
haustible even locally. A well of large diameter would
probably yield from these deposits up to 3,000 to 4,000
gallons a minute without seriously lowering the water
table.\(^4\)

In the Jackson Purchase area of Kentucky, that part
of the state lying west of the Tennessee River, the velocity
of wells in various localities in 1951 ranged from 26 gal-
lons per minute to continuous yields of 1,300 and 1,400
gallons per minute. Surface water was being used by
only one public (Paducah) and two industrial (Calvert
City) systems in this part of Kentucky, although they used
60 per cent more than the total amount of ground water
used by 29 other systems. "The present rapid industrial
expansion in the Jackson Purchase will greatly increase
the use of both ground and surface water within the
next few years, but large reserves of ground and surface
water should satisfy these additional demands."\(^5\)

While the eastern Arkansas portion of this Gulf Coastal
Region shares in the general characteristics noted, excep-
tionally large demand for rice irrigation has resulted in a
rather sharp decline in the water table in some places.
It is estimated that in the area ground water was pumped
in 1938 at an average rate of 320 million gallons per day
and in 1952 at a rate of 685 million gallons per day. The
water table between 1915 and 1953 has shown declines
ranging from 10 to 60 feet, the greatest lowering center-
ing around Stuttgart.\(^6\) A project is now underway at the
University of Arkansas Rice Experiment Station near
Stuttgart to test artificial recharging of the ground water.

In the Missouri Bootheel, wells are generally expected
to yield large quantities of water at relatively shallow
depths. For example, a well near Wardell in Pemiscot
County has a capacity of 4,700 gallons per minute at a
depth of less than 100 feet.

\(^1\) Thomas, Harold E., "Underground Sources of Our Water," Water, The
Yearbook of Agriculture, 1935, United States Department of Agriculture.

\(^2\) Talley, Robert, "Water," The Commercial Appeal, Memphis, July 6,
1952. For a technical report, consult: Water-Supply Paper 658, United

\(^3\) Wells, Francis G., and Foster, Margaret D., Ground-Water Resources
of Western Tennessee, Water-Supply Paper 656, U. S. Geological Survey,
Wash., 1935.

\(^4\) Stephen, Lloyd W., Logan, William N., and Waring, Gerald A.,

\(^5\) Fret, H. L., Jr., and Walker, W. H., Public and Industrial Water
Supplies of the Jackson Purchase Region, Kentucky. Geological Survey Cir-
cular 287, Wash., D. C., 1953, 1, 2.

\(^6\) Baker, R. C., "Arkansas' Ground-Water Resources," a preliminary
study prepared by the United States Geological Survey in cooperation with
the Arkansas Resources and Development Commission, and University of
Arkansas. (Research Memorandum No. 2 on House Concurrent Resolution
Other underground-water resources are broadly distributed,...

In addition to the river basins and coastal plain areas stressed thus far, other sections of the district also have considerable water potentials. One rather comprehensive area of generally moderate ground-water supply is the Unglaciated Central Region. It includes the Ozarks section of Missouri and Arkansas, a small part of southern Illinois, much of southern Indiana, and all of district Kentucky except the Jackson Purchase area. Compact, sedimentary rocks dominate most of the area, and limestone is by far the most productive and extensive ground-water reservoir of these. In the St. Francois Mountains and a few other isolated areas, granites, yielding little water, predominate. The most productive deposits, although also of limited extent, are gravel and sand found in stream beds.

Large underground streams are formed in some localities. They, or the springs issuing from them, have characteristics similar to those of surface water of other areas, fluctuating in response to precipitation and sometimes carrying considerable sediment. Nevertheless, even at minimum flow such limestone springs may afford large supplies. For example, Big Spring, near Van Buren, Missouri, could adequately meet the present water needs of St. Louis.

But even if these springs do yield large amounts of relatively pure water they may never be used for manufacturing or harnessed for generating electricity because of their great recreational value. Many groups advocate that these larger springs and the rivers they supply be left as a natural wilderness area.

Sandstone is another important bedrock formation in the Central Unglaciated Region. It outcrops in some areas and is found below the limestone in others. But these sandstones have not proven particularly productive and are generally of such mineral content, particularly at deeper levels, that they are unacceptable for many uses.

An indication of the limited availability of ground-water supplies in the Central Unglaciated Region is shown by the fact that the three largest cities, Springfield, Little Rock, and Fort Smith, all rely principally on surface reservoirs. At Little Rock, a daily capacity of 23 million gallons is available from a highly scenic as well as useful reservoir known as "Lake Winona." Construction of a new dam at another location is planned to furnish an additional 83 million gallons per day. Fort Smith obtains its municipal water from a reservoir that provided 9 million gallons of water daily during the driest period of 1953, and a new reservoir is expected to increase dependable daily capacity to about 40 million gallons. At Springfield, Missouri, the main source of supply for many years was also a surface reservoir, supplemented by three deep wells and a spring. In 1954, however, following three drouth years, the water supply became critically short, and the city began construction of another reservoir and authorized drilling of additional wells to supplement the reservoir supply.

Besides much of Missouri and Arkansas, a major part of district Kentucky and southern Indiana lies in the Unglaciated Central Region. In Kentucky the subregions are the Mississippian Plateau Region and the Western Coal Region. In the Mississippian Plateau Region, of a total daily pumpage of 33 million gallons about 25 million was obtained from ground-water sources and about 8 million gallons from surface water during the years 1951-1953. The largest producing wells in the region were from the alluvium of the Ohio River Valley, which the Geological Survey calls "the only known potential source of very large public and industrial supplies in the region." However,
in the Pennyroyal Area a large number of towns and several industrial firms obtain water from wells and springs in the limestone. Elizabethtown in Hardin County, the largest town in the county using ground water, obtains its municipal water supply from a spring having a minimum flow of about 1,200 gallons per minute. Two large companies in Warren County obtain water for industrial use from springs that have a minimum flow of more than 1,000 gallons per minute.

In Kentucky's Western Coal Region, as in the Mississippian Plateau Region to the south, ground-water supplies come largely from river bed sources. Most of the rest, less than 10 per cent of the total, is derived from sandstones which become highly mineralized in deeper wells. However, they yield as much as 500 gallons per minute, about one-half the gallonage obtained on the average from the river gravels.

The Blue Grass Region lies largely outside the Eighth District. In general, the outer Blue Grass has only moderate ground-water possibilities and district Indiana is considered in the following section, which emphasizes surface supplies.

Although surface waters meet the needs of major cities in the Unglaciated Central Region, ground-water resources of this region nonetheless provide a large number of smaller municipalities with their supplies. Many wells are noted for their purity. There is every reason to believe that excellent underground supplies are available for many medium-sized industries and for a considerable expansion of farm irrigation needs. This is in contrast to the Glaciated Region, to be next considered, where surface waters appear to offer the most feasible means of increasing water supplies.

...but surface supplies appear to afford the best source for much of northern Missouri...

Another area of generally moderate water resources, named the Glaciated Central Region, is shown by the map to lie north of the Missouri River in the State of Missouri, and in a large part of district southern Illinois and southern Indiana.

This region is underlain by compact, sedimentary rocks in which the water supply is generally rather poor. The deep bedrock formations are apt to have salt water, while much of the shallow or near-surface bedrock has a relatively low permeability, hence yields only small quantities of water. These conditions of the bedrock lead to a consideration of the debris left by continental glaciation as in general the best source of underground water in this region.

The continental glacier, a huge mass of ice from perhaps 4,000 to 8,000 feet thick extended some half million years ago from Canada to approximately the present course of the Missouri and Ohio Rivers in the district.

In fact, the original course of these streams were formed by the waters rushing from beneath the frontal lobe of the ice cap as it remained relatively stationary at its point of farthest advance. Crushed and churned beneath the glacier, or piled irregularly over the existing drainage pattern, was a layer of rock and finely ground rock particles, known as glacial till. At a later period some of the till was further weathered and with the addition of plant humus formed soil. In other areas the glacial till was buried under a covering of wind-blown soil from farther west. The significant feature from the standpoint of ground water is that this glacial till provides only indifferent supplies of water today. Where deep pre-glacial valleys were filled there is apt to be more water, but in most cases the supply is sufficient only for farm and home use. Thus, surface storage must be the answer in many sections of northern Missouri, southern Illinois and southern Indiana.

Edward L. Clark, for many years Missouri State Geologist, has divided northern Missouri into two ground-water provinces as noted on the map, (figure 6). He has written that in the first area "we obtain very small quantities of water from the glacial drift. Where buried valleys are present we get considerably more water, but not what you would call a great abundance. Below the glacial drift in this area the bedrocks at relatively shallow depth contain salt water."

"Area No. 2 across northern Missouri is essentially the same as area No. 1 except that the salt water is a little deeper in the bedrocks, and we are, therefore, able to develop some wells at depths of 500 to 600 feet. However, these wells are small producers. In area No. 2 in the vicinity of St. Louis and along the Mississippi River in Perry County we encounter salt water at depths of from 300 to 600 feet."
O. W. Beimfohr reported that about 75 per cent of the public water supply in southern Illinois is of surface origin. However, an apparently exceptional ground-water supply is available in the Cache River Valley, just north of the Ohio near Cairo.\(^\text{19}\)

\textit{... and southern Indiana.}

Anton Hulman, Jr., Chairman of the Indiana Flood Control and Water Resources Commission wrote in 1954 that: “With the Commission recognizing that surface storage must be the answer in many sections of southern Indiana, cities have been encouraged and assisted in creating reservoirs having adequate capacities at minimum costs. It is thought that perhaps rather large reservoirs, centralized to serve several farms, and several towns, by pipeline, may be practical in the near future.”

Thus, while ground-water supplies may be generally moderate in this region, it should not be overlooked that many localities have access to the river basin deposits such as those of the Grand, Chariton, and Wabash, or even the Illinois, Missouri, or Mississippi and Ohio.

\textit{In conclusion, the physical quantity of water appears sufficient for needs over many decades in major district cities...}

In view of the exceptional ground-water and surface-water resources that have been described as available to three of the district’s major cities (Louisville, Memphis, and St. Louis), it is difficult to foresee any shortages within the next generation, provided facilities are increased and abuses lessened. In Louisville and its environs industrial use of ground water is said to be only about one-tenth of recharge capacity, and the Ohio River has been used only moderately. Memphis has not yet tapped the surface waters of the Mississippi River for municipal purposes, and the ground-water supply is still abundant.

\textit{... and to meet further farm irrigation demands.}

In much of the Eighth District, large supplies are available for further farm irrigation. In much of the Coastal Plain Region, wells yielding from 1,000 to 4,000 gallons per minute and better can often be reached at relatively shallow levels. In the Central Nonglaciated Region, some wells may yield 450 gallons per minute, enough to supply an acre of farm land with one inch of water in an hour, but supplies are not nearly as broadly distributed or reliable as in the Coastal Region. In northern district Missouri, in southern Illinois and Indiana, surface supplies may have to be relied upon primarily, though many farmers there will be able to draw upon ground waters of river basins.

\textit{But only a small part of the district’s water resource potential is being realized today.}

This study has shown that the ground-water resources of the district are much more than a mere supplement to surface waters. In their own right, they offer many opportunities to agriculture and industry for the most advantageous source of water supply. But their possibilities need to be further developed. The inability in many district areas to tap these supplies for relief from drought in recent years shows that a long path lies ahead before supply has been anywhere near equated with demand.

\textit{Harry B. Kircher}

\textbf{SUBSCRIPTIONS to the \textit{Monthly Review} are available to the public without charge. For information concerning bulk mailings to banks, business organizations and educational institutions, write: Research Department, Federal Reserve Bank of St. Louis, St. Louis 2, Missouri.}
District Member Bank Earnings in 1955

Net current earnings of district banks were higher during 1955 than in 1954...

The year 1955 was good, profitwise, for most Eighth District member banks. Net current income of these banks was at an all-time peak of $75 million, about 11 per cent higher than in the previous year. However, after deducting net losses on security sales (in contrast to profits in the previous year) net profits both before and after taxes were lower than in 1954. Nevertheless, the amount of cash dividends paid to holders of common stock continued to rise.

Member banks in the rest of the nation had a similar experience. Preliminary figures indicate that net current earnings rose to $2.1 billion in 1955, compared with $1.8 billion a year earlier. However, after adjusting for net losses (as against net profits a year ago) and income taxes, net profits after taxes fell to $1.0 billion from $1.1 billion in 1954. Cash dividends declared, on the other hand, increased from $450 million to a level of $500 million...

...reflecting greater current earnings...

During 1955 total operating earnings of district banks continued to expand, and all major categories of earnings contributed to the gain. Over 60 per cent of the dollar growth in earnings was the result of a greater return on loans. The larger income from advances was occasioned by a rise in the average volume of loans outstanding and a higher rate of return on these loans. Businessmen, consumers, real estate owners, farmers and others all borrowed more from district banks than in the previous year. At the bigger banks the higher average rate of interest on loans reflected a rise in the prime lending rate from 3 per cent to a level of 3½ per cent during the year and the relatively larger growth of higher-than-average rate consumer loans. At smaller banks most rates remained firm but a few were marked higher.

Earnings on securities, both United States Government and other, continued to increase. For Government securities the higher return reflected a rise in interest rates which was fairly sharp for Treasury bills and other short-term securities. Average holdings of Government obligations, however, contracted over the year as banks applied more of their available funds to meet the credit demands of their customers. The higher income on municipal and corporate securities reflected both the rise in interest rates and larger holdings. Preliminary indications are that earnings from service charges on deposit accounts continued to rise but at a slower rate than in the previous year...

...partially offset by larger expenses.

The higher earnings at district member banks during 1955 were partly offset by an increase in expenses. Thus, although total earnings were $13.4 million higher than during 1954, net earnings rose only $7.6 million. For the third straight year it appears that the sharpest jump (9 per cent in the most recent year) in a major expense item was in interest paid on time and savings accounts. Both the volume of time deposits and the average amount of interest paid on these accounts continued to edge up. A few additional institutions increased their payment rates, and indications are that the greatest increases in savings accounts tended to be in banks paying relatively high rates.

The biggest dollar amount of increase in expense from 1954 to 1955 at district member banks was in salaries and wages. This expense item rose approximately $3 million. Average wages of bank employees and officers were each estimated to be about 3 per cent higher than during the preceding year. In addition to the higher average payments per staff member, it appeared that district banks maintained on their payrolls a few more officers and employees in 1955 than during 1954 to handle the increased volume of deposits, checks, lending and other work.

Another increase in expenses for a few district banks was in costs of using borrowed money. In the aggregate district banks borrowed substantially more funds in 1955 than in the previous year, and the average interest rate on these funds was higher. The heavier borrowings and increased rates reflected the tighter reserve positions of...
banks generally as the demands for credit by customers became more vigorous. Preliminary figures indicate that most other expense items also worked up, such as depreciation, taxes (other than income), supplies, utilities and advertising.

However, net profits were lower than in 1954.

Although net operating earnings of district member banks were $7.6 million higher during 1955 than in the previous year, net profits (before taxes) declined from $70 million to $61 million. The drop in profits in 1955 reflected net losses and charge-offs compared with large profits on security sales in 1954. The losses in 1955 reflected primarily: (1) the decline in prices of most securities (especially intermediate-term), (2) the need for funds by many banks, requiring liquidation of a part of these holdings, and (3) tax advantages to certain banks of taking losses on securities in 1955 by shifting their portfolios.

Actual losses on bad loans during 1955 were quite small for most district banks. However, charges against earnings to increase reserves for loan losses continued to increase.

From these profits, income taxes took less...

Income taxes on district member banks took, in the aggregate, just over $24 million in 1955 as against $29 million in the previous year. When the income tax levy is related to net profits (before income taxes), it took 40 per cent compared with 41.5 per cent in the previous year. 

... and banks retained a smaller portion to strengthen capital...

For many years, retained earnings have been the major source of funds contributing to growth of capital accounts of district member banks. Preliminary figures show that these banks "plowed back" nearly $21 million of their net profits in 1955 to strengthen capital structures. However, in the previous year these banks retained $27 million. Even on a percentage basis, the amount of profits (after taxes) retained was lower (57 per cent) than in 1954 (64 per cent).

Despite the smaller volume of retained profits, member banks for the third straight year added to their capital structures during 1955 at a more rapid rate than total assets or total deposits increased. On the other hand, since loans expanded greatly, "risk" assets (i.e., assets other than cash and Government securities) rose somewhat more sharply than total capital accounts.

...but stockholders received a larger amount of dividends.

During 1955 the distribution of cash dividends on common stock by Eighth District member banks amounted to nearly $16 million, the greatest amount on record. In 1954 these banks declared cash dividends of $15 million. Some banks raised their regular rates; others declared extra dividends. Compared with total capital accounts, cash dividends were about the same as in the previous year (2.9 per cent compared with 3.0 per cent).

NORMAN N. BOWSHIER

<table>
<thead>
<tr>
<th>EARNINGS AND EXPENSES</th>
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<tr>
<td>Eighth District Member Banks</td>
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<tr>
<td>(In Millions of Dollars)</td>
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<td>1953</td>
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<tr>
<td>Interest and Discount on Loans</td>
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<tr>
<td>Interest on U. S. Government Securities</td>
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<tr>
<td>Interest on Other Securities</td>
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<tr>
<td>Other current operating earnings</td>
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<tr>
<td>Total Current Operating Earnings</td>
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<td>Salaries and Wages</td>
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<td>Interest on Time Deposits</td>
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<tr>
<td>All other expenses</td>
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<td>Total Current Operating Expense</td>
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<td>Net Current Operating Earnings</td>
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<tr>
<td>Net Losses and Charge-offs</td>
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<tr>
<td>Net Profits Before Taxes</td>
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<td>Taxes on Net Income</td>
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<td>Net Profits After Taxes</td>
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<tr>
<td>Cash Dividends on Common Stock</td>
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p—Preliminary

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<th>SELECTED OPERATION RATIOS</th>
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<td>(In per cent)</td>
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<tr>
<td>Net Profits (after taxes) to Capital Accounts</td>
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<tr>
<td>Cash Dividends to Capital Accounts</td>
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<tr>
<td>Net Profits (after taxes) to Total Assets</td>
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<tr>
<td>Expenses to Total Earnings</td>
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<td>Net Losses and Charge-offs to Total Earnings</td>
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<tr>
<td>Income Taxes to Total Earnings</td>
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<tr>
<td>Net Profits to Total Earnings</td>
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<tr>
<td>Interest on Government Securities</td>
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<tr>
<td>Interest and Dividends on Other Securities</td>
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<tr>
<td>Earnings on Loans</td>
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<tr>
<td>Capital Accounts to Total Assets</td>
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<tr>
<td>Capital Accounts to Risk Assets</td>
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<td>Capital Accounts to Total Deposits</td>
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<td>Time Deposits to Total Deposits</td>
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<td>Interest to Time Deposits</td>
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EARLY RETURNS on February’s business pace in the Eighth Federal Reserve District indicated a continuation of January’s leveling off. Industrial production in February generally held close to the high rate of recent months. New construction undertaken in the district in January was greater than the large amount contracted a year earlier, but in the first half of February, contract awards dropped sharply from year earlier levels. The demand for credit at district banks contracted about seasonally during the four weeks ended February 22. However, the number of persons claiming unemployment insurance rose more sharply in February than a year ago in all of the district’s major cities. And, although district farmers were heartened by the much needed rain and snow fall in January and February, they were faced with the prospect of lower price supports on some major crops.

Nationally, too, the leveling off of business activity in January apparently continued into February. Weekly indicators of important segments of industrial production declined slightly during February, and insured unemployment rose from early January to early February, in contrast to a decline last year. On the other hand, construction contracts awarded and department store sales continued above year earlier levels.

The fact that business activity has leveled off, after more than a year of fairly steady advance, raises the question as to whether the economy was at the peak of a business cycle, or whether it is merely pausing on its upward march. In time this question will, of course, be answered, but, even now, some indication of the future trend of business could be obtained by assessing recent trends. One of the chief generating forces in the rise in business activity during the past year was the expansion in consumer spending. Rising income, an increased willingness to spend, and greater use of credit were factors in this growth of consumer outlays. Recent developments, however, indicate some modification in these factors. For example, in the fourth quarter, the rate of personal saving rose. Extensions of instalment credit, after seasonal adjustment, declined in the fourth quarter from the record rate in the third quarter of 1955. Thus, despite rising income in the final quarter of 1955, seasonally adjusted retail sales remained almost unchanged from September to January. In January personal income was affected by a somewhat lower dividend rate than in December and by reduced earnings of factory production workers, reflecting cutbacks in the average work week. This latter influence, however, may have been moderated by increased wage and salary payments in nonmanufacturing industries.

Inventory building also added to demand last year, and some further inventory accumulation apparently continued in the first two months of 1956. In the first three quarters of 1955, inventories grew less rapidly than sales, but in the fourth quarter this relationship shifted. A continuation of the fourth quarter accumulation would tend to an overbalance of stocks relative to sales. Thus, the stimulus to business activity in recent months derived from inventory building may moderate in the months ahead.

Other sectors of demand, however, continued to increase. Businesses plan to expand their expenditures on new plant and equipment, according to recent announcements and surveys. Contracts awarded in recent months indicate that construction activity will remain high, and perhaps even reverse its recent moderate downtrend. Furthermore, state and local governments are expected to continue to increase their outlays, reflecting the need for additional public facilities, such as schools and highways.

D **Industry**

District industrial production generally continued close to recent levels in early February. Automobile assembly was at a reduced rate, reflecting the large dealer inventories on hand. Southern pine output declined slightly, reflecting bad weather conditions. And crude oil output was a shade below earlier production this year, although the trend last February was upward. Slightly higher figures, however, were shown early in the month for steel ingot production and railroad freight interchanges at St. Louis, and for Southern hardwood lumber output. Trade sources reported that shoe production appears to be headed for a first quarter mark that may surpass last year’s record. Livestock slaughter in the St. Louis area declined seasonally but was almost one-fifth above that during the comparable period of 1955. Coal output increased slightly.

**Construction**

January reports on new construction undertaken in the district were favorable, but in the first half of February
contracts awarded in the St. Louis territory of F. W. Dodge Corporation dropped sharply from year earlier levels. Reflecting the high rate of awards in the three months ending in January, the most recent seasonally adjusted index of construction contracts awarded in the Eighth Federal Reserve District rose from the preceding period and was about one-eighth higher than a year earlier. In comparison with a year ago, residential construction lagged both in January and in the first half of February. In January this lag, however, was more than made up by larger amounts of other construction.

Trade

Consumers maintained a high rate of buying at district department stores in January and the first part of February. The seasonally adjusted index of sales in January was 126 per cent of the 1947-49 average, compared with 125 in December and 123 in January 1955. In the first three weeks of February, sales were 6 per cent ahead of the corresponding weeks last year.

Automobile sales in the nation picked up in the first ten days of February, partially reflecting seasonal trends, but continued to lag the record rate set last year. In January, dealer sales of new autos had declined and were moderately below the record of a year ago.

Labor Markets

The recent slowdown in some industries augmented the usual seasonal layoffs in the district's major metropolitan areas. As a result, insured unemployment in the four largest cities rose more in the four weeks ended February 18 than in the comparable period a year ago. The increase in St. Louis and Evansville was large enough to raise the number of insured unemployed above that of a year ago. On the other hand, for the nation and in Louisville and Memphis the number claiming unemployment insurance was less than a year before.

In Evansville, which was declared a surplus labor market area in January, Whirlpool-Seeger Corporation took possession of the plant formerly owned by International Harvester and began installation of machinery. About 500 were at work there already and more will be employed when operations begin.

The general leveling off in business activity was also indicated by the absence of change in seasonally adjusted employment in nonagricultural establishments in the nation in January. Nevertheless, employment was at a record level of 50.2 million, 1.8 million higher than a year ago. Manufacturing employment actually declined in January and the average work week also fell more than usual. The reduction in manufacturing employment was offset by gains in trade and some other lines.

Agriculture

Growing conditions improved during the last half of January and early February as a result of much needed precipitation. Some moisture fell over most of the district states, bringing relief from a prolonged late fall and early winter drought. Greater than normal rainfall fell at most weather stations in the southern district states. The amount of snow and rain falling in other district states varied widely but was generally sufficient to meet current crop moisture needs.

As a result of the precipitation, prospects improved for both fall seeded crops and spring plantings. Grain crops in the northern district states have good prospects for winter survival, having suffered only light damage from soil heaving. Pastures in the southern part of the district made good growth after a slow beginning, but were still not in condition to support much grazing.

Winter is traditionally a period of planning for the farmers. This year their plans will be shaped, in part, by the recently announced Federal support levels for major crops. In early February, the support level for 1956 corn crop was announced as 11 per cent below last year. Support prices for other feed grains were changed little, however, and those for oilseed were raised about 5 per cent. The support price for wheat, which was announced earlier, will be 13 per cent less than in 1955.

Average prices of district agricultural products declined slightly for the four-week period ending February 24. A fourteen per cent decline in hog prices led the downward move. Broiler, cattle, tobacco, and rice prices also weakened. Offsetting the general decline were price increases for milk, eggs, cotton, soybeans, corn, wheat and oats.

Banking

During the four weeks ended February 22 the demand for credit at district banks indicated that business activity remained at a high level. Total loans (excluding interbank lending) at weekly reporting banks contracted $19 million, or 1 per cent. Most of the contraction was of a seasonal nature. Businesses, accounting for about half of total borrowings, made smaller reductions in their indebtedness than the average decline of corresponding weeks in recent years. By major industry classification, the pattern varied as some borrowers showed strength while others made more than the usual amount of net repayments. Producers of metals and metal products and petroleum, coal, chemicals and rubber added more to their loans outstanding than the average increase of the like weeks of 1952-55. Processors and distributors of agricultural products made smaller than usual net repayments. On the other hand, sales finance companies made sizable reductions in their outstanding indebtedness probably indicating continued financing in other markets. Contractors also repaid on balance perhaps reflecting the smaller number of housing starts in recent months.

"Other," largely consumer, loans at reporting district banks declined less than the average contraction during the corresponding weeks of recent years. Loans to finance the purchase or carrying of securities were up in the period. Real estate loans, however, contracted moderately.
VARIOUS INDICATORS OF INDUSTRIAL ACTIVITY

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<tr>
<th>Jan. 1956</th>
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INDUSTRIAL USE OF ELECTRIC POWER (Thousands of KWH per working day, selected industrial firms in 6 district cities)

- Steel ingot rate, St. Louis area (operating rate, per cent of capacity)
- Coal Production Index—Sth Dist. (Seasonally adjusted, 1947-49 = 100)
- Crude Oil Production—Sth Dist. (Daily average as thousands of bbls.)
- Freight Interchanges at RRs—St. Louis. (Thousands of cars—25-gal. bbls.)

LIVESTOCK SAUGHTER—St. Louis area. (Thousands of head—weekly average)

- Lumber Production—S. Pacific (Average weekly production—thousands of bd. ft.)
- Whiskey Production—S. Pacific
- Operating rate, per cent of capacity

- Percentage change figures for the steel ingot rate, Southern hardwood rate, and the coal production index, show the relative per cent change in production, not the drop in index points or in per cent of capacity.

N. A. Not available.

INDEX OF CONSTRUCTION CONTRACTS

AWARDED EIGHTH FEDERAL RESERVE DISTRICT (1947-1949 = 100)

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<thead>
<tr>
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<tr>
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<tr>
<td>Other</td>
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<tr>
<td>Total</td>
<td>1984.4 2008.8</td>
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</table>

Seasonally adjusted |

Total | 1958.4 2020.4 |
Residential | 1914.4 2045.4 |
Other | 44.4 55.4 |
Total | 1958.4 2020.4 |

Based on three-month moving average (centered on mid-month) of value of awards, as reported by F. W. Dodge Corporation.

ASSETS AND LIABILITIES EIGHTH DISTRICT MEMBER BANKS

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LIABILITIES AND CAPITAL

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PERCENTAGE DISTRIBUTION OF FURNITURE SALES

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<td>Credit Sales</td>
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Note: Figures shown are preliminary and subject to revision.

1 Preliminary.

2 Fayetteville, Pine Bluff, Arkansas; Harrisburg, Mt. Vernon, Illinois, Vincennes, Indiana; Danville, Rockville, Mayfield, Owensboro, Kentucky; Chillicothe, Missouri, Greenville, Mississippi, and Jackson, Tennessee.

3 In order to permit publication of figures for this city (or area), a special sample has been constructed which is not confined exclusively to department stores, but for which no such nondepartment store figures, however, are not used in computing the district percentage changes or in computing department store indexes.

4 Fayetteville, Pine Bluff, Arkansas; Harrisburg, Mt. Vernon, Illinois, Vincennes, Indiana; Danville, Rockville, Mayfield, Owensboro, Kentucky; Chillicothe, Missouri, Greenville, Mississippi, and Jackson, Tennessee.

5 Fayetteville, Pine Bluff, Arkansas; Harrisburg, Mt. Vernon, Illinois, Vincennes, Indiana; Danville, Rockville, Mayfield, Owensboro, Kentucky; Chillicothe, Missouri, Greenville, Mississippi, and Jackson, Tennessee.

6 N. A. Not available.

7 Outstanding orders of reporting stores at the end of January 1956 were 10 percent larger than on the corresponding date a year ago.