DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MICHIGAN GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-354 (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, 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.

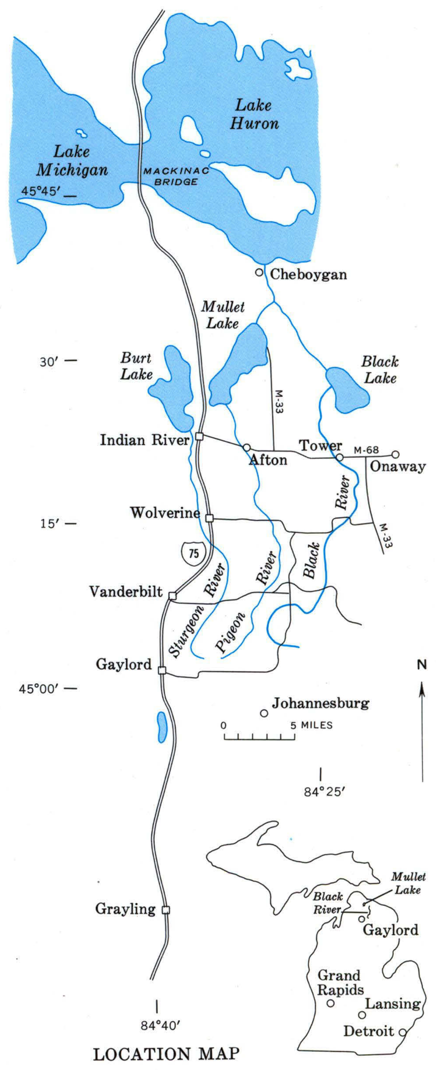
The Black River north of Johannesburg in Otsego County has been rated by many fisherman as the number one brook-trout stream in the north-central part of the southern peninsula of Michigan. Headwaters are a few miles north of Johannesburg, and the Black flows northward to join the Cheboygan river a few miles south of Cheyboygan. Only the part of the Black upstream from the impoundment at Tower is included in this report.

The headwaters of the Black can be reached by driving east and north from Gaylord, or east from Vanderbilt. The lower reaches included in this study can be reached from Tower or Onaway.

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

Some of the information presented here was derived from basic records of the U.S. Geological Survey's Water-Resources Division. Additional information was obtained in field reconnaissance surveys in 1966 and 1968. 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 character of the stream channel, bed and banks, and shows how it relates to streamflow, water quality, and recreational use.



LOCATION MAP

MAP OF MICHIGAN

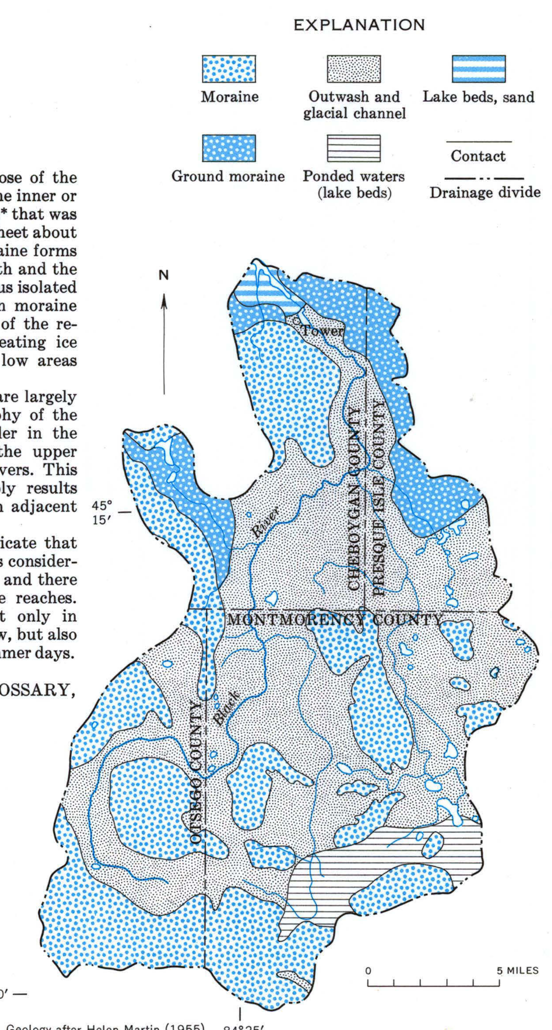
GEOLOGIC SETTING

The headwaters of the Black, like those of the Sturgeon and Pigeon to the west, front the inner or northern slope of the Port Huron moraine* that was deposited in front of the Port Huron ice sheet about 13,000 years ago. The crest of this moraine forms the divide between the Black on the north and the Au Sable drainage on the south. Numerous isolated morainal areas north of the Port Huron moraine were deposited during temporary halts of the retreating ice. Meltwaters from the retreating ice deposited sand and gravel outwash in low areas between the moraines.

The flow characteristics of the Black are largely controlled by the geology and topography of the basin. Ground-water discharge is smaller in the upper reaches of the Black than in the upper reaches of the Sturgeon and Pigeon Rivers. This smaller ground-water discharge probably results from a smaller inflow to the Black from adjacent basins to the south.

Preliminary studies on the Black indicate that the amount of ground-water inflow varies considerably in different segments of the stream, and there is a net loss from the stream in some reaches. Ground-water inflow is important, not only in maintaining a relatively high drought flow, but also in keeping the water cool during hot summer days.

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



SURFICIAL GEOLOGIC MAP

STREAMFLOW

INTRODUCTION

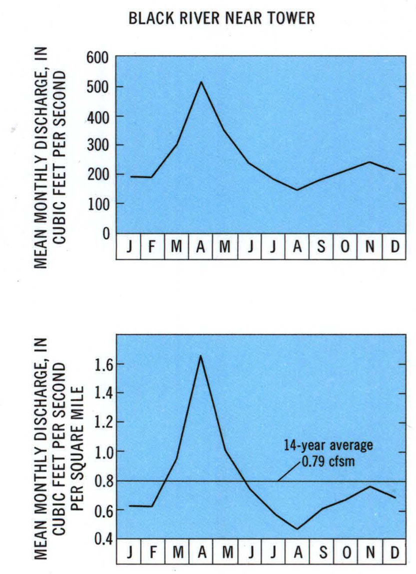
The flow of any uncontrolled river varies from day to day and from year to year. This variation may be measured in units of discharge (volume of water discharged per unit of time), velocity (speed of movement of water), and stage (elevation of water surface). These units are related—a high discharge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

DISCHARGE

Daily discharge of the Black River is recorded at a station 400 feet downstream from Kleeber Dam near Tower. Because the flow here is regulated by the power dam, the natural flow of the unregulated river above Tower is not precisely indicated. However, the volume of control is not large enough to drastically affect the mean monthly discharge shown here. 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 normally declines through late spring and summer and remains relatively low during the winter.

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 sections of the same stream. The discharge on the Black averaged 0.79 cfsm during the period 1952 to 1966. This is about average for rivers of the lower peninsula, but lower than the discharge of the nearby Sturgeon and Pigeon rivers. The geology and topography of the Black River basin would suggest a relatively high ground-water discharge to the Black, but it appears that the contributing area of ground-water inflow is relatively small, and water is lost in some reaches—possibly flowing northwesterly into the Pigeon River basin.

A series of measurements was made at seven points on the main stem of the Black and one point on the East Branch of the Black on July 18, 1966, to determine the relative discharge per unit drainage area when the flow was almost entirely derived from ground-water discharge. Results of these measurements are tabulated at the top of the next column.



GRAPHS OF MEAN MONTHLY DISCHARGE

STREAMFLOW

DISCHARGE (CONTINUED)

Location	Approximate drainage area (square miles)	Discharge	
		cfs	cfsm
NW¼NE¼ sec. 27, T.31 N., R.1 W., near Johnson's Crossing, 13.1 miles southeast of Vanderbilt, Mich.	12	4.18	0.35
NE¼SE¼ sec. 32, T.32 N., R.1 W., 10.7 miles east of Vanderbilt, Mich.	45	17.2	.38
NW¼NW¼ sec. 35, T.32 N., R.1 W., at Tin Shanty Bridge, 12.5 miles east of Vanderbilt, Mich.	50	16.5	.33
NW¼NW¼ sec. 21, T.32 N., R.1 E., at Main River Bridge, 14 miles south of Tower, Mich.	80	30.1	.38
NW¼NE¼ sec. 22, T.32 N., R.1 E., at Barber Bridge, 12.8 miles northwest of Atlanta, Mich.	45	27.2	.60
NE¼NE¼ sec. 29, T.33 N., R.1 E., at bridge on Clark Bridge Rd., 9.2 miles south of Tower, Mich.	150	71.7	.48
SW¼NW¼ sec. 12, T.33 N., R.1 E., at highway bridge, 6.7 miles southeast of Tower, Mich.	175	77.4	.44
NW¼NW¼ sec. 13, T.34 N., R.1 E., at bridge on Warboys Rd., 2.0 miles southeast of Tower, Mich.	290	103	.35

The discharge on the main stem at this time ranged from 0.33 to 0.48 cfsm. The single measurement on the East Branch was 0.60 cfsm, substantially higher than any point on the main stem. The large ground-water inflow noted on the headwaters of the Sturgeon and Pigeon is not evident on the headwaters of the Black. The exposed area of moraine separating the Au Sable River basin to the south from the Sturgeon, Pigeon, and Black river basins to the north is wider near the headwaters of the Black than it is near the headwaters of the other two streams. This greater width probably combines with less permeable drift to reduce the ground-water inflow into the Black.

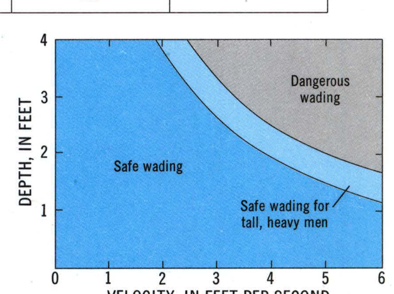
STREAMFLOW

VELOCITY

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

Location	Midstream velocity in riffles, in feet per second	Midstream velocity in pools, in feet per second
NW¼NE¼ sec. 27, T. 31 N., R. 1 W., near Johnson's Crossing, 13.1 miles southeast of Vanderbilt, Mich.	1.5	0.4
NE¼SE¼ sec. 32, T. 32 N., R. 1 W., near McKinnan Bend, 10.7 miles east of Vanderbilt, Mich.	3.2	.6
NW¼NW¼ sec. 35, T. 32 N., R. 1 W., at Tin Shanty Bridge, 12.5 miles east of Vanderbilt, Mich.	2.8	.4
NW¼NW½ sec. 21, T. 32 N., R. 1 E., at Main River Bridge, 14 miles south of Tower, Mich.	1.5	1.2
NW¼NE¼ sec. 22, T. 32 N., R. 1 E., East Branch at Barber Bridge, 12.8 miles northwest of Atlanta, Mich.	2.8	1.0
NW¼NE¼ sec. 29, T. 33 N., R. 1 E., at bridge on Clark Bridge Rd., 9.2 miles south of Tower, Mich.	1.6	.5
SW¼NW¼ sec. 12, T. 33 N., R. 1 E., at highway bridge, 6.7 miles southeast of Tower, Mich.	3.0	.9
NW¼NW¼ sec. 13, T. 34 N., R. 1 E., at bridge, miles southeast of Tower, Mich.	2.0	.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, if the velocity is 3 feet per second, the fisherman should not wade into water more than 3.3 feet deep. This assumes a firm bottom. If bottom material is slippery clay, even 2 feet may be too deep. Fortunately, clay bottoms on the Black River are present only in a very short reach south of Tower (Map 2, Sheet 2).



GRAPH SHOWING RELATION OF DEPTH AND VELOCITY TO WADING

STREAMFLOW

STAGE

The stage, or water level, of the Black fluctuates with discharge. This correlation is used to interpolate the discharge of the river at a gaging station between measurements. For a given change in discharge, fluctuations in stage are relatively large where the river channel is narrow and banks are high, and relatively small where the channel is broad and the banks are low.

The stage of the Black at the gaging station near Tower is influenced by releases from the dam so that it does not represent changes in stage on the upper river above the pond. Field observations indicate that the normal range in stage in most reaches of the upper river probably is not more than 2 feet.

SUMMARY

The following table summarizes the streamflow characteristics of the Black 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 Black River
Trout fishing	High drought flow helps keep summer water temperatures low. Excessive floodflow removes cover and may cause erosion of banks	Drought flow on the Black is high enough to prevent excessively high summer water temperatures. Floodflows generally not high enough to cause damage
	A variety of fast and slow reaches adds interest for 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 above Tower generally are moderate. May be abrupt below the power dam
Boating	Boating season reduced by periods of flood and drought	Flood season usually over before vacation season begins. Late summer drought flows discourage boating in much of river
	A variety of fast and slow reaches adds interest for boaters	Velocity variable in different reaches
	Small velocity makes upstream travel easier	Velocity too great 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

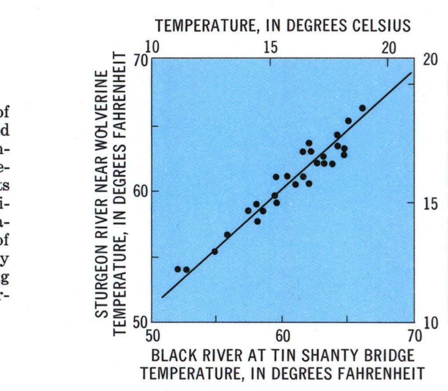
QUALITY OF WATER

INTRODUCTION

The quality of water in a river is expressed in terms of dissolved solids and gasses, suspended and floating materials, and physical properties of the water. Dissolved materials generally important to recreational uses are dissolved oxygen and nutrients—nitrates and phosphates. Other dissolved substances, such as toxic wastes, may affect the recreational quality of streams, but no wastes other than a minor amount of septic-tank effluent are discharged into the Black River. Suspended and floating materials include all undissolved materials, chiefly clay, silt, sand, and organic material moved in the stream. Physical properties important to recreation are temperature, pH, specific conductance, odor, and color.

TEMPERATURE

Temperature of water is a critical requirement of a trout stream—especially one that is inhabited chiefly by brook trout. Continuous records of temperature are not available on the Black, but correlation of short-term records and spot measurements with records on the Sturgeon near Wolverine indicate the probable temperature range (see illustration at right). Maximum summer temperatures of the Black River near the Tin Shanty are slightly higher than those on the Sturgeon—probably going above 21.1°C (70°F) on most hot summer afternoons.

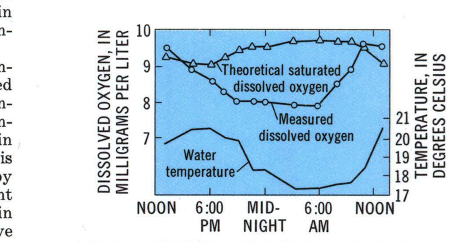


GRAPH SHOWING WATER TEMPERATURE CORRELATIONS FOR TWO STREAMS

DISSOLVED OXYGEN

Another critical requirement of recreational rivers is dissolved oxygen. Dissolved oxygen is of greatest importance for trout habitat, but the aesthetic quality of the river is also affected. A stream with very low dissolved oxygen content may contain decomposing organic material which cause unsightly slime growth and unpleasant odor.

Because the Black is free of significant contamination the dissolved oxygen content is controlled chiefly by water temperature and plant photosynthesis and respiration. As water temperatures increase the capacity of the water to hold oxygen in solution decreases. The effect of temperature is masked in summer by the oxygen given off by plants during daylight hours and the small amount used by plants at night. Thus, dissolved oxygen in the Black usually is at saturation or slightly above saturation during daylight hours and one to two parts per million below saturation at night (see graph at right).



GRAPH SHOWING DISSOLVED OXYGEN AND WATER TEMPERATURES AT CAMPSITE BELOW TIN SHANTY BRIDGE

QUALITY OF WATER

pH

The hydrogen ion concentration or pH is an indicator of the acidity or alkalinity of water. Waters with a pH of 7.0 are said to be neutral; a pH less than 7.0 indicates acidity; pH above 7.0 indicates alkalinity. The water of the Black is moderately alkaline, with pH values from 7.8 to 8.4. This is a favorable range for trout habitat and other recreational use.

SPECIFIC CONDUCTANCE

Specific conductance is related to the concentration of dissolved solids in water. Specific conductance on the Black ranges from 255 to 399 micromhos, which is in the normal range for an unpolluted river in this area.

HARDNESS

Hardness of water is expressed as the equivalent concentration of calcium carbonate. The water in the Black is moderately hard. Hardness of 3 samples ranged from 128 to 214 mg/1. Moderately hard water may be desirable in that it reduces the toxicity of some substances in water (Tarzwell, 1957). However, there is no indication of toxic material in the Black River.

NUTRIENTS—NITRATES AND PHOSPHATES

Nitrates and phosphates strongly influence the growth of aquatic vegetation. If the concentration of these substances is too high, vegetation may become so abundant that the stream is choked and the supply of dissolved oxygen is depleted. The one sample analyzed for nitrates and phosphates showed low concentrations of these nutrients. The relatively sparse growth of water vegetation is further evidence that nutrients are not now a problem in the recreational quality of the Black.

SUSPENDED AND FLOATING SOLIDS

Suspended solids in the Black were not measured in this study. Turbidity as an index of suspended materials apparently was low during most of the summer of 1966, as the bottom was clearly visible at depths up to 3 feet. During the spring season of higher runoff, turbidity may increase somewhat, especially in the lower reaches. The sandy soils and low flat land near the river in the upper reaches probably do not contribute much sediment even at high water.

No evidence of floating solids, other than natural leaf fall, was observed on the river. The relatively sparse development, especially on the upper river, probably keeps the river free of oil slicks and undesirable floating solids.

OTHER DISSOLVED MATERIALS

Chemical analyses of water from the Black are listed below. The water is of the calcium bicarbonate type with dissolved constituents in the normal range for an unpolluted river in this area. None of the reported dissolved materials are so concentrated as to cause problems in the recreational value of the stream.

ODOR AND COLOR

The Black appears to be free of noticeable color and odor.

*At concentrations normally found in fresh water, dissolved materials expressed in units of milligrams per liter (mg/l) are equivalent to dissolved solids expressed in units of parts per million (ppm).

QUALITY OF WATER

CHEMICAL ANALYSIS

Measured parameter	Public Access Site in SW¼SW¼ 36, T.32 N., R.1 W.	Gaging Station near Tower, Michigan	
	8-17-66	3-31-67	8-14-67
Calcium (Ca) mg/1	53	—	—
Magnesium (Mg) mg/1	20	—	—
Sodium (Na) mg/1	1.8	—	—
Potassium (K) mg/1	.3	—	—
Bicarbonate (HCO_3) mg/1	254	150	206
Carbonate (CO_3) mg/1	0	—	—
Sulfate (SO_4) mg/1	8.8	13	7.0
Chloride (Cl) mg/1	1.0	2.0	3.0
Fluoride (F) mg/1	.2	—	—
Nitrate (NO_3) mg/1	.5	—	—
Phosphorus (as PO_4) mg/1	.04	—	—
Dissolved Solids* mg/1	220	—	—
Hardness (as $CaCO_3$) mg/1	214	128	172
Noncarbonate Hardness	6	5	0
Specific Conductance **	399	255	310
ph	7.8	8.1	8.4
Discharge at time of sampling (cfs)	—	1270	278

* Calculated
** Micromhos per centimeter at 25°C

QUALITY OF WATER

SUMMARY

The following table summarizes the quality of water characteristics of the Black 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 Black River
Trout fishing	Temperature Criteria for intrastate waters, as established January, 1968, by the Water Resources Commission, Michigan Department of Conservation (1968) specify 21.1°C (70°F) as the maximum limit for intolerant fish (cold-water species)	Maximum temperatures on the Black probably exceed 21.1°C (70°F) on many hot summer days
	Dissolved oxygen The Water Resources Commission (1968) specifies a minimum of 6 mg/1. At water temperatures above 20°C (68°F), Tarzwell (1957) indicated full air saturation is required for the full range of activity for brook trout	Dissolved oxygen on the Black probably does not drop below 6 mg/1 at any time. At night may drop 1 to 2 mg/1 below saturation
	Hydrogen ion concentration (pH) Water Resources Commission (1968) specifies limits of 6.5 and 8.8	pH of the Black 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	The Black River is generally free of undesirable weeds, algae, and slime
Trout fishing, boating, camping, and cabin-living	Floating and suspended solids Water Resources Commission (1968) specifies that there should be no objectionable unnatural turbidity, color, or deposits sufficient to interfere with designated use; no floating solids, or evidence of residues of unnatural origin	Black River appears to be free of floating solids and residues of unnatural origin

OUTLOOK FOR THE FUTURE

The Black River above Tower is neither highly developed nor intensely used at present. It is free from municipal and industrial wastes, and the few cabins and club houses on the river probably do not discharge significant quantities of waste into the river. The state-owned land in the headwaters area is protected from future development, but many miles of private frontage in the lower reaches may be developed in future years.

Boating and canoeing may become more popular in the lower reaches of the river where portages are not required. However, the numerous rocky shoals probably will not allow an important canoe-livery industry on the Black because damage to canoes would be excessive.

Warm water temperatures, which adversely affect trout population and propagation, does not appear to be a serious problem at this time, although temperatures in the lower reaches may be too high for the best trout water. The warming of the water probably is caused by insufficient ground-water inflow, and, in a few short reaches, by sparse tree cover. Impoundments may also cause water temperature to rise, but the few small impoundments above Tower pond probably have little effect on water temperatures. Any changes on the upper river that would increase the water temperature would seriously threaten the brook trout fishery. Building of additional dams and cutting of trees along the riverbank in the upper reaches could cause warming of the water.

Ground-water inflow possibly could be increased somewhat by constructing recharge ponds which would divert some of the overland runoff into ground-water discharge. However, the effectiveness of such ponds has not been demonstrated in this area. Restrictions on cutting of trees on river banks and replanting the banks of the few open areas may help protect the river from excessive warming.

Sand bottoms, which generally are unfavorable environment for trout, occur in several reaches of the river. Erosion of banks that would bring in sand and silt to cover gravel spawning beds should be avoided. Excavation for foundations of cabins and for engineering construction such as highways, bridges, and pipe lines can contribute to undesirable sedimentation of the river bottom.

In general, all natural cover should be left in the river. Removal of drowned logs and trees from the river channel reduces cover for trout, affects the character of streamflow to some extent, and may cause a shifting of sediment load.

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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 BLACK RIVER, A COLD WATER RIVER IN THE NORTHCENTRAL PART OF MICHIGAN'S SOUTHERN PENINSULA

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

1971

For sale by the U.S. Geological Survey, price $1.25 per set