DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MICHIGAN GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-333 (SHEET 1 OF 2)

INTRODUCTION

The cold-water streams of the northern states provide unique recreational values to the American people (wilderness or semi-wilderness atmosphere, fast-water canoeing, and trout fishing), but the expanding recreational needs must be balanced against the growing demand of water for public and industrial supplies, for irrigation, and for the dilution of sewage and other wastes. In order to make intelligent decisions regarding use and management of the water resource for recreation and other demands, an analysis of the hydrologic factors related to recreational values is essential.

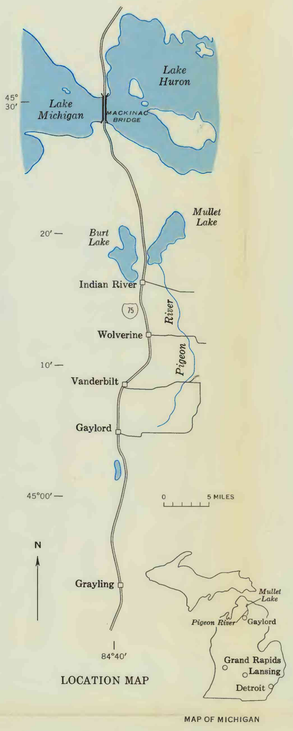
The Pigeon River is one of Michigan's outstanding trout streams and is the favorite of a large number of anglers who return year after year. Camping is also popular and is usually, but not always, associated with fishing. Boating is very rare on the Pigeon because of numerous portages around log jams. Cabin-living and resorting are relatively minor on this river as yet, but much of the private river front may be developed in future years.

The Pigeon is located in the north-central part of the southern peninsula of Michigan (see index map). Headwaters are a few miles northeast of Gaylord, and the mouth is at Mullet Lake, a few miles northeast of Indian River. Interstate Highway 75 roughly parallels the river about 5 to 10 miles to the west. Exits from this highway at Gaylord, Vanderbilt, Wolverine, and Indian River, provide easy access to the Pigeon.

The recreational value of the river depends on the streamflow characteristics, quality of water, and character of stream channel, and bed and banks. The purpose of this atlas is to describe these characteristics, and to show how they relate to recreational uses.

Most of the information presented here was obtained from a field reconnaissance in June, 1966, and from basic records of the U.S. Geological Survey's Water Resources Division. The area of field study is limited to the channel, bed, and banks of the main stem of the Pigeon from source to mouth. The study was made in cooperation with the Michigan Geological Survey, Gerald E. Eddy, Chief. Advice and assistance were also obtained from other sections of the Michigan Conservation Department.

Sheet 1 of this atlas presents information on streamflow characteristics and water quality. Sheet 2 describes the physical characteristics of the stream channel, and bed and banks, and shows how these physical characteristics relate to streamflow, water quality, and recreational use.



LOCATION MAP

MAP OF MICHIGAN

GEOLOGIC SETTING

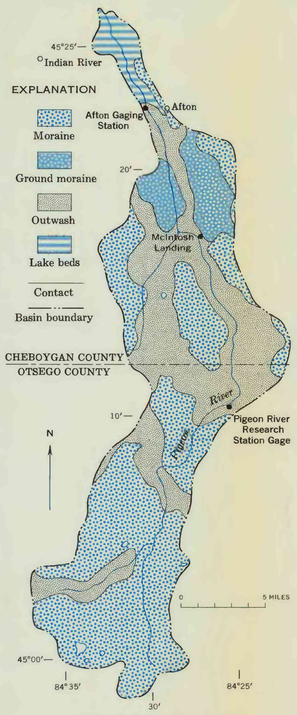
The headwaters of the Pigeon River flow northward down the inner slope of a prominent moraine* that was deposited in front of the Port Huron ice sheet some 13,000 years ago. The crest of this ridge forms the drainage divide between the Pigeon on the north and the Au Sable on the south. The Pigeon continues generally northward, cutting through a series of lesser morainal ridges left by the retreating ice. Between the ridges are terraces of sand and gravel outwash deposited by meltwaters. A few miles north of Afton, the Pigeon crosses an area of sandy lake beds that were laid down in ponded meltwater south of the ice front (Map 2, Sheet 2). The mantle of glacial drift is relatively thin from McIntosh landing to a few miles below Afton, and limestone bedrock is exposed in a few places (Map 2, Sheet 2).

The steep slopes of the moraine at the headwaters of the Pigeon contribute a large amount of surface runoff during periods of heavy rain and spring snow melt. The headwaters also receive a large contribution of ground water, part of which probably is derived from the broad area of outwash south of the Pigeon watershed. Downstream, the moraine areas contribute a moderate amount of surface runoff but relatively little ground-water discharge; the areas of sand and gravel (Map 2, Sheet 2) contribute a moderate amount of ground-water discharge but relatively little surface runoff.

The amount of ground-water discharging to any segment of a stream is controlled chiefly by climate and the nature and thickness of the materials underlying the basin and adjacent basins, and the topography of the basin and surrounding areas. The interrelationship of these factors is complex and can be fully understood only by studying the geology and hydrology of the area in detail. Preliminary studies on the Pigeon River indicate that ground-water inflow varies considerably in different segments of the stream, and that there may be a considerable flow of ground water from one basin to another.

Ground-water discharge is important to the recreational values of the river, because ground water is the principal source of water in the stream during rainless periods. Ground water is also a major control of water temperatures. Segments of the river where ground-water discharge is great generally are cooler in summer and warmer in winter than segments where ground-water discharge is small.

*For definition of geohydrologic terms, see GLOSSARY, in lower-right corner of sheet.

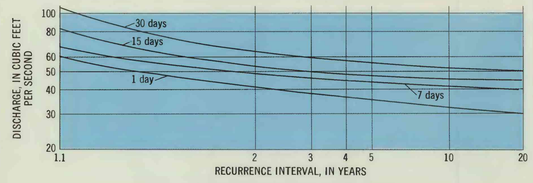


SURFICIAL GEOLOGIC MAP

STREAMFLOW

FREQUENCY OF LOW FLOW ON THE PIGEON RIVER NEAR VANDERBILT, MICHIGAN

The frequency of deficient flow periods on the Pigeon River are of interest to recreationists, because periods of excessively low-flow are generally unfavorable for most recreational uses. A discharge of less than 50 cfs on the Pigeon at this station generally is unfavorable for fishing or canoeing. The graph below shows frequency curves of low flow for periods of 1, 7, 15, and 30 days, occurring during the six months May through October, on the Pigeon River at the Trout Research Station near Vanderbilt (see sheet 2). The graph shows that a discharge no greater than 50 cfs for 7 consecutive days can be expected about once every 2 years during the period May through October. About once every 5 years there will be a discharge no greater than 50 cfs for 15 consecutive days. Thirty consecutive days of discharge no greater than 50 cfs will occur only about once in 20 years.

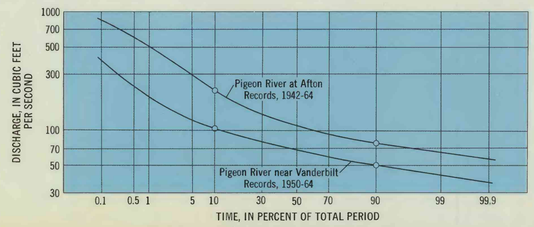


GRAPH SHOWING FREQUENCY OF LOW FLOW

FLOW-DURATION CURVES

Discharge characteristics of streams can also be illustrated graphically by flow duration curves that show the percentage of time that specified discharges are equaled or exceeded during a given period. Flow duration curves for the Pigeon River near Vanderbilt and at Afton are illustrated below.

The curves show that 10 percent of the time the discharge of the Pigeon is equal or greater than 105 cfs near Vanderbilt and 205 cfs at Afton. Ninety percent of the time the discharge is equal or greater than 50 cfs near Vanderbilt and 80 cfs at Afton.



GRAPH SHOWING FLOW-DURATION CURVES

STREAMFLOW

SUMMARY

The following table summarizes the streamflow characteristics of the Pigeon River and shows how these characteristics are related to recreational uses.

Recreational use	Relation of streamflow to recreational use (Prepared by the Michigan Department of Conservation)	Characteristics of Pigeon River
Trout fishing	High drought flow helps keep summer water temperatures low. Excessive floodflow removes cover and may cause erosion of banks	Relatively high drought flow per unit drainage area in upper reaches. Drought flow relatively lower in lower reaches. Floodflows may cause some damage to river
	A variety of fast and slow reaches adds interest to fishermen. Excessively high velocities make wading dangerous	Velocity variable in different reaches. Velocity not too fast for safe wading in most reaches, except at flood times
	Abrupt and large increases in stage are a hazard to wading fishermen	Increases in stage generally moderate. Increases may be abrupt when water is released from Lansing Club dam
Boating	Boating season reduced by periods of flood and drought	Flood season usually over before vacation season. Late summer drought flows discourage boating in much of river
	A variety of fast and slow reaches adds interest to boaters	Velocity variable in different reaches
	Small velocity makes upstream travel easier	Velocity too fast for easy upstream travel in most reaches of river
Camping and cabin living	Streamflow characteristics favorable to fishing and boating also are generally favorable to camping and cabin living	See descriptions above

QUALITY OF WATER

SUMMARY

The following table summarizes the quality of water characteristics of the Pigeon River and shows how these characteristics are related to recreational uses.

Recreational use	Relation of quality of water to recreational use	Quality of water in Pigeon River
Trout fishing	Temperature Criteria for intrastate waters, as established January, 1968, by the Water Resources Commission, Michigan Department of Conservation (1968) specify 70°F (21.1°C) as the maximum limit for intolerant fish (cold-water species)	Maximum temperatures of the Pigeon at Trout Research Station exceed 70°F (21.1°C) during summer months
	Dissolved Oxygen The Water Resources Commission (1968) specifies a minimum of 6 ppm. At water temperatures above 68°F (20°C), Tarzwell (1957) indicated full air saturation is required for the full range of activity for brook trout	Dissolved oxygen in the Pigeon probably does not drop below 6 ppm at any time. At night may drop 3 to 4 ppm below saturation
	Hydrogen Ion Cencentration (pH) Water Resources Commission (1968) specifies limits of 6.5 and 8.8	pH of Pigeon River generally ranges from 7.5 to 8.5
	Nutrients (chiefly nitrates and phosphates) Water Resources Commission (1968) requires nutrients to be limited to the extent necessary to prevent stimulation of growths of algae, weeds, and slime, which are or may become injurious to the designated use. Because these nutrients are rather quickly taken up by plants, exact limits of desirable concentrations are difficult to determine	Pigeon River is generally free of undesirable weeds, algae, and slime
Trout fishing, boating, camping, and cabin-living	Floating, Settleable, and Suspended Solids Water Resources Commission (1968) specifies no objectionable unnatural turbidity, color, or deposits sufficient to interfere with designated use; no floating solids, or evidence of residues of unnatural origin	Pigeon River generally appears to be free of floating solids and residues of unnatural origin except for occasional clumps of floating algae which probably originate in the pond above Lansing Club dam. Turbidity and color generally are low

OUTLOOK FOR RECREATION IN THE FUTURE

Pollution, which would affect trout propagation, and population, and aesthetic values, is not a problem at this time. No municipal sewage-disposal systems empty into the river and the few cabins and resorts now located near the river do not add significant quantities of wastes or nutrients to the river. The large area of State-owned lands in the middle part of the basin is protected from future overdevelopment. Development on private lands near the river will probably increase in the future, especially in the northern part of the basin. This development may affect the quality of the river's water.

Warm water temperature, which adversely affects trout propagation and population, is a problem at this time in the northern reaches of the river. Small ground-water inflow in parts of the northern reaches probably cause the warming of the water. Impoundments may also cause water temperature to rise. The problem of small ground-water inflow probably cannot be fully solved. Removal of tree cover adjacent to the river and additional ponding of the river could cause additional warming of the river's water. Reforestation of the few open parts of the river might cause a slight cooling of the water.

Sand bottoms, which adversely affect trout propagation and population, occur in several reaches throughout the length of the river. Addition of significant amounts of sand to the river by erosion, caused by man's activities or natural phenomena, would reduce the trout population.

The many portages required to circumvent fallen trees and log jams have discouraged boating on the river. Clearing the river of these obstacles would make boating more popular, but would also reduce trout cover. The clearing of the fallen trees and log jams would also have some effects on the hydraulics and bottom sediment of the river. However, the nature and extent of the effects would not be known until the clearing was accomplished.

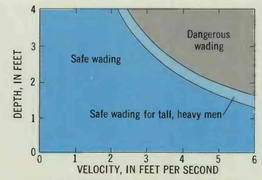
STREAMFLOW

VELOCITY

Velocity of flow of the Pigeon River varies in time and place. Increased discharge generally is accompanied by increased velocity. Velocity generally is faster near the surface at midstream than near the bottom or banks of the river. Velocity is obviously faster in rapids and riffles than in deep pools (Map 1, Sheet 2). Midstream velocities in several riffles and pools on the Pigeon on July 18, 1966 are listed below:

Location (see Map 1, Sheet 2)	Midstream velocity in riffle, in feet per second	Midstream velocity in pool, in feet per second
Near Bridge north of Sparr on N-S road on east line sec. 29 (between sections 28 and 29) T. 31 N., R. 2 W.	1.94	0.16
Near Bridge in SW¼ sec. 25, T. 32 N., R. 2 W. (Old Vanderbilt Road)	1.94	.35
Near Pigeon River Bridge on north line sec. 20, T. 32 N., R. 1 W.	3.73	.66
Near Bridge (Tin Bridge) in NE¼ sec. 28, T. 33 N., R. 1 W.	3.98	.41
Near Bridge (Red Bridge) on north line sec. 8, T. 33 N., R. 1 W.	2.82	.22
Near Bridge on north line sec. 24, T. 34 N., R. 2 W. (Pigeon River Road)	2.8	1.2
Near Access site at east end of dirt road along north line of sec. 27, T. 35 N., R. 2 W.	5.8	.7

A rule of thumb for safe wading velocities is that depth in feet, multiplied by velocity in feet per second, should not be greater than 10. For example, at station 7 (above) the midstream velocity was 5.8 feet per second. At this velocity, the fisherman should not wade into water more than 1.7 feet deep. This assumes a firm bottom. If bottom material is slippery clay, even one foot may be too deep. Fortunately, clay bottoms on the Pigeon River are present only in a very short reach north of Afton (Map 2, Sheet 2).



GRAPH SHOWING RELATION OF DEPTH AND VELOCITY TO WADING

QUALITY OF WATER

INTRODUCTION

The quality of water in a river is expressed in terms of dissolved and suspended substances and in physical properties of the water. Dissolved substances are the solids (salts) and gases in the water. Suspended materials include all undissolved materials, chiefly clay, silt, sand, and organic material moved in the stream. Physical properties important to recreational values are temperature, pH, specific conductance, odor, and color

TEMPERATURE

Continuous temperature records on the Pigeon River at the Trout Research Station near Vanderbilt have been collected since October, 1950. Monthly high and low temperatures for the period 1957-66 are shown at right. The maximum summer temperatures, greater than 70°F, at this station are too high for the best trout water. The high summer temperatures at this station may be attributed in part to relatively low ground-water inflow in this reach of river (normal shallow ground-water temperature in this area is about 48°F). Another possible cause of high temperature could be the warming of the water in the pond above the Lansing Club dam. Simultaneous measurements of water temperatures at the bridges above and below this pond on July 22, 1966, showed a rise in temperature of 7° to 9°F in this reach of river.

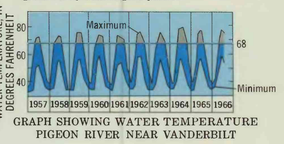
The vegetation on the banks of a river also affects water temperatures. Tall trees, which shade the water from the sun, help keep the water cool. Low brush or grasslands allow the sun to shine directly on the water and cause a warming of the water. Because trees line the banks along most of the Pigeon River (Map 3, Sheet 2) the effect of the sun on water temperatures is probably not as great as the effect caused by lack of ground-water inflow and impoundments.

Maximum and minimum temperatures in four study areas on the Pigeon recorded in July, 1951 (Benson, 1953, p. 270) are shown in the graphs at right. These records showed increasing temperatures downstream, which were attributed to reduced ground-water inflow. Inflow, determined by discharge measurements, was much higher in the upstream areas than in downstream areas. Trout populations and spawning areas were substantially greater in the two upstream areas where ground-water inflow kept the water cool.

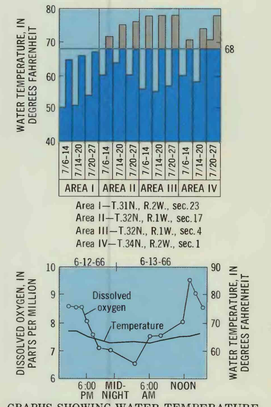
DISSOLVED OXYGEN

Dissolved oxygen in the Pigeon varies with temperature, and during the growing season, with the intensity of plant photosynthesis and respiration. As temperature increases, the solubility of oxygen in water decreases. Thus, other things being equal, colder waters contain higher concentrations of dissolved oxygen than do warmer waters. Ground water entering the stream contains no dissolved oxygen, but in summer the cooling that results from addition of ground water makes possible a greater oxygen content. The warming of the water as the percentage of ground-water flow decreases downstream probably results in a decline in dissolved oxygen content.

During daylight hours, plants give off oxygen; at night they use up a small amount of oxygen. In the graph below the temperature effect on the amount of dissolved oxygen is masked by oxygen given off by submergent plants.



GRAPH SHOWING WATER TEMPERATURE PIGEON RIVER NEAR VANDERBILT



GRAPHS SHOWING WATER TEMPERATURE AND DISSOLVED OXYGEN, PIGEON RIVER AT PIGEON RIVER BRIDGE

STREAMFLOW

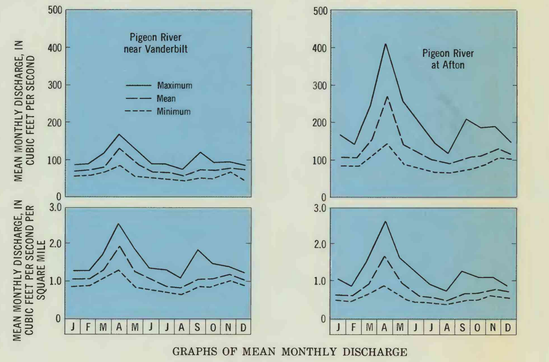
INTRODUCTION

The flow of any uncontrolled river varies from day to day and from year to year. This variation may be measured in units of discharge (volume of water discharged per unit of time), velocity (speed of movement of water), and stage (elevation of water surface). These units are related—a high discharge results in high stages and, usually, in high velocities. Velocity also varies in different reaches of the river, the velocity generally being greater in reaches of steep fall than in the flatter reaches. The gradients of the reaches of the river are shown on the river profile (Sheet 2).

DISCHARGE

Daily discharge of the Pigeon River is recorded at two gaging stations—one at the Trout Research Station 13 miles east of Vanderbilt, and one at the bridge on State Highway 68 near Afton (Map 1, Sheet 2). Records of mean monthly discharge at the two stations for the period October, 1951 through September 1965, are shown below. Discharge is shown in cubic feet per second (cfs) and cubic feet per second per square mile (cfsm). The highest rates of discharge normally occur during the spring snowmelt season—usually in April. Discharge generally declines through the summer months and remains fairly low through fall and winter. However, fall rains after killing frosts often cause a moderate increase in discharge, and unusually heavy rains may bring high discharge at any season. Abrupt changes in discharge may occur at times when water is released at the Lansing Club dam.

Discharges, expressed in terms of cubic feet per second per square mile, are used to compare the flow of streams having different drainage areas, or to compare different stations on the same stream. A comparison of the two stations on the Pigeon shows that the discharge at the upstream station per unit surface drainage area usually is higher except during extremely high flows, than the discharge per unit area at the lower station. This is attributed chiefly to the larger contribution from ground-water sources from the upper than from the lower reaches and is partly the result of a larger ground-water contributing area than is indicated by the surface divide. The large ground-water discharge is not only important in maintaining a stable flow in the upper Pigeon during dry periods, but is equally important in keeping the water cool during hot summer days.

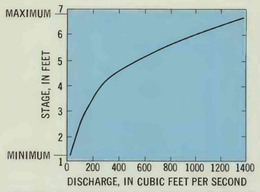


GRAPHS OF MEAN MONTHLY DISCHARGE

STREAMFLOW

STAGE

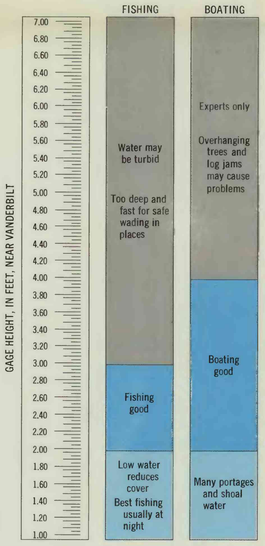
The stage, or water level, of the Pigeon fluctuates with discharge. This correlation is used to interpolate the discharge of the river between measurements. For a given change in discharge, fluctuations in stage are relatively large where the river channel is narrow, and the banks are high, and relatively small where the channel is broad and the banks are low. Channel width and bank heights are shown on Maps 1 and 3, Sheet 2.



GRAPH OF MAXIMUM AND MINIMUM STAGE

The above graph shows maximum and minimum stages recorded at the Pigeon River station near Vanderbilt for the period of record (1950-66). The record high stage was caused by the failure of the Lansing Club dam on May 15, 1957. High stages in the Pigeon usually occur during the spring snowmelt, and the river does not normally rise high enough to cause any considerable damage to cabins or campgrounds.

The staff gages on the Pigeon can be used as an aid to determine the suitability of the river for fishing and canoeing. This illustration should be used with discretion, because other factors than stage influence the suitability of the river for these recreational uses. For example, the position of log jams and number of fallen trees change from year to year and these hazards could be dangerous at any water level.



GAGE HEIGHT RELATED TO RECREATION USE

QUALITY OF WATER

pH

The pH of water is an indicator of its acidity or alkalinity. Waters with a pH of 7 are said to be neutral. A pH lower than 7 indicates acid water; a pH above 7 indicates alkaline water. The water of the Pigeon is moderately alkaline, with pH values from about 7.5 to 8.5

DISSOLVED SOLIDS

Chemical analyses of water from the Pigeon River are listed below. The water is moderately hard, of the calcium bicarbonate type, and dissolved solids are in the normal range for an unpolluted stream in this area. Nitrates and phosphates are low in all samples. Location of sampling sites shown on Map 1, Sheet 2.

SUSPENDED AND FLOATING SOLIDS

Suspended solids in the Pigeon were not measured in this study. Turbidity, an index of suspended materials, was apparently low during most of the summer season as the bottom was clearly visible at depths up to 3 feet. During the spring high water season when relatively large amounts of overland runoff reach the river turbidities are higher. Possibly more important than the apparent turbidity is the sand and silt moved along the bottom of the river which may cover gravel spawning beds. No measure of movement of this material was made, but fishermen long familiar with the river reported that many areas of gravel bottom have been covered with sand. No reports were received of former sandy areas that have been eroded to expose gravel beds. Floating clumps of algae, probably originating in the pond above Lansing Club dam cause odor problems.

SPECIFIC CONDUCTANCE

The specific conductance of water is an indicator of concentration of dissolved solids. It is useful in measuring changes in the dissolved load of a stream. During the period October 1965, to February, 1967, the water from the Pigeon at the gaging station near Vanderbilt fluctuated in specific conductance between 220 and 380 micromhos. Fluctuations showed no apparent relationship to discharge.

	Afton 4/27/66	Pigeon River Campsite 4/16/66	Trout Research Station 4/17/66	Trout Research Station 2/02/67
Calcium (Ca) ppm	52	47	46	—
Magnesium (Mg) ppm	13	18	16	—
Sodium (Na) ppm	2.9	2.0	1.5	—
Potassium (K) ppm	.6	.2	.4	—
Bicarbonate (HCO_3) ppm	208	222	210	220
Carbonate (CO_3) ppm	0	0	0	—
Sulfate (SO_4) ppm	12	11	12	14
Chloride (Cl) ppm	3.0	3.0	1.0	17
Flouride (F) ppm	.2	.2	.1	—
Nitrate (NO_3) ppm	.3	.2	.2	.6
Phosphorous as PO_4 ppm	.03	.26	.05	—
Dissolved solids* ppm	193	200	—	—
Hardness as $CaCO_3$ ppm	183	191	—	—
Specific Conductance**	338	358	—	—
pH	8.0	7.5	—	—

* Calculated
** Micromhos per centimeter at 25°C

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GLOSSARY

Discharge.....Rate of flow in volume per unit of time.
Ground moraine....Gently rolling hills underlain by till. Usually lack the ridgelike character of moraines.
Ground water.....Water in permeable earth materials in the zone of saturation—below the water table.
Lake beds (glacial)..The bottom surface of abandoned lakes that were formed by glacial meltwaters. Usually underlain by layered deposits of sand, silt, and clay.
Moraine.....Hills or ridges composed of glacial till
Outwash.....Sorted and bedded glacial drift deposited by meltwater streams beyond active glacial ice.
Riffle.....A shallow extending across the bed of a river; a small rapid.
Stage.....Elevation of water surface above any chosen datum plane; water level; gage height.
Till.....Mixture of clay, silt, sand, gravel, and stones deposited directly by glacial ice with little or no sorting by meltwaters.
Turbidity.....Cloudiness of water.

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RECONNAISSANCE OF THE PIGEON RIVER, A COLD-WATER RIVER IN THE NORTHCENTRAL PART OF MICHIGAN'S SOUTHERN PENINSULA

By
G. E. Hendrickson and C. J. Doonan

1970

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