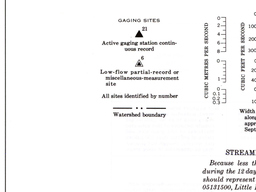
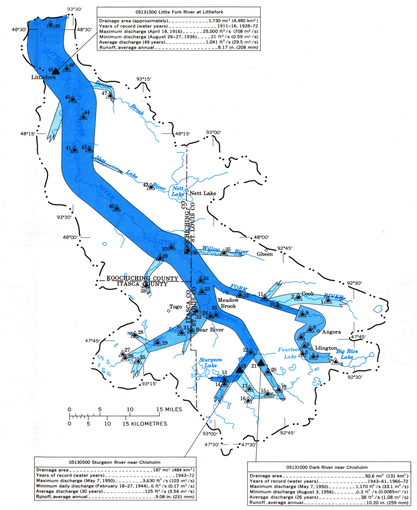
SURFACE WATER

Map key	Station number	Gaging station partial record or miscellaneous discharge measurements site	Approximate drainage area (mi²)	Measurement period October 16–20, 1972 Discharge (ft³/s)	Specific conductance (micromhos/cm)	Base-flow period September 19–21, 1973 Discharge (ft³/s)	Specific conductance (micromhos/cm)	7-day minimum discharge 10-year recurrence interval (ft³/s)
1	—	Little Fork River near Cook	—	18.6	<50	8.80	—	—
2	05129050	Little Fork River at Cook	—	28.2	50	9.03	—	—
3	—	Rice River near Britt	—	4.24	55	1.39	—	—
4	05129090	Rice River near Angora	—	22.7	65	24.1	—	3
5	—	Johnson Creek near Islington	—	5.92	<50	5.26	—	—
6	—	Rice River near Islington	—	37.2	50	26.0	—	—
7	—	Rice River near Stevenson Corner	—	39.5	60	27.0	—	—
8	—	Rice River at Angora	—	38.6	60	29.2	—	—
9	05129900	Rice River near Cook	—	43.5	70	33.4	—	4
10	—	Rice Creek near Meadow Brook	—	7.1	55	43.2	—	—
11	—	Rice Creek near Angora	—	9.07	65	5.84	—	3
12	05129920	Little Fork River near Gheen	—	110	55	52.8	—	—
13	—	Sturgeon River near Side Lake	—	57.2	<50	39.2	85	—
14	—	Shannon River near Side Lake	—	26.9	70	15.5	150	—
15	—	Sturgeon River near Sturgeon River near Mountain Iron	—	8.61	<50	4.27	95	—
16	05130300	Bertin Creek near Chisholm	13.7	2.60	80	1.49	160	—
17	—	East Branch Sturgeon River near Side Lake	—	13.4	55	9.38	115	—
18	05130500	Sturgeon River near Chisholm	187	109	<50	66.6	80	7
19	—	Dark River near Mountain Iron	—	9.48	115	9.19	395	—
20	—	Dark River near Side Lake	—	15.0	120	11.8	155	—
21	05131000	Dark River near Chisholm	50.6	21.7	92	18.6	135	2.5
22	—	Sturgeon River near Idlington	—	148	88	90.8	100	—
23	—	Sturgeon River near Meadow Brook	—	3.48	90	1.13	110	—
24	—	Sand Creek near Meadow Brook	—	9.54	70	4.61	115	—
25	—	Bear River near Side Lake	—	11.9	<50	7.19	120	—
26	—	Bear River tributary near Side Lake	—	4.09	121	3.25	205	—
27	—	Bear River tributary No. 2 near Togo	—	2.47	78	1.74	150	—
28	—	Bear River tributary near Togo	—	6.63	90	1.90	430	—
29	—	Bear River near Bear River	—	41.6	80	24.0	295	—
30	—	Bear River near Togo	—	57.8	69	31.5	—	—
31	—	Stony Brook at Bear River	—	10.48	120	7.04	255	—
32	05131310	Bear River near Togo	—	66.6	108	40.0	—	9
33	05131320	Sturgeon River near Togo	—	146	90	100	—	20
34	—	Little Fork River near Meadow Brook	—	2.68	100	240	—	—
35	—	Little Fork River near Togo	—	15.8	110	3.72	—	—
36	05131322	Willow River near Silverdale	—	15.8	110	3.40	—	—
37	—	Little Fork River near Rauch	—	412	—	237	—	—
38	—	Valley River near Togo	—	5.38	90	1.13	220	—
39	05131325	Valley River near Rauch	—	11.9	90	3.19	—	<1
40	—	Little Fork River near Nett Lake	—	228	106	76.1	—	—
41	—	Little Fork River near Big Falls	—	532	110	299	—	—
42	—	Nett Lake River near Nett Lake	—	73.1	130	0.54	—	—
43	05131470	Nett Lake River near Littlefork	—	71.5	125	0.00	—	—
44	—	Little Minnesota near Littlefork	—	2.90	145	0.00	—	—
45	—	Cross River near Littlefork	—	14.1	95	8.58	—	—
46	05131500	Little Fork River at Littlefork	1730	752	130	293	—	40
47	—	Beaver Brook near Bay	—	17.8	210	3.21	—	—
48	05131510	Beaver Brook near Littlefork	—	30.4	260	5.47	—	0
49	—	Little Fork River near Pelland	—	764	—	—	—	—



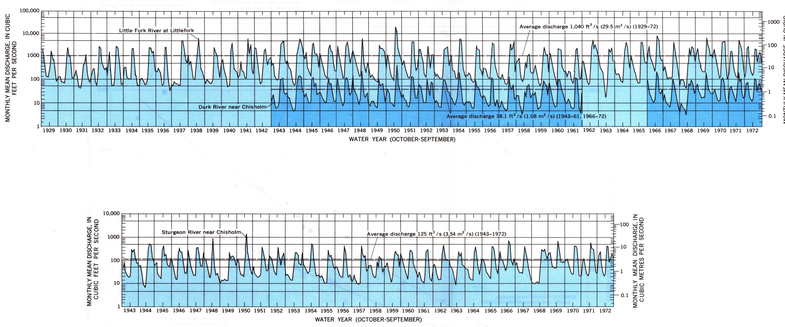


STREAMFLOW DISTRIBUTION FOR SEPTEMBER 19–21, 1973, IS SHOWN BY THE FLOW DIAGRAM

Because less than 0.1 inch of rain fell in the watershed during the 12 days preceding the measurements, the discharge should represent base flow. The discharge at gaging station 05131500, Little Fork River at Littlefork, was at the 51 percentile on the flow-duration curve (near the 50 percentile on the daily duration hydrograph; and 05130500, Sturgeon River near Chisholm, was at the 43 percentile.

During the base-flow period, discharge of Little Fork River near Rauch (map key number 37) was about 30 percent of the discharge at Littlefork (map key number 46). The higher base flows in the upper end of the basin are chiefly attributed to a greater abundance of lakes and surficial sand, which sustain streamflow during dry periods.

A series of discharge measurements was also made October 16–20, 1972 (table). Streamflow during this period was not entirely base flow, but included some direct runoff from precipitation.

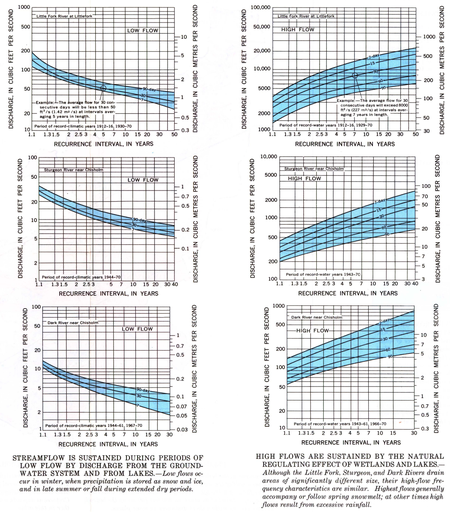


STREAMFLOW IS GENERALLY GREATEST IN SPRING WHEN RUNOFF IS PRIMARILY DERIVED FROM SNOWMELT AND RAINFALL

During the 14 years of record at station 05131500, Little Fork River at Littlefork, the annual maximum monthly discharge occurred 37 times in April and 9 times in May. Streamflow recedes during winter, when base-flow conditions prevail, almost always reaching a minimum in February or March. The annual minimum monthly flow was in the winter during 11 of the 14 years.

Streamflow gaged at stations 05131000, Dark River near Chisholm and 05130500, Sturgeon River near Chisholm, shows variations similar to Little Fork River at Littlefork.

Records from the above-gaging stations indicate considerable variation in annual runoff. For their respective periods of record, runoff of Little Fork River at Littlefork ranged from 2.11 inches (61 mm) in water year 1931 to 15.00 inches (381 mm) in 1946; that of Sturgeon River near Chisholm ranged from 1.61 inches (117 mm) in 1934 to 15.09 inches (383 mm) in 1950; that of Dark River near Chisholm ranged from 5.37 inches (136 mm) in 1956 to 15.14 inches (385 mm) in 1950.



STREAMFLOW IS SUSTAINED DURING PERIODS OF LOW FLOW BY DISCHARGE FROM THE GROUND-WATER SYSTEM AND FROM LAKES.—*Low flows occur in winter, when precipitation is stored as snow and ice, and in late summer or fall during extended dry periods.*

HIGH FLOWS ARE SUSTAINED BY THE NATURAL REGULATING EFFECT OF WETLANDS AND LAKES.—

Although the Little Fork, Sturgeon, and Dark Rivers drain areas of significantly different size, their high-flow frequency characteristics are similar. Highest flows generally accompany or follow spring snowmelt; at other times high flows result from excessive rainfall.

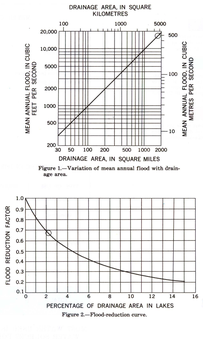


Figure 1.—Variation of mean annual flood with drainage area.

Figure 2.—Flood-reduction curve.

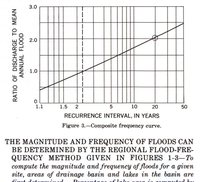


Figure 3.—Composite frequency curve.

THE MAGNITUDE AND FREQUENCY OF FLOODS CAN BE DETERMINED BY THE REGIONAL FLOOD-FREQUENCY METHOD GIVEN IN FIGURES 1–3.—*To compute the magnitude and frequency of floods for a given site, areas of drainage basin and lakes in the basin are first determined. Percentage of lake area is computed by dividing the area of lakes by the total drainage area and multiplying by 100. The flood reduction factor in figure 2 is not used for sites that have lake areas of less than 0.2 percent.*

Example.—Determine the magnitude of a flood having a 20-year recurrence for the Little Fork River at Littlefork, which has a drainage area of 1,730 mi² (4,480 km²) and a lake area in the basin of 38 mi² (98 km²)

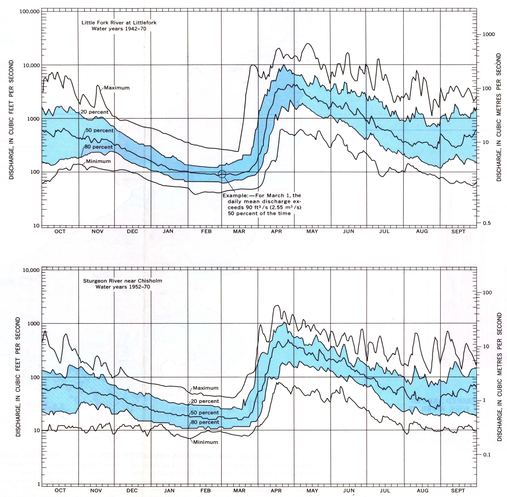
1. From the curve in figure 1, the mean annual flood for a drainage area of 1,730 mi² is 17,000 ft³/s .

2. The percentage of lake area in the basin is 38 mi²/ 1,730 mi²×100=2.2 percent. From the curve in figure 2, where the percentage of lake area is 2.2, the flood reduction factor is 0.67.

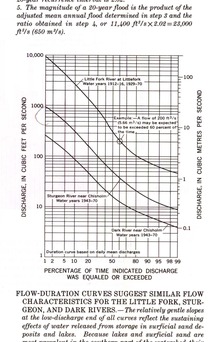
3. Then, adjust mean annual flood by reduction factor determined in step 2. Adjusted mean annual flood= 17,000 ft³/s×0.67 = 11,400 ft³/s.

4. The ratio of a flood of a given recurrence interval to the mean annual flood is obtained from the curve in figure 3. In this example, the ratio for a flood having a 20-year recurrence interval is 2.02.

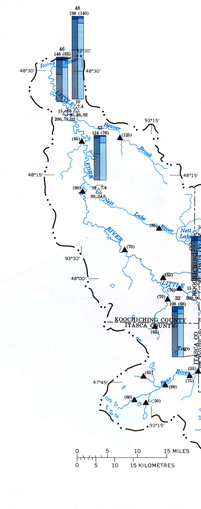
5. The magnitude of a 20-year flood is the product of the adjusted mean annual determined in step 3 and the ratio obtained in step 4, or 11,400 ft³/s×2.02=23,000 ft³/s (650 m³/s).

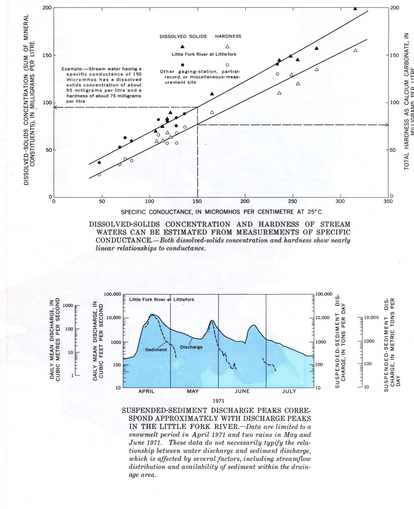


DAILY-DURATION HYDROGRAPHS SHOW VARIATIONS OF DAILY-MEAN DISCHARGES AT THE LITTLE FORK AND STURGEON RIVER STATIONS.—*The annual maximum discharge for most streams is in late April during the snowmelt period. Streamflow generally recedes during the summer to an open-water minimum in August and then gradually increases in the fall as evapotranspiration diminishes. Annual minimum daily flows and lowest ranges in flow for a given day generally occur in the winter.*



FLOW-DURATION CURVES SUGGEST SIMILAR FLOW CHARACTERISTICS FOR THE LITTLE FORK, STURGEON, AND DARK RIVERS.—*The relatively gentle slopes at the low-discharge end of all curves reflect the sustaining effects of water released from storage in surficial sand deposits and lakes. Because lakes and surficial sand are most prevalent in the southern part of the watershed, their contribution to streamflow is greatest in that area.*





DISSOLVED-SOLIDS CONCENTRATION AND HARDNESS OF STREAM WATERS CAN BE ESTIMATED FROM MEASUREMENTS OF SPECIFIC CONDUCTANCE.—*Both dissolved-solids concentration and hardness show nearly linear relationships to conductance.*

SUSPENDED-SEDIMENT DISCHARGE PEAKS CORRESPOND APPROXIMATELY WITH DISCHARGE PEAKS IN THE LITTLE FORK RIVER.—*Data are limited to a snowmelt period in April 1971 and two rains in May and June 1971. These data do not necessarily typify the relationship between water discharge and sediment discharge, which is affected by several factors, including streamflow distribution and availability of sediment within the drainage area.*

CALCIUM BICARBONATE TYPE WATER CHARACTERIZES STREAMS IN THE WATERSHED

Relative concentrations of major ions are similar areally, as indicated by analyses of samples collected October 16–19, 1972 (map above and table below). Dissolved-solids concentration and concentrations of individual constituents vary with time. Because streamflow during the sampling period included some direct runoff from precipitation, mineralization during ideal base-flow conditions would likely be higher than that shown. Some chemical characteristics showed considerable variation areally. Dissolved-solids concentration is relatively low in the headwaters area, which contains lakes and surficial outwash sand, and is higher farther north, where surficial material is chiefly glacial-lake sediments.

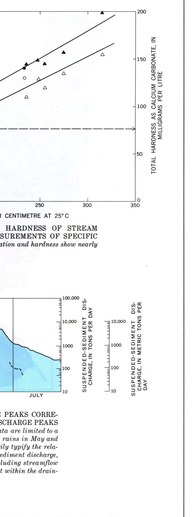
Color tends to be highest in streams draining areas containing significant amounts of peat. The widespread occurrence of peat probably accounts for the large difference commonly observed between dissolved-solids residue (includes organic constituents) and dissolved solids as sum of mineral constituents. The Minnesota Water Pollution Control Commission's recommended limit for domestic consumption for color was exceeded in all samples collected October 16–19, 1972. Iron concentration exceeded the Minnesota Water Pollution Control Commission's recommended limit in all but one sample. The low concentrations of nitrite plus nitrate probably reflect the sparse population and general lack of development.

Map key	Station number	Station name and date of collection	Discharge (ft³/s)	Chemical constituents and hardness, in milligrams per litre: Dissolved solids	Iron	Manganese	Calcium	Magnesium	Dissolved sodium	Dissolved potassium	Bicarbonate	Dissolved sulfate	Dissolved chloride	Fluoride	Nitrite and nitrate as nitrogen	Boron	Dissolved solids	Total hardness as $CaCO_3$	pH	Temperature (°Cels.)	Color (platinum-cobalt units)
2	05129050	Little Fork River at Cook October 17, 1972	28.2	80	0.80	0.02	8.9	3.2	2.8	1.3	29	9.2	4.0	0.4	0.02	0.25	53	35	7.4	3.0	200
4	05129090	Rice River near Angora October 17, 1972	22.7	81	.62	.04	6.0	2.2	1.5	1.0	20	6.1	1.3	.3	.02	.13	37	24	8.1	2.0	100
12	05129920	Little Fork River near Gheen October 19, 1972	110	11	.82	.04	11	3.3	2.4	1.3	41	9.5	3.2	.3	.04	.15	63	41	7.5	13.0	300
18	05130500	Sturgeon River near Chisholm October 18, 1972	109	11	1.2	.04	10	3.4	1.9	1.3	44	6.9	1.9	.3	.07	.11	60	39	7.4	2.0	100
21	05131000	Dark River near Chisholm October 18, 1972	21.7	13	.93	.05	1.3	6.0	3.7	1.6	56	14	3.7	.3	.12	.10	84	57	7.5	2.0	100
32	05131310	Bear River near Togo October 17, 1972	68.6	8.0	.68	.04	20	5.8	2.7	1.4	82	7.1	1.3	.4	.02	.15	88	74	7.8	2.5	90
33	05131320	Sturgeon River near Togo October 19, 1972	146	13	1.1	.03	15	4.8	2.8	1.3	60	9.0	2.9	.3	.06	.08	80	57	7.7	8.0	100
36	05131322	Willow River near Silverdale October 19, 1972	15.8	9.0	.90	.04	18	5.2	2.4	1.5	62	11	2.7	.5	.02	.23	82	66	7.5	2.0	300
43	05131470	Nett Lake River near Littlefork October 17, 1972	71.5	3.6	.24	0	17	6.3	1.4	1.3	71	9.4	1.0	.3	0	.10	76	68	7.4	2.0	80
46	05131500	Little Fork River at Littlefork October 16, 1972	752	10	.78	.02	18	5.6	2.0	1.1	65	10	2.7	.3	0	.19	83	68	6.8	5.5	200
48	05131510	Beaver Brook near Littlefork October 16, 1972	30.3	13	.36	.02	32	12	1.6	1.2	145	7.0	1.5	.3	0	.17	140	130	7.4	5.0	80
46	05131500	Little Fork River at Littlefork: Ten samples collected during 1963, 1967–68, and 1971–73 — Maximum	14,400	18	.78	.07	41	13	7.2	2.5	182	25	3.6	.3	.39	.19	199	160	8.2	12.0	200
		Median	186	11	.46	.02	26	10	4.6	2.2	114	12	2.6	.2	.21	.06	127	104	7.4	0	95
		Minimum	57.4	5.4	.10	.01	.16	3.7	1.6	1.1	58	5.0	0	.1	0	.04	71	54	6.8	0	25
Recommended limits for domestic consumption (Minnesota Water Pollution Control Commission, 1967)					.30	.05						250	250	1.5	10		500				15

(Analyses by U.S. Geological Survey)

CHANGES IN WATER QUALITY OF THE LITTLE FORK RIVER AT LITTLEFORK ARE RELATED TO DISCHARGE

Although all samples are of the calcium bicarbonate type, dissolved-solids concentration and other water-quality parameters vary considerably (table above and graphs at right). Dissolved-solids concentration is generally lowest at high discharges, when the ratio of direct runoff to base flow is large. Turbidity is greatest during high flows, when erosion is most active. Coliform count tends to be lowest at high discharges, as a result of dilution. The Minnesota Water Pollution Control Commission's recommended limit of color in water for domestic consumption was exceeded in all samples collected from the Little Fork River. The Minnesota Water Pollution Control Commission's recommended limit of iron concentration was exceeded in most.



SUMMARY AND CONCLUSION

CONCLUSIONS

1. Water resources are not intensively developed anywhere in the Little Fork River watershed. Most development is in the southern and northern parts; the central part is largely wilderness and includes many areas of wetlands. About 217 million gal (821 million l) of water was withdrawn in 1973, almost entirely from ground-water sources.
2. Average annual precipitation was 26.5 inches (673 mm), runoff 5.2 inches (208 mm), and evapotranspiration 18.3 inches (465 mm) during 1931–70.
3. Regional ground-water movement is largely from the watershed boundary, through glacial drift, toward the Little Fork River. Near the Little Fork, deep ground water assumes a dominantly northward component and is discharged at or near the Rainy River basin.
4. Glacial drift ranges in thickness from 0 to more than 200 feet (61 m). Buried sand and gravel within the drift is the most favorable source of ground water in most of the watershed. Well yields of several hundred gallons per minute may be obtainable locally. Where drift is thin or lacks water-yielding zones, relatively small water supplies might be obtained from bedrock.
5. Most ground water is of the calcium or calcium magnesium bicarbonate type. Dissolved-solids concentration increases in the direction of regional flow. Water in bedrock is typically more highly mineralized than water in drift. Dissolved-solids concentration, hardness, and iron and manganese concentrations may in places be troublesome for some uses.
6. Annual maximum flows in streams are generally in April during snowmelt. High flows are sustained by the natural regulating effect of lakes and wetlands.
7. Annual minimum flows usually occur in February or March. Minimum flows during the summer are generally in August, when evapotranspiration is high. Low flows are sustained by discharge from the ground-water reservoir and from lakes, chiefly in the southern part of the watershed.
8. Although having different size drainage areas and discharge magnitudes, the Little Fork, Sturgeon, and Dark Rivers have similar flow-frequency and duration characteristics.
9. Water in streams is of the calcium bicarbonate type. Dissolved-solids concentration is highest in streams draining areas of glacial-lake sediments and lowest in those draining areas of lakes and surficial sand in the southern part of the watershed.
10. Water quality in streams varies with discharge. Color and iron concentration exceed the Minnesota Water Pollution Control Commission's recommended limits for domestic consumption in nearly all samples analyzed.

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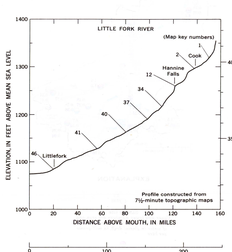
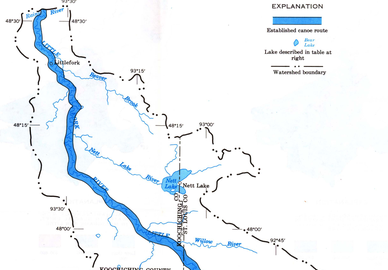


THE AVERAGE GRADIENT OF THE LITTLE FORK RIVER IS 1.8 FEET PER MILE (0.34 METRE PER KILOMETRE).—*The gradient of the Little Fork River decreases from the headwaters to the mouth, resulting in a concave profile. Rapids and falls, generally caused by bedrock outcrops, are most common in the upper half of the stream. The river follows a gently meandering course along most of its length, though sinuous meanders have developed in the gently sloping lower reaches.*

The Little Fork River is an established canoe route between Cook and the mouth. Much of the route is wilderness and heavily forested. Several access points, campsites, and points of interest are located along the route. Many of the rapids are portaged because they are dangerous. The reach below Littlefork, which has no rapids, is navigable except at very low stage. Larger tributaries to the Little Fork River are also canoeable at times.



Lake name	Surface area (acres)	Depth (feet) Maximum	Depth (feet) Median	Outlet control	Ecological classification	Management classification	Public waters classification	Remarks
Bear	328	16	—	Dam	—	Walleye	Recreational development	Public access
Big Rice	2,072	—	—	—	—	—	Natural environment	—
Fourteen	266	18	8.4	Natural	Northern pike-panfish-walleye