POLLUTION OBSERVATIONS

IN THE

LAKE SUPERIOR BASIN

POLLUTION OBSERVATIONS IN THE LAKE SUPERIOR BASIN
(INITIAL RECONNAISSANCE FINDINGS)

GENERAL

Lake Superior is the largest fresh-water lake in the world and is the most northwesterly lake of the Great Lakes of North America. It is bounded on the east and north by the Province of Ontario, on the west by the State of Minnesota, and to the south by Wisconsin and Michigan. Lake Superior is characterized by deep water, high bluffs, and a rocky shore along a large portion of its coast. It is the deepest of the Great Lakes, having a maximum depth of 1333 feet. Its shape is roughly that of a wide crescent convex toward the north. The maximum distance follows the curve of its axis from west to east and is about 383 miles in length. The extreme width is approximately 160 miles. Lake Superior has a mean elevation of 602 feet above sea level and is approximately 21 feet higher than Lake Michigan and Lake Huron.

The St. Louis River at the extreme western end of Lake Superior is the largest river in the Lake Superior basin. Approximately 200 rivers of lesser magnitude empty into Lake Superior. Lake Superior has a total surface area of 31,800 miles and a total drainage area of 80,900 square miles. Lake Superior is part of the St. Lawrence Waterway System and discharges through the St. Marys River into Lake Huron.

The north shore of Lake Superior from Duluth, Minnesota, to Silver Bay appears to have little other than rock along the shore. Rivers and streams discharging into Lake Superior along the north shore carry significant quantities of colored material into the lake during periods of high flow. From Duluth, Minnesota, and Superior,

Wisconsin, around the southern shore of Lake Superior to Ashland, Wisconsin, there are large areas of fine sand and silt. Most rivers discharging along this shoreline have a sand bar formed by the debris carried into the lake by the rivers. During periods of even moderate wave action a band of turbid water is visible along the south shore of Lake Superior from a distance of a few hundred feet to over a mile into the lake.

RECONNAISSANCE STUDIES

Reconnaissance studies on the Lake Superior watershed and in the St. Louis River drainage area were carried out by personnel from the Chicago Program Office between May 6 and October 28, 1967. The findings of this report are based on observations and information obtained from ground and aerial reconnaissance and from local and state sources. The reconnaissance studies consisted of the following:

1. Aerial Reconnaissance and Photography
2. Ground Reconnaissance
3. Stations sampled on the St. Louis River and in the Duluth-Superior Harbor area
4. A deepwater cruise of the entire lake
5. A study conducted in the vicinity of Silver Bay, Minnesota, for the purpose of evaluating the effect on Lake Superior resulting from taconite pelletizing wastes from the Reserve Mining Company.

Many visual observations were made both from the air and from ground surveillance of potential sources of pollution which will have to be followed up at a later date. It was not possible to obtain sample and flow information of pollution sources with the small reconnaissance staff available for this purpose.

ST. LOUIS RIVER

The St. Louis River has a total length of approximately 225 miles and a total watershed area of 4950 square miles of which 77 are in Wisconsin. At a point approximately 25 miles from Lake Superior the St. Louis River becomes an interstate stream forming the boundary between the States of Wisconsin and Minnesota.

Cloquet, Minnesota

The town of Cloquet, Minnesota, is located approximately 15 miles above the international portion of the St. Louis River. Cloquet is approximately 23 miles southwest of Duluth, Minnesota, and has a population (1960) of approximately 10,000 people. A primary sewage treatment plant discharging to the St. Louis River handles the municipal wastes and some of the industrial wastes for the city of Cloquet, Minnesota. Primary treatment plants as such do not provide sufficient treatment for municipal or industrial wastes. Biochemical oxygen demands are seldom reduced more than 35%. A flotation and settling action helps to remove major floating solids and some of the sludge-forming materials. A primary sewage treatment plant does not provide enough treatment for wastes discharged to the Lake Superior watershed.

Major industries in the Cloquet area are pulp and paper type of operations. The Northwest Paper Company, the Wood Conversion Company, and the Diamond Match Company all have operations at this location.

The Wood Conversion Company discharges directly to the St. Louis River.

The Northwest Paper Company discharges both directly to the river and through a series of lagoons. Both of these companies discharge organic wastes which exert a high biochemical oxygen demand on the stream and contribute substantially to the discoloration of the water as well as having high loadings of suspended materials. As a result, the waters of the St. Louis River are very dark for many miles below Cloquet, Minnesota.

The St. Louis River between Cloquet and Duluth, Minnesota, traverses many miles of gorge area, the total fall being several hundred feet. Considerable amounts of foam are generated and waters going through these gorge areas have an amber color. Some of this color may come from natural bog conditions, but a large amount of this color can be attributed to the wood processing industries located at Cloquet.

A number of hydro-electric power plants are located on the St. Louis River and its tributaries. The power plants on the St. Louis River are:

Scanlon	M.P.	32.0
Knife Falls	M.P.	34.3
Fond du Lac	M.P.	22.5
Thomson Falls	M.P.	24.8

Additional power developments are located on tributaries of the St. Louis River at

Fish Lake Dam and Reservoir
Rice Lake Dam and Reservoir
Island Lake Dam and Reservoir
Boulder Lake Dam and Reservoir
Whiteface Dam and Reservoir.

These plants have been in existence since the early 1900's and during periods of low flow, usually the summer months, the entire flow of the St. Louis River goes through some of these hydro-electric power plants. The natural bed of the river through some of the gorge areas is left without flow by these hydro-electric plant diversions. At one point in the vicinity of the Jay Cooke State Park all water is diverted from the river and passes through a canal. Approximately 12,500 cfs of water is so diverted and is not available for scenic and recreational purposes in the St. Louis River at this location.

Between Cloquet, Minnesota, and Duluth-Superior Harbor area are located several small towns which provide only primary treatment or less for their municipal wastes. These are the towns of Fond du Lac, Minn., Gary, Minn., and New Duluth, Minn., Morgan Park, Minn. and Oliver, Wis. After the St. Louis River passes the towns of New Duluth, Minn. and Oliver, Wis., it flows into and through a series of channels and lakes including Mud Lake and Spirit Lake before discharging to St. Louis Bay, and the harbor areas of Duluth, Minn. and Superior, Wis. In the Duluth, Minn. area the Chung King Corporation (R. J. Reynolds Foods, Inc.) and Western Paint Company have operations which discharge to the St. Louis River. Between Gary, Minn. and Morgan Park, Minn. there are two major industrial complexes: Universal Atlas Cement Co. and

American Steel and Wire Division of U. S. Steel. The Universal Atlas Cement Co. appears to add little to the pollution of the St. Louis River. The American Steel and Wire Division of U. S. Steel manufactures steel fence posts and various types of fence and woven steel mats. The plant has two blast furnaces in addition to the usual heavy steel manufacturing facilities. The plant discharges a rust-colored to red effluent which carries for miles below the plant before losing itself in the Spirit Lake and St. Louis Bay areas of the St. Louis River. This discoloration is typical of steel cleaning operations. Sulphuric acid is used to de-scale the steel before forming operations can be carried on and thus contributes large amounts of iron and sulphate to the receiving waters. In addition to the red discoloration so typical of steel pickling operations, lagoons containing oily wastes were observed discharging to the river. This oil overflow or spillage caused oil slicks and oily conditions on the surface of the water and along the banks for a considerable distance below the steel plant.

In the harbor area between Duluth, Minn. and Superior, Wis. bounded on the upstream by the Northern Pacific RR bridge and to the lakeward by the High Bridge (Route 53) is the area containing the so-called upper channel, north channel, south channel, cross channel areas and the Westgate Basin all within the St. Louis Bay area. This area is heavily discolored and has at times large areas of oil.

Minnesota Power and Light Co.

The Minnesota Power and Light Company is a source of thermal pollution and possibly pollution of an acid nature from coal storage areas. To the northeast of this power plant are some industrial plants such as the Duluth Brass Works, National Iron Company, Elliot Packing Company, Globe-Duluth Iron Works, and the Chung King Corp. plant (R. J. Reynolds Food Co.). (This is a different plant from the previously-mentioned plant). A series of lagoons discharge to the harbor in this area.

Located on the North Channel is an ore-loading facility operated by the Duluth Missabe and Iron Range Railway. Water near these ore-loading docks is very dark and has a considerable amount of floating oil.

Duluth Sewage Treatment Plants

Four primary type sewage disposal plants serve the City of Duluth. The main plant discharges into the St. Louis Bay near the north channel. This plant has a large flow which is visible from the air and does not seem to provide adequate treatment.

Superior, Wisconsin

On the Superior, Wis. side of St. Louis Bay are located coal docks, fuel docks, general merchandise docks, grain elevators, and the Fraser-Nelson Ship Building and Dry Dock Company.

Duluth Harbor Basin

The Duluth Harbor Basin area is bounded by Rice's Point to the west, the City of Duluth to the north, and Minnesota Point to the east and the East Gate Basin to the south. This area has elevators

for grain, iron and metal docks, fuel docks and a scrap metal terminal, contracting and dredging companies, a paper mill, the Superwood Company, refrigerated and general purpose docks, marine repair facilities, a Coast Guard Base, a Naval Reserve Training Center, and the U. S. Army Reserve Center. A major source of pollution in this area is the Superwood Corporation Plant. The Duluth Ship Canal leads into the Duluth Harbor basin from Lake Superior. This is an artificial channel cut through Minnesota Point about 1872. The discolored water from Duluth Harbor can be seen discharging almost continuously through the Duluth Ship Canal into Lake Superior. At times this discolored water can be seen a mile or more into Lake Superior.

Superior, Wisconsin Harbor

The City of Superior docking area extends generally southeast for approximately 5 miles from the High Bridge (Route 53). This area contains general storage warehouses, coal storage docks, a paper manufacturing facility, a cement plant, a sewage treatment plant, grain elevators, and iron ore loading docks. The natural outlet of the St. Louis River to Lake Superior is through the Superior entry. This entry is approximately 7 miles southeast of the Duluth Ship Canal and is directly opposite the Nemadji River. The most obvious sources of pollution along the Superior waterfront are the City of Superior's Sewage Treatment Plant, the Superior Fiber Products Pulp and Paper manufacturing facility, the Nemadji River,

The Allouez River, and the iron loading facilities operated by the Great Northern Railroad Company and the Northern Pacific Railroad Company. All pollute the harbor. This discolored harbor water plus the muddy appearing water from the Nemadji River is discharged through the Superior entry directly into Lake Superior. This causes a discoloration which extends as much as two miles into Lake Superior, and on occasion extends for several miles along the Wisconsin shoreline south and east of Superior, Wisconsin.

LAKE SUPERIOR

Area Along the North Shore of Lake Superior from Duluth, Minnesota to Taconite Harbor, Minnesota

The two major operations which could contribute pollution to Lake Superior in the stretch of coastline between Taconite Harbor and Duluth, Minnesota are:

1. The Erie Mining Company's private harbor and
2. The taconite pelletizing operation at Silver Bay, Minn.

Taconite Harbor, Minn.

Taconite Harbor is used for the storage and stockpiling of processed taconite pellets. These pellets are shipped on ore boats to Great Lake ports for use by the steel industry. Some ore vessels on their return trip unload coal at Taconite Harbor. A large power plant converts this coal into electric power which is transmitted to Babbitt, Minn. where the taconite pelletizing operation for the Erie Mining Company is located. Pelletized taconite is shipped by rail from Babbitt, Minn. to Taconite Harbor.

There appears to be little pollution from the storage and stockpiling of this pelletized taconite. The power plant contributes some pollution directly to Lake Superior. This pollution is from boiler blowdown and water treatment wastes. Some pollution to Lake Superior may come from the stockpiled coal.

Silver Bay, Minn.

Silver Bay, Minn. is located approximately 60 miles from Duluth, Minn. along the north shore of Lake Superior. The Reserve Mining Company has created a taconite pelletizing plant along with a town of approximately 3,000 people. The physical facilities for producing taconite pellets are housed in several large buildings. Taconite ore is brought to Silver Bay by rail and is processed by a grinding operation. The magnetic iron is separated from the crushed ore. The waste materials or tailings from this crushing and grinding operation are discharged directly to Lake Superior. Approximately 60,000 tons of these tailings are discharged every 24 hours. From the taconite processing operation at the Reserve Mining Company a large flume several hundred feet in length and approximately 10 to 15 feet in width carries process water plus solid and colloidal materials to Lake Superior. A delta has been built up along the shore which extends into Lake Superior. The bulk of the solid material is deposited in this delta and from time to time the flume must be extended or relocated. The colloidal material and some finely divided suspended material flow over this

delta and cause a green color in the lake which under certain conditions can extend from the Reserve Mining Company's operation at Silver Bay, Minn. along the north shore of Lake Superior for a distance of approximately 15 miles to the southwest. This "green water" has been observed to extend in an unbroken line from Silver Bay past the Split Rock Lighthouse to the Gooseberry River. This plume of "green water" is especially noticeable after storm or wind conditions.

Green Water Study

A "green water" study and a sampling program were carried out in the vicinity of Silver Bay, Minn. during September 1967. Samples were obtained from various outfalls at the Reserve Mining Company's taconite ore pelletizing plant and from Lake Superior at distances as far as 6½ miles into the lake proper. Analysis of these samples showed high concentrations of heavy metals such as iron, copper and zinc. The report has a complete list of sample locations, chemical analyses, and interpretation of the effect of this waste material on Lake Superior.

South Shore of Lake Superior from Superior, Wis. to Ashland, Wis.

The south shore of Lake Superior from Superior, Wisconsin to Ashland, Wisconsin has had aerial reconnaissance and ground reconnaissance in the vicinity of Barksdale, Wis. No samples have been obtained from this segment of Wisconsin. There appears to be few major sources of pollution from Superior, Wis. to Bayfield, Wis.

Ashland, Wis.

Ashland, which is located on Chequanegon Bay, is a city of approximately 11,000. This population is served by a primary type sewage treatment plant. This plant was surveyed by personnel from the State of Wisconsin over a 24-hour period on September 7 and 8, 1965. The results of this survey showed that only 4½% of the BOD was removed by this treatment plant. Primary treatment plants should be able to remove 35 to 40% of the BOD loading.

Marathon Division of the American Can Co.

Also located at Ashland is the Marathon Division of the American Can Company. This plant makes waxing tissues, machine creped tissues, and plain and embossed napkins. Waste materials from this paper plant operation consist of chemical treatment and settling of approximately 2,400,000 gallons of waste per day. This waste has a BOD loading equivalent to 12,000 people. The plant has a small lagoon located along the shore of Lake Superior. A white waste material spills from this lagoon and causes a discoloration of the lake which extends for approximately ½ mile outward from the discharge point.

Power Plant

A power plant burning fossil fuel is also located at Ashland, Wis. This plant has an extensive stockpile of coal which may contribute acid pollution to Lake Superior in addition to the used boiler blowdown and water treatment wastes.

The DuPont Company

The DuPont Company has an explosives manufacturing plant at Barksdale where TNT is manufactured. The waters of Boyd Creek were bright red from these TNT wastes. This red color extended into Lake Superior and along the shore for a distance of approximately one mile. TNT manufacture is generally carried out in three steps. Each step consists of a nitration procedure. Nitric acid is used for the nitration process and a fuming sulphuric acid called oleum is used to absorb the water generated from the nitration procedures. Most of the waste material produced from a TNT manufacturing plant is generated at the so-called tri-house. At this point the acids and TNT are neutralized using a sodium carbonate solution. After this neutralization, a selliting operation is performed. In this procedure the previously neutralized TNT is treated with sodium sulfite, which separates the various isomers of TNT from the desirable alpha phase. The wastewater on discharge from the tri-house contains various isomers of TNT and some suspended alpha TNT which is generally recovered. A bright red color characterizes this waste material. Generally speaking, the volume of red water per ton of alpha TNT produced is approximately 22,000 gallons. TNT manufacture at this DuPont plant appears to be on a batch basis. In addition to the red color which is caused by aniline-type by-products of TNT manufacture these wastes contain high nitrates, high sulphates, and approximately 900 to 1200 pounds per 100,000 gallons of dissolved solids. Fish and other aquatic organisms have comparatively low tolerance for this "red water". Water into which TNT wastes have been placed is generally unsatisfactory as a source

of drinking water due to a bitter taste.

Commercial Fishing Operations

Commercial fishing operations are conducted in the vicinity of the Apostle Islands. Fish processing plants, most of them in the vicinity of Bayfield, Wis. discharge fish wastes and entrails to Lake Superior. Only one fishery professes to dispose of fish waste on land. Return of this fish offal and inedible parts to Lake Superior may account for increased plankton and benthic organisms in the vicinity of the Apostle Islands.

Lake Superior East of Ashland, Wisconsin

Lake Superior east of Ashland, Wis. has had no reconnaissance of any kind by personnel of the Chicago Program Office. There is an Immediate Needs Report showing municipalities and industries contributory to the Montreal River. The Montreal River forms part of the boundary between Wisconsin and Michigan's Upper Peninsula.

That part of the Upper Peninsula of Michigan which borders on Lake Superior is sparsely populated. The major communities are Houghton-Hancock, Marquette, Munising, Grand Marais, and, on the St. Marys River, Sault Ste. Marie. Smaller communities such as Eagle Harbor, Baraga, L'Anse, have comparatively small populations. There are a number of active and inactive copper mines, iron mines, refineries, and ore processing plants on the Keweenaw Peninsula. The contribution of these industrial areas is difficult to assess without some rather extensive surveys. Abandoned iron and copper mines may contribute acid and metallic ions of copper and iron to Lake Superior. The effect of these metallic ions is impossible to determine until further information can be developed.

KNOWN SOURCES OF POLLUTION ON LAKE SUPERIOR

A list of industries and municipalities known to be contributing pollution to Lake Superior is as follows:

Fish Processing Plants

Booth Fisheries Division of Consolidated Foods Corp., Bayfield, Wis.
Sand Bay Fisheries, Bayfield Area, Wis.
Bodin Fisheries, Bayfield, Wis.
Everett Fisheries, Port Wing, Wis. - (2 Locations)

Milk, Cheese and Dairy Processing

Fuhrmann's South Shore Dairy, 3 miles North of Iron River, Wis.
Harten's Dairy
Mountain Valley Cheese Factory, Route 3, Ashland, Wis.
Farmers Cheese Factory, Mason, Wis.
Moquah Cheese Factory, Moquah, Wis.
Twin Ports Dairy, Near Benoit, Wis.
Andersonville Co-op Dairy Assn., Route 1, Ashland, Wis.
Radhoff Cheese Co., Highbridge
Marengo Co-op Dairy Corp., Near Mellen, Wis.
Mason Milk Products, Mason, Wis.

Paper Mills

Marathon Div. of American Can Co., Ashland, Wis.
Superwood Corp., formerly Superior Wood Products, Inc., Duluth, Minn.
Northwest Paper Co., Cloquet, Minn.
Celotex Corp., L'Anse, Mich.
Kimberly-Clark Corp., Munising, Mich.
Huss Ontonagon Pulp & Paper Co., Ontonagon, Mich.
Superior Fiber Products, Superior, Wis.

Munitions Plants

DuPont at Barksdale, Wis.

Steel Mills

U. S. Steel Corp., Morgan Park, Minn.

Taconite Processing Industry

Reserve Mining Co., Silver Bay, Minn.

KNOWN SOURCES OF POLLUTION ON LAKE SUPERIOR

Municipalities With a Population of Over 2,000

Hurley, Wis.
Bayfield, Wis.
Ashland, Wis.
Washburn, Wis.
Superior, Wis.

Alger, Mich.
Munising, Mich.
L'Anse, Mich.
Bessemer, Mich.
Wakefield, Mich.

Duluth, Minn. 4 Plants
Aurora, Minn.
Babbit, Minn.
Buhl, Minn.
Chisholm, Minn.
Eveleth, Minn.
Gilbert, Minn.
Hibbing, Minn.
Hoyt Lakes, Minn.
Virginia, Minn.
Cloquet, Minn.
Lake, Minn.
Silver Bay, Minn.
Two Harbors, Minn.
Beaver Bay, Minn.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF LAKE SUPERIOR, DULUTH AND SUPERIOR HARBORS AND SOME TRIBUTARIES

A cruise was made the latter part of May and the first part of June 1967, covering Lake Superior. Samples were collected at widely scattered stations at top, middle and bottom depths. Low concentrations of all parameters analyzed were observed over the entire lake.

Concentrations of 0.010 mg/l of phosphorus and 0.30 mg/l of inorganic nitrogen present in the water at the beginning of the growing season is sufficient to cause nuisance algal blooms (Sawyer, 1947).*

Concentrations observed in the lake for the following parameters were as follows:

	Total Phosphorus	Inorganic Nitrogen	Total Iron
Average (mg/l)	0.13	0.23	0.10
Range (mg/l)	0.003-0.047	0.16-0.37	0.02-0.36

Concentrations of phosphorus and inorganic nitrogen at the two entries to the harbors were quite high. At the Duluth Ship Canal, concentrations of the phosphorus were about 4 times the amount found in the lake and the concentration of inorganic nitrogen was slightly higher than was found in the lake. Iron concentration in the Duluth Ship Canal was about 5 times that found in the lake. At the Superior Entry, the phosphorus was about 7 times the amount noted in the lake and the inorganic nitrogen was about the same as found in the lake. Iron concentrations at this site were 10 times those found in the lake.

Samples collected in a slip in the northern part of Duluth Harbor Basin near Superwood Corp. showed phosphate values 37 times those noted in the lake and the inorganic nitrogen values were about the same as those noted in the lake. Iron concentrations at this site were 12 times those found in the lake. Temperature and dissolved solids were very high. pH values were low and the dissolved oxygen was depleted. All other parameters were very high.

A sample collected near Superior Fiber Products, Inc. in a slip in the northwestern part of the Lake Superior Front Channel showed phosphate values 10 times those found in the lake and inorganic nitrogen concentrations 3 times those in the lake. Iron concentrations were 10 times those in the lake.

A sample collected near a Duluth Sewage Disposal Plant outfall in the northern part of the North Channel showed phosphate values about 20 times those in the lake and the inorganic nitrogen values about 4 times those in the lake. Iron concentrations were 9 times those in the lake. The dissolved oxygen reading at this site was low (3.7 mg/l).

*This assumes that temperature and other environmental conditions are favorable.

A sample collected near a Superior Sewage Treatment Plant outfall in the central part of the Superior Front Channel indicated phosphate values of about 5 times those in the lake and inorganic nitrogen values 2 times those in the lake. Iron concentrations were about 9 times those in the lake.

The mean value of nine other harbor stations for phosphate was 11 times that of the lake. The mean value of inorganic nitrogen was 2 times that of the lake. The mean iron concentration was 9 times that recorded in the lake and the lowest value was higher than the maximum value observed in the lake.

Not only were high phosphorus and nitrogen concentrations observed at all harbor stations but low dissolved oxygen levels and high sodium, total iron, chloride, silica and MBAS concentrations were observed.

Between the bridges over St. Louis River at U.S. Highway 2 and U.S. Highway 61, there was a marked degradation in water quality of the river due to low dissolved oxygen levels, high COD levels and an increase in nutrients (phosphorus and nitrogen), solids and other parameters.

Relatively high concentrations of iron are entering the Superior Harbor Basin west of the Superior Entry from the Nemadji River. Phosphate concentrations in the Nemadji River at U.S. Highway 2 Bridge were about 7 times those observed in the lake.

Relatively high concentrations of iron were noted in Bluff Creek as it enters Allouez Bay. However, the flow of this stream is rather small as compared to the flow of the Nemadji and St. Louis Rivers.

Boyd Creek receives the discharge from a TNT manufacturing plant operated by the DuPont Co. at Barksdale, Wis., which is west of Ashland and south of Bayfield, Wis. This creek was sampled at Highway 13 Bridge located near Lake Superior. This creek was grossly polluted during a sampling period in June and one in August 1967. Concentrations (mg/l) of the various parameters analyzed are listed below:

COD	537	Organic Nitrogen	67
Suspended Solids	260	MBAS	168
Dissolved Solids	4,055	Na	145
Total Soluble Phosphorus	.336	Cl	93
Total Phosphorus	.463	SO_4	1,080
Ammonia Nitrogen	6.2	Si	9.7
Nitrate Nitrogen	190	Total Iron	9.2
pH	9.0		

Boyd Creek was a deep red color at each sampling period. Aerial reconnaissance indicated that this colored material extends for a considerable distance into Lake Superior.

In summary, physical and chemical conditions of the lake at the stations sampled, indicated that the water quality was good. However, high levels of pollutants noted in the harbors and in some tributaries indicated that these waters were grossly polluted and create pollutional hazards to the lake.

Reference:

Sawyer, Clair N. Fertilization of Lakes by Agriculture and Urban Drainage. Journal New England Water Works Association. 61-2:109-127 (1947).