Region Four

Benton, Carroll, Clinton, Fountain, Montgomery, Tippecanoe, Warren, and White Counties, located in west-central Indiana, form Region Four. The region contains approximately 3,459 square miles and is bounded by Illinois to the west; Newton, Jasper, and Pulaski Counties to the north; Cass, Howard, Tipton, Boone, and Hendricks Counties to the east; and Putnam, Parke, and Vermillion Counties to the south, as shown in Figure 110.

The 1975 population of Region Four was 254,499, of which forty-four percent resided in Tippecanoe County. The official Indiana Population Projections indicate that by the year 2000 the region's population may increase by almost fourteen percent, with the greatest growth in Tippecanoe County. The 1975 population and projections for each county are presented below.

Table 79
The 1975 and projected populations for Region Four.

County	*1975*	*1980*	*1990*	*2000*
Benton	10,828	10,880	10,500	10,200
Carroll	17,962	19,100	21,000	23,200
Clinton	30,518	31,100	31,300	31,300
Fountain	18,419	19,000	19,500	19,600
Montgomery	34,444	35,100	36,700	37,600
Tippecanoe	112,408	117,600	127,000	134,100
Warren	8,290	8,600	8,700	8,800
White	21,630	23,200	25,300	27,400
Total	254,499	264,500	280,000	292,200

The major population centers within the region are Lafayette and West Lafayette in Tippecanoe County,

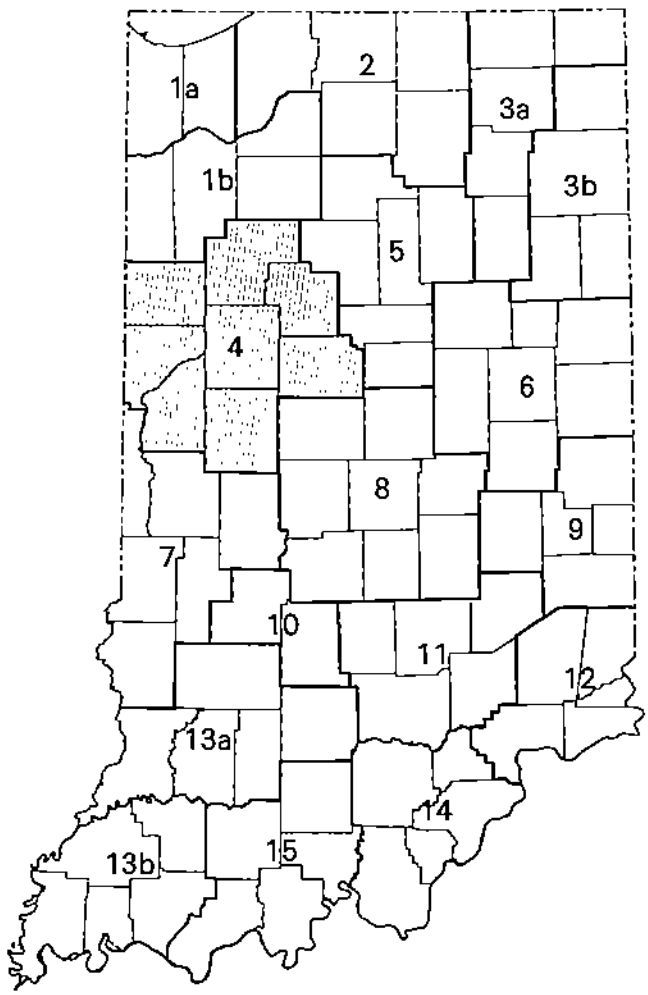

Figure 110
Map of Indiana showing the location of Region Four.

Frankfort in Clinton County, and Crawfordsville in Montgomery County. These cities accounted for thirty-seven percent of the 1975 population.

Agriculture is the dominant land use within the region with more than eighty-five percent of the area devoted to farming purposes. Approximately six percent of the land is forested, while the remaining nine percent is urban and of miscellaneous character.

Although agriculture is by far the most significant land use, it is not the major source of employment. Nonmanufacturing activities, including wholesale and retail trade, services, and government employ fifty-four percent of the work force. Manufacturing employs thirty-six percent of the work force. The three largest industrial employers are electrical machinery, primary metals, and printing. More than fifty percent of the region's work force is employed in Tippecanoe County.

The region receives approximately 37.5 inches of precipitation annually. This varies from a high of 4.3 inches in May, June, and July to a low of 2.0 inches in February. Of the 37.5 inches of precipitation, approximately 11.5 inches appear as streamflow while 26.0 inches are consumed through evapotranspiration.

Region Four has a moderate temperature with monthly averages ranging from 26°F. in January to 74°F. in July. The average annual temperature is 51.5°F. The annual prevailing wind, determined by averaging data from surrounding regions, is from the southwest at 10.0 miles per hour.

THE WATER RESOURCE

Ground Water

The occurrence of ground water in Region Four is controlled largely by the effects of glaciation, especially the Wisconsinan glacial advance. The unconsolidated deposits consist of till, outwash sand and gravel, wind-blown sand, and alluvium. The thickness of these materials varies from less than ten feet to over four hundred feet. The deeper deposits are associated with the buried Teays River Valley which contains variable amounts of glacial till, sand and gravel, and fine sand. Elsewhere, glacial till predominates in areas away from the major stream valleys, while extensive outwash and valley train sand and gravel are found adjacent to the Wabash River, Tippecanoe River, and Wildcat Creek. Windblown sand occurs at the surface in northern White County and overlies the till and outwash deposits.

In areas where the unconsolidated deposits are thin or do not contain adequate ground water supplies, wells are completed in the underlying bedrock. These sedimentary rocks range in age from the older Silurian limestone and dolomite sequence through the Pennsylvanian age sandstone, shale, and coal deposits. Silurian and Devonian limestones and dolomites make up the most important bedrock aquifers. The Mississippian and Pennsylvanian bedrock units generally have lower permeabilities and do not readily yield water.

The availability of ground water is associated with the nature and type of aquifer materials present in a given area. In this region, there is a pronounced variability in ground-water occurrence from west to east, as shown in Figure 111.

In significant portions of Benton, White, Warren, Tippecanoe, Fountain, and Montgomery Counties, the scarcity of adequate sand and gravel zones and the low water-yielding potential of the bedrock usually limits well yields to less than 100 gallons-per-minute (gpm). Several areas, most notably in northwestern White County and parts of Warren and Fountain Counties, have very poor ground-water potential. Well yields up to 10 gpm appear to be a maximum, with some dry holes reported. Potentially higher yields, of 400 to 1,000 or more gpm, are possible in areas near the Wabash River or in the buried Teays drainage system. The Teays Valley is currently under study and additional information will be available in the future. In areas around and east of Lafayette, properly constructed wells can produce from 200 to 600 gpm, with sand and gravel deposits and limestone and dolomite bedrock being the main sources of water. Well yields of up to 2,000 gpm can be obtained in saturated sand and gravel deposits associated with the Wabash River in the Lafayette and West Lafayette area.

Ground-water hardness within the region is normal (300 to 400 parts-per-million) with iron ranging from 0.2 to 1.5 ppm. Iron is low enough in Lafayette to preclude the need for iron removal while West Lafayette, across the river, controls iron by chemical treatment. Other communities having higher iron concentrations utilize iron removal plants. High sulfur concentrations exist in wells in portions of White, Carroll, Tippecanoe, and Benton Counties.

Surface Water

Streamflow Most of the region is within the Wabash River basin except northern Benton and White Counties, which are drained by the Iroquois River system. Flowing in a northeast to southwest direction, the major streams are Sugar Creek, Big Pine Creek, Wildcat Creek, Tippecanoe River, and the Wabash River. Big Pine Creek and Sugar Creek originate within the region.

The seven day, once in ten year (Q7-10); one day, once in thirty year (Q1-30); and average annual flow in million-gallons-per-day (mgd) for streams with gaging stations in Region Four are presented in Table 80.

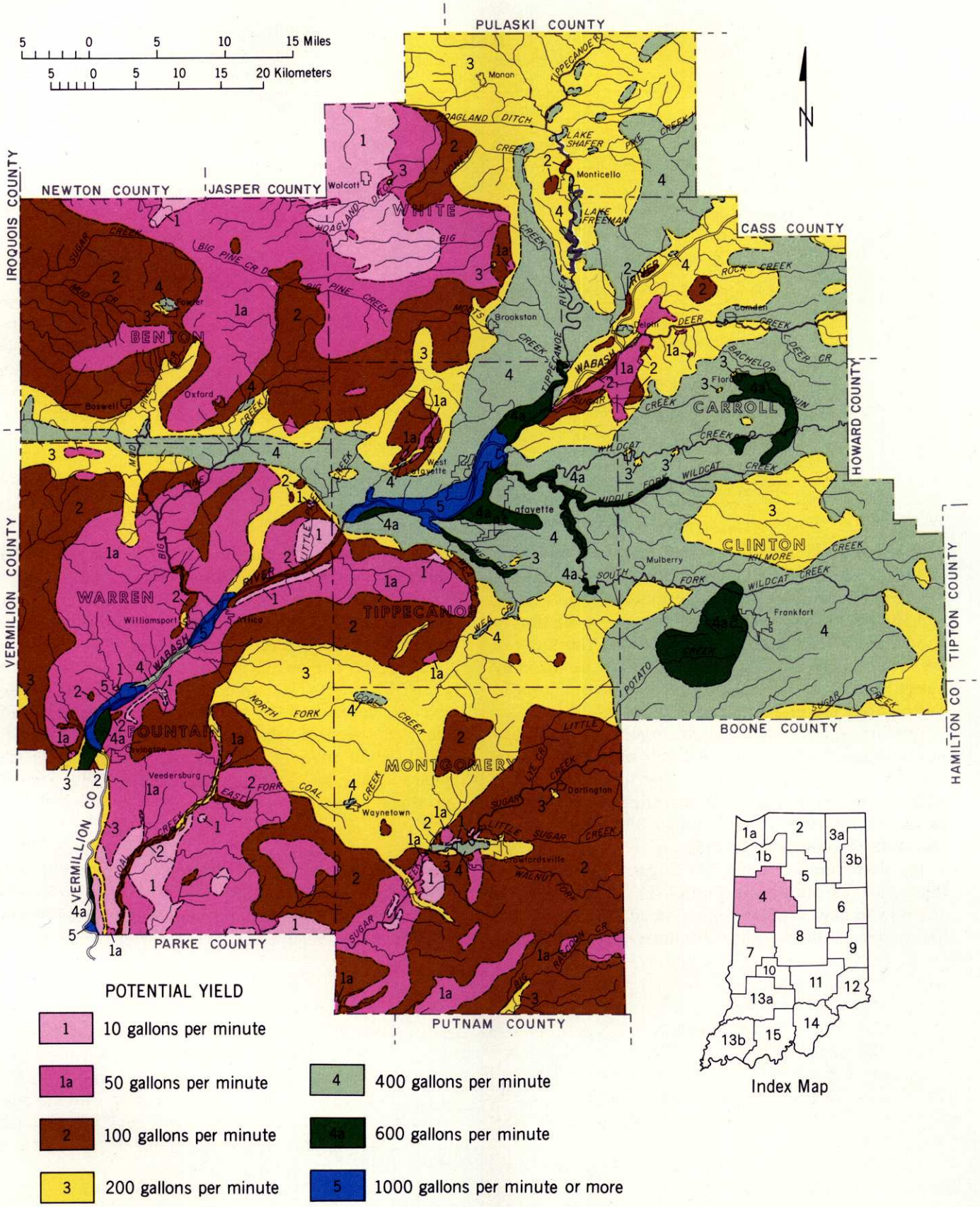

Figure 111
Map of Region Four showing the general location and potential yield of ground water from properly constructed large diameter wells.

Table 80
Flow characteristics of streams.

Stream	Drainage Area (square miles)	Million-Gallons-Per-Day		
		Average Annual	Q7-10	Q1-30
Big Pine Creek near Williamsport	323	160	5.1	3.5
Coal Creek at Coal Creek	214	na	3.0	na
Deer Creek near Delphi	274	146	6.0	4.2
Sugar Creek at Crawfordsville	509	304	4.5	2.3
Tippecanoe River at Delphi	1,865	1,040	120.0	65.0
Tippecanoe River near Monticello	1,732	960	120.0	66.0
Wabash River at Covington	8,218	4,600	460.0	340.0
Wabash River at Delphi	4,072	2,120	143.0	110.0
Wabash River at Lafayette	7,267	4,100	370.0	280.0
Wildcat Creek near Lafayette	794	470	36.0	26.0
Wildcat Creek at Owasco	396	230	12.0	7.8

na: not available.

As is typical in Indiana streams, there is a wide variability of stream flow. Flows in the Wabash River are modified by operation of the Salamonie, Mississinewa, and Huntington reservoirs, resulting in a reduction in flood flows and an increase in low flows. The flows of the lower reaches of Tippecanoe River are modified by Lakes Shafer and Freeman. Otherwise streamflows in Region Four are essentially unregulated.

The largest and most reliable streamflows are those in the Wabash River. The seven day, once in ten year, and the one day, once in thirty year low flows for the Wabash River at Delphi reveal that the river will have a sustained flow of at least 110 mgd, while the average annual flow exceeds 2,100 mdg.

The flow duration curve for Sugar Creek at Crawfordsville, as shown by Figure 112, indicates the stream will have a dependable flow of at least 18 mgd ninety percent of the time. The slope of the flow duration curve suggests that the Sugar Creek basin contains aquifers which provide significant ground-water contribution to streamflow. To verify this, the technique of hydrograph separation was applied to three annual hydrographs representing "dry," "average," and "wet" years. The results indicate that the ground-water contribution to streamflow amounts to fifty-one, twenty-five, and twelve percent for dry, average, and wet years respectively. Conversely, from forty-nine to eighty-eight percent of the flow, depending on the year, is due to direct surface runoff from runoff-producing precipitation events or from snowmelt.

Lakes The lakes within the region that are at least 50.0 acres in size or have a storage capacity of 32.5 million or more gallons are presented in Table 81 and are located on Figure 113. These thirteen lakes have a

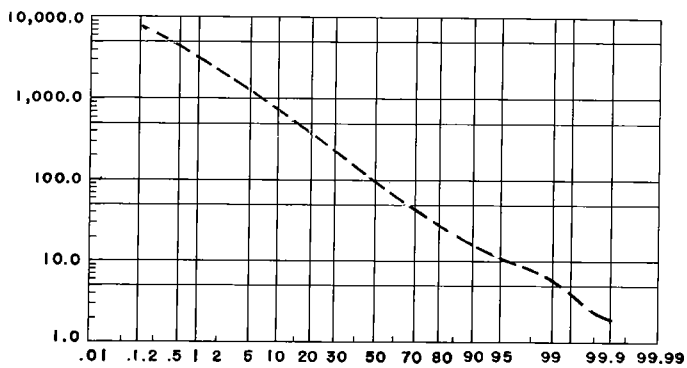

Figure 112
The flow duration curve for Sugar Creek at Crawfordsville.

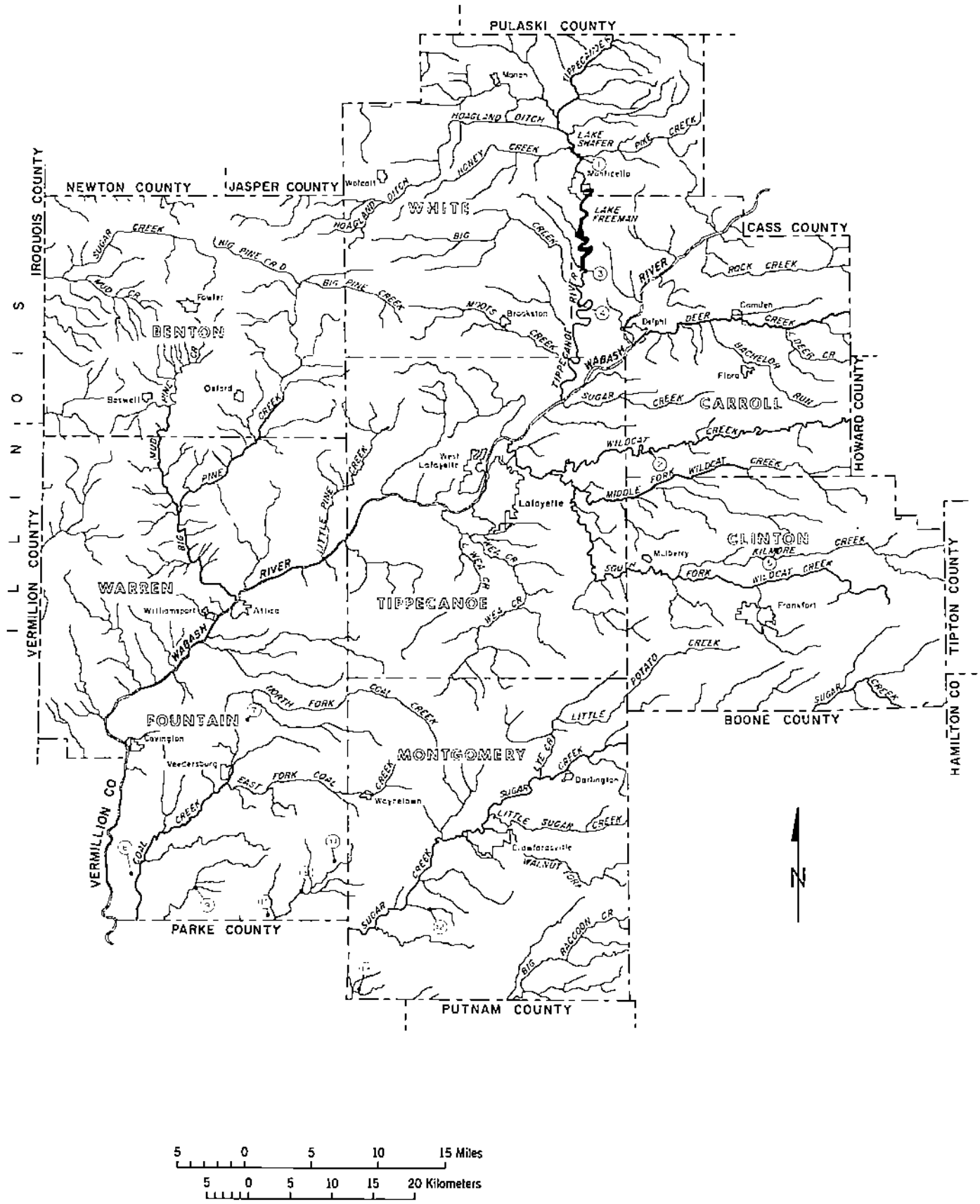

Figure 113
Map of Region Four showing the location of lakes that are at least 50.0 acres in size or that have a storage capacity of 32.5 million gallons or more.

combined surface area of approximately 3,600 acres with a gross storage capacity of 15,450 million gallons.

Lake Shafer in White County and Lake Freeman in White and Carroll Counties, both located on Tippecanoe River, are the two largest reservoirs in the region. They have a combined surface area of approximately 2,840 acres and a combined gross storage of 12,747 million gallons.

The third largest reservoir, Waveland Lake in Montgomery County, has a surface area of 360 acres and a gross storage of 1,199 million gallons.

Table 81
Lakes at least 50 acres in size or with a storage capacity of 32.5 million gallons.

Lake Number	*Lake Name*	*Drainage Area (square miles)*	*Surface Area (acres)*	*Gross Storage (million gallons)*
1	Lake Shafer	1,732.00	1,291.0	4,275
2	Knop Lake	na	na	55
3	Lake Freeman	1,792.00	1,547.0	8,472
4	Wally's Woods Lake	na	na	48
5	Little Lake	na	na	74
6	Colfing Brothers Lake	na	31.2	78
7	Harrison Lake	na	8.8	32
8	Hemlock Lake	na	31.2	58
9	Mill Creek Lake	12.10	122.0	273
10	Painter Lake	na	13.0	42
11	Sugar Mill Lake	2.50	32.3	68
12	Holiday Lake	na	182.3	793
13	Waveland Lake	11.30	358.0	1,198

na: not available

UTILIZATION OF THE WATER RESOURCE

Instream Uses

The supply and demand analysis for recreational uses of water by the residents of Region Four is presented in Table 82. The existing supply for recreational activity is expressed as a percentage of the demand. When this percentage exceeds one hundred the supply exceeds the demand. Conversely, when the supply as a percentage of demand is less than one hundred the supply will be less than the projected demand.

Boating and Waterskiing Lakes Shafer and Freeman are the largest in the region and number among the twenty largest lakes in Indiana. These lakes, in conjunction with the Wabash and Tippecanoe Rivers and Waveland Lake, make up the major recreational sites and constitute the major supply of the region's boating and waterskiing resources. It is estimated that by 1980 only seventy-two percent of the boating needs and eighty-two percent of the waterskiing needs will be met by the existing supply of open water within the region. The demand for boating and waterskiing by residents of Region Four is expected to exceed the available supply of open waters through the year 2000.

Table 82
The outdoor recreation demand and supply analysis.

Activity	*Percent of Population Participating*	*Density Guideline*	*Approximate Supply*	*Existing Supply as a Percentage of Projected Demand*		
				1980	*1990*	*2000*
Boating	24	19.6 boats/acre/year	7,500 acres	72	66	63
Waterskiing	9	34.4 skiers/acre/year	2,500 acres	82	82	81
Canoeing	13	585 canoes/mile/year	265 miles	100+	100+	100+
Swimming	39	76,600 swimmers/acre/year	11 acres	41	39	38
Ice-Skating	10	6,678 skaters/acre/year	12 acres	86	92	80
Fishing	39	66 persons/acre/year	10,200 acres	48	46	45

This table is based upon the 1979 Indiana State Outdoor Recreation Plan. Only the supply and recreational demands by residents of the region are displayed. The available recreational opportunities outside the region are not considered, nor are the recreational demands of nonresidents considered.

Canoeing Approximately 165 miles of free-flowing streams provide opportunities for canoeing. The canoeable streams include sixteen miles of Sugar Creek, forty miles of Wildcat Creek (including the North and South Forks), nineteen miles of the Tippecanoe River, seventy-five miles of the Wabash River, and fiteen miles of Big Pine Creek. Sugar Creek is probably the most popular canoeing stream in Indiana.

The available canoeing streams are more than enough to meet current and future demands. Projections for the year 2000 indicate a surplus of canoeing streams.

Swimming and Ice-Skating The supply of swimming areas, both beach and pool acreage, does not meet the current or projected demands for residents of Region Four. Estimates indicate the existing supply will meet only forty-one percent of demand by 1980 and thirty-eight percent by the year 2000.

The demand for ice-skating, including both natural and man-made acreage, exceeds the supply. A shortage of ice-skating acreage may continue through the year 2000.

Fishing The quality of the fisheries habitat is indicated in Figure 114. The size of the Tippecanoe and Wabash Rivers is primarily responsible for the excellent warmwater fisheries. Both streams offer sunfish, white bass, sauger, and catfish to sport fishermen. The majority of streams provide good aquatic habitat for warmwater fish, however, the fisheries habitat in some smaller tributaries decreases in quality in agricultural areas. Pine Creek in Warren County is known for smallmouth bass fishing. Big Raccoon Creek in Montgomery County is noted for sunfish, white bass, and catfish; and Sugar Creek for sunfish, sauger, and catfish.

The four man-made lakes: Lake Schafer, Lake Freeman, Waveland Lake, and Clingan Mill Lake, also support warmwater fisheries. Waveland Lake has the least developed shoreline and is noted for largemouth bass, other sunfish, catfish, and suckers.

Shades State Park, on Sugar Creek, offers the only state-owned access for fishing. Other access for fishing is available in city and county parks or from private boat rentals.

Approximately forty-eight percent of the fishing demand by residents of Region Four is being met. By the year 2000, nearly forty-five percent of the demand will be supplied by the fisheries resource.

Riparian Habitat The quality of the wildlife habitat associated with lakes and streams is shown in Figure 115. Wetlands along smaller streams are limited by high stream gradients and rocky stream beds. Wooded stream banks, occurring predominantly in the central and southern counties, are heavily used by upland game and various birds. Significant wetland areas are not associated with many of the lakes. Waveland Lake has the least residential development and consequently provides good wildlife habitat.

Hydroelectric Power The Northern Indiana Public Service Company operates two hydroelectric plants on the Tippecanoe River. These plants are located in the dams of Lakes Freeman and Shafer and are known as the Oakdale Plant and Norway Plant respectively. Their combined power capacities are only ten megawatts (mw). Due to the limitations of topography and streamflow characteristics, no future commercial hydroelectric developments are anticipated.

Withdrawal Uses

Public Water Supplies The eight counties of Region Four are served by forty-nine public water utilities. An estimated 157,800 or sixty-two percent of the population was served by a public utility in 1975. Information about public water systems is tabulated below. Figure 116 shows the water service areas.

Table 83
The 1975 public water supply system.

County	*Number of Systems*	*Service Population*	*Total Average Daily Use in Million-Gallons-Per-Day*
Benton	6	6,200	.62
Carroll	3	4,900	.69
Clinton	5	17,600	3.78
Fountain	5	9,800	1.64
Montgomery	9	19,400	2.19
Tippecanoe	11	86,800	14.53
Warren	3	2,500	.20
White	7	10,600	1.52
Total	49	157,800	25.17

Forty-one of the public water utilities primarily serve a particular city or town. Seven serve suburban developments near or within existing municipalities. One of these subdivision systems is near Monticello in White County while the other six are in or near Lafayette and West Lafayette in Tippecanoe County. A special category of public water supply is Purdue University's self-supplied system in West Lafayette.

The public water utilities withdrew an average of 25.2 mgd, with ten percent consumption in 1975. All systems obtain their water from ground water derived from well fields usually located within the limits of the city or subdivision.

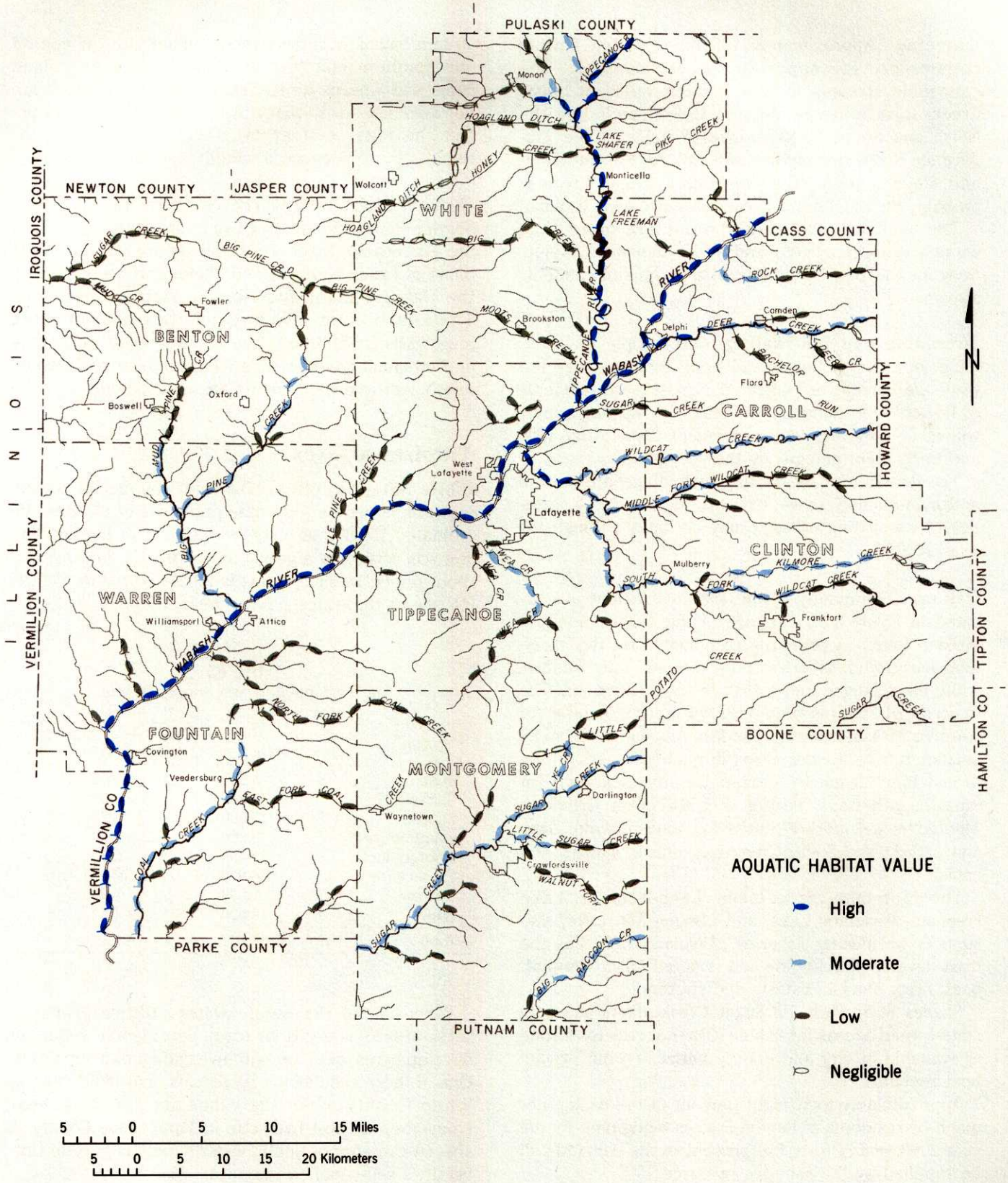

Figure 114
Map of Region Four showing the quality of the fisheries habitat.

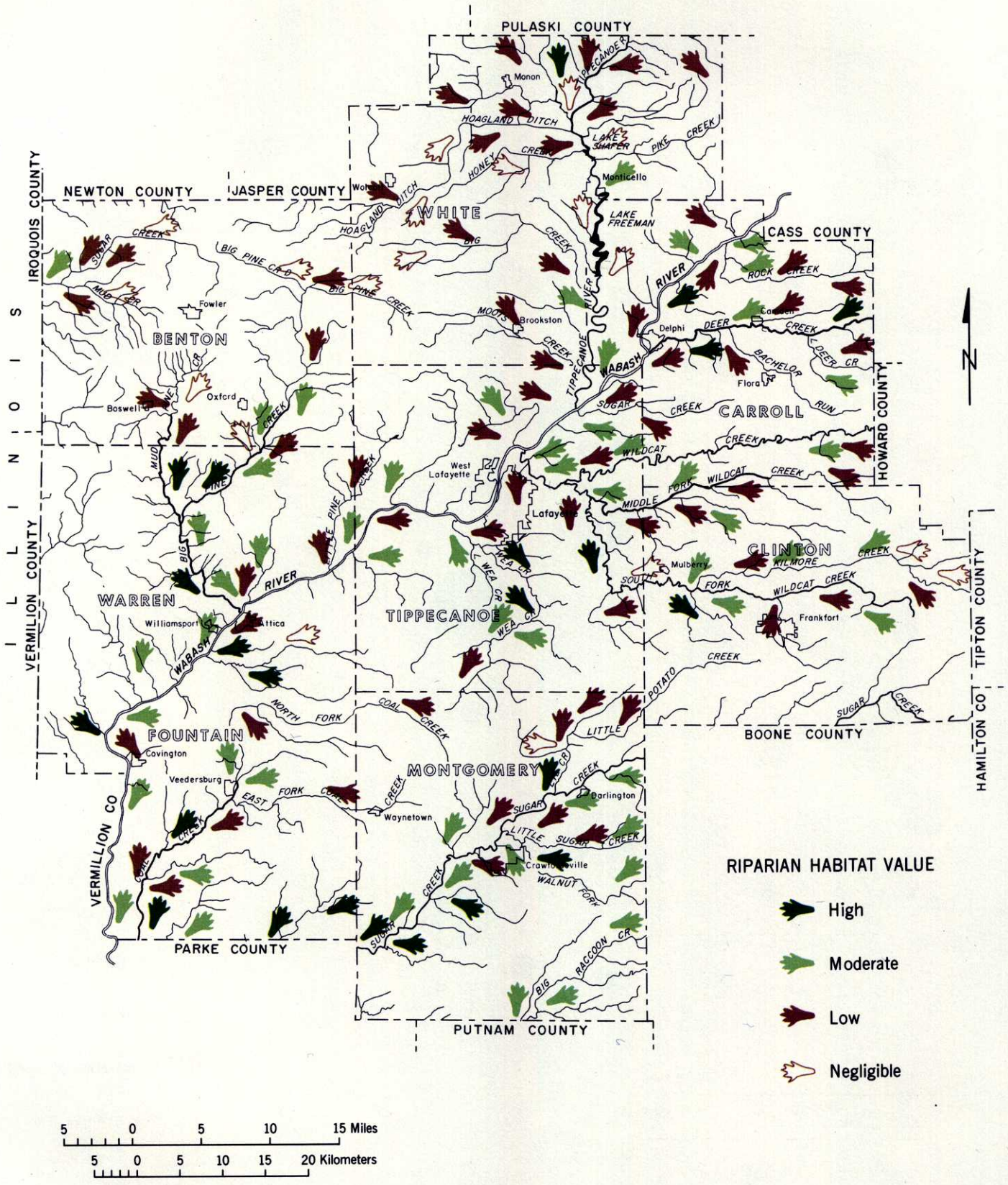

Figure 115
Map of Region Four showing the quality of the riparian habitat.

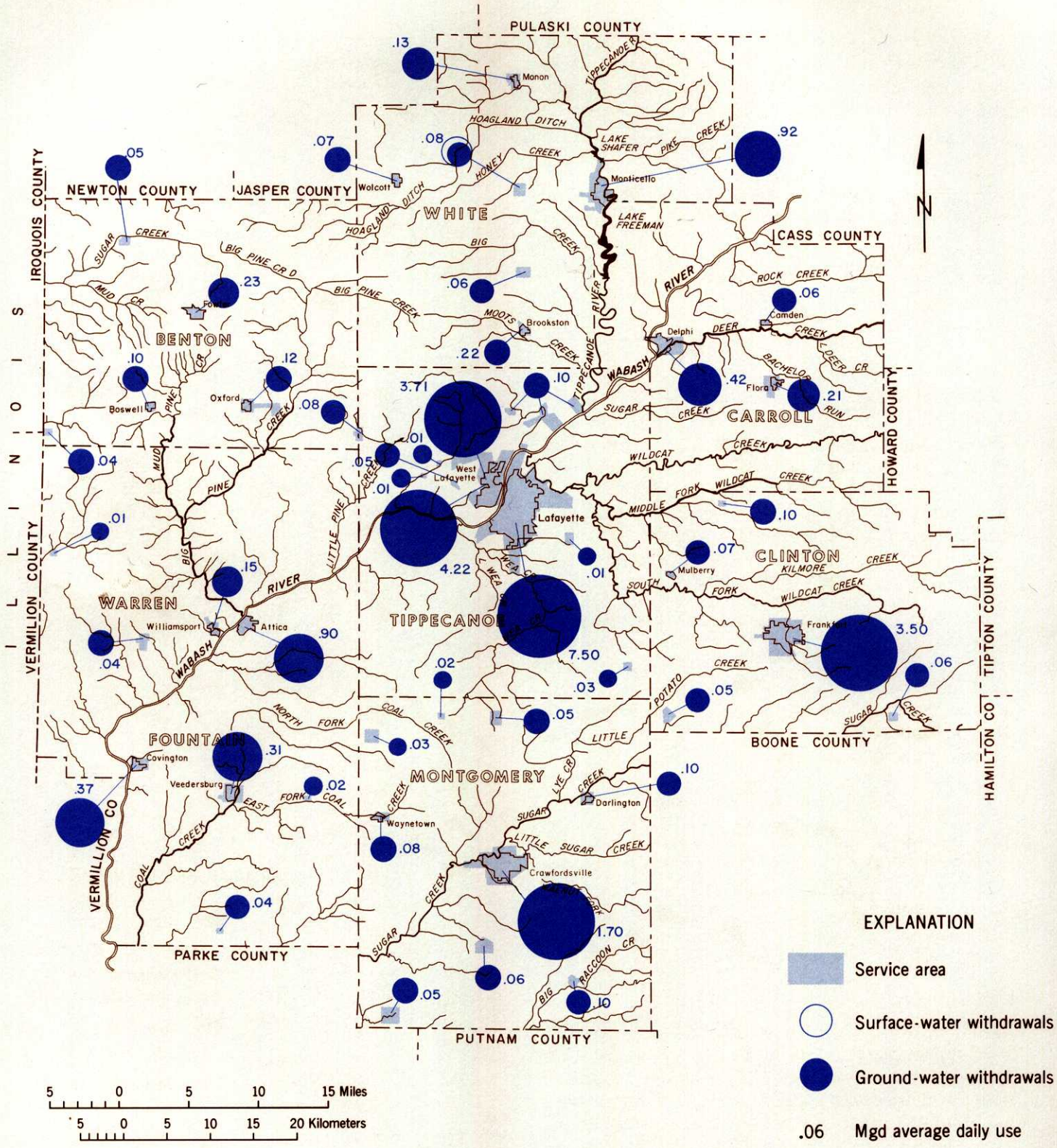

Figure 116
Map of Region Four showing the service areas of the public water utilities and average daily use in million-gallons-per-day.