BIOLOGICAL SURVEY OF THE STREAMS AND LAKES OF THE SUDBURY AREA: 1965

June, 1966

ONTARIO WATER RESOURCES COMMISSION

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REPORT
on the
BIOLOGICAL SURVEY OF STREAMS AND LAKES IN THE SUDBURY AREA: 1965

by

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Biology Branch

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SUMMARY AND CONCLUSIONS

A total of 71 stream stations and 21 lakes in the Sudbury area were examined in June, 1965. Collections of bottom fauna and water were made from streams; bottom fauna, algae and water ware collected from lakes. Pertinent analyses of biological collections were made. Total solids, calcium, sulphates, alkalinity and pH, organic nitrogen, copper, nickel and iron were determined and used as indices of the degree of contamination of natural watercourses by industrial, sanitary and combined wastes.

Mining and associated activities together with residential developments are included in approximately 200 square miles of the headwaters of the Vermilion and Wanapitei rivers. Most of the development is on smaller tributaries of these major rivers, including the Roberts River, Whitson River, Onaping River and Junction Creek, which are tributaries of the Vermilion River, and Emery Creek and Coniston Creek, tributaries of the Wanapitei River. Twelve underground mines, two major open pit mines, six copper nickel mills and three smelters, three iron ore mills and two sulphuric acid-sulphur dioxide by-product plants are located in the area investigated. A total of about 125,000 people are resident in the area, mostly in the City of Sudbury and nearby towns of Copper Cliff, Levack, Chelmsford, Lively and Coniston.

Both biological and chemical parameters showed that the Roberts River and Whitson River were in satisfactory condition. However, Moose Creek was in a deplorable state and evidence of damage to the biota of the Onaping River by heavy metals below Levack was found. The condition of the Onaping River above its confluence with the Vermillion River appeared to be reasonably good. Junction Creek and four of its five tributaries were heavily polluted by both sanitary and industrial wastes. The Frood-Stobie branch, Nolin Creek, Copper Cliff Creek and Meatbird Creek all carried considerable amounts of heavy metals as well as sanitary wastes to Junction

Creek.

Robinson Creek showed evidence of only moderate organic enrichment. The afore-mentioned streams did not affect the Vermilion River adversely. Even the entry of the extremely polluted Junction Creek had not altered the biota and water quality of the Vermilion River to any marked degree, although some evidence of moderate organic enrichment was apparent. Adequate dilution was responsible for reservation of apparently good water quality, as well as the moderating influence and assimilative capacity of the Junction Creek lake chain.

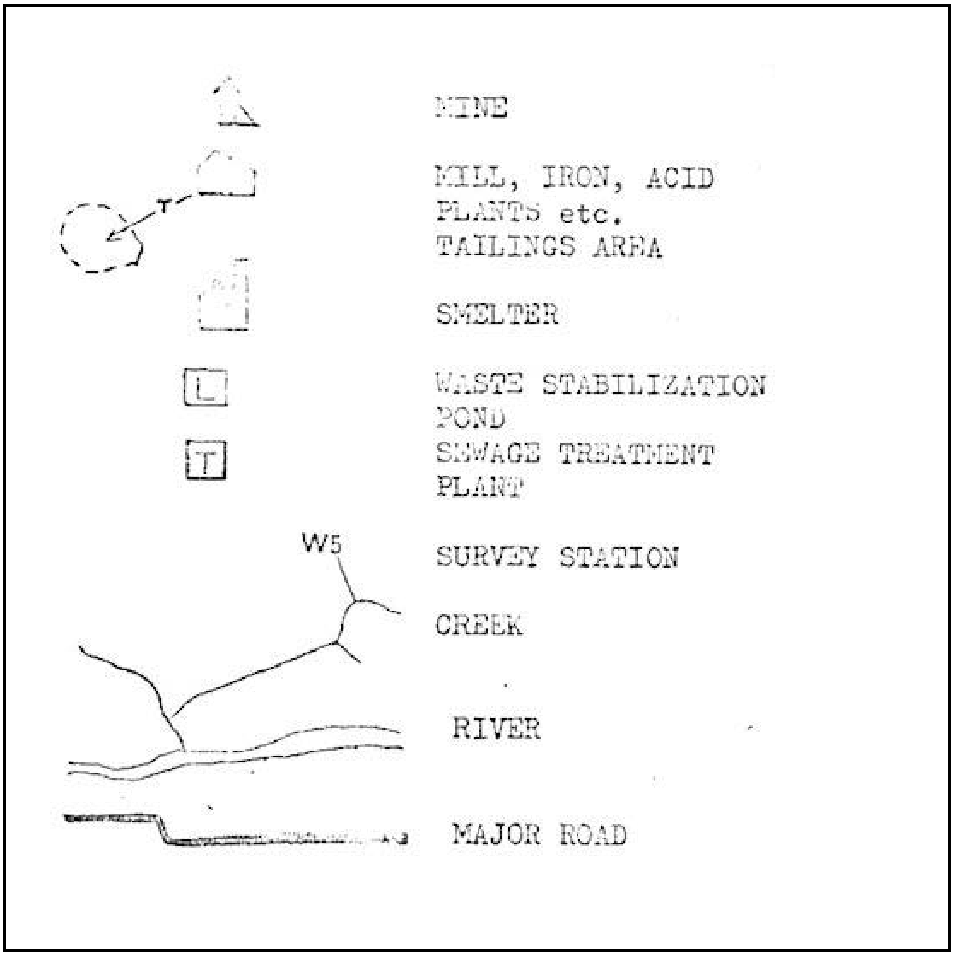
Both Emery Creek and Coniston Creak were heavily polluted by industrial wastes. Undesirable concentrations of heavy metals were detected chemically and their toxic effects were indicated in each case by an impoverished bottom fauna. Water quality on the basis of chemical analyses was good in the Wanapitei River at the time of the survey, but biological data indicated otherwise at several stations. Because the Wanapitei River passes close to the Coniston smelter and is not protected by lake chains on Emery Creek or Coniston Creek, the Wanapitei River may be subject to periodic contamination by runoff carrying to tie elements, together with the addition of industrial wastes in the two creeks.

The results of bioassays demonstrated that heavy metal concentrations and pH disturbance are indeed toxic to fish at levels found in five streams in the Sudbury area which were judged to be most polluted. sonic cases considerable dilution was required to eliminate toxic effects and even greater dilution would he required to minimize effects on fish under stream conditions of continuous exposure.

No evidence of contamination, atmospheric or from surface discharge, could be detected in eight lakes 10 to 20 idles from the nearest smelter. Eight lakes within five miles of smelters showed some evidence of impaired water quality, particularly Lady Macdonald Lake and Clarabelle Lake, where high heavy metal concentrations and low levels restricted the number of taxa and individuals in both the algae population and bottom fauna. Vermilion Lake appeared to be in good condition, but Kelly Lake, Simon Lake, Moose Lake and Norway Lake were considerably polluted. Because only a small number of lakes (21) were visited and minimal sampling was carried out, these data are of limited value. However, phytoplankton samples and bottom fauna collections should be useful in the future surveillance of water quality in these and other lakes in the Sudbury area.

Research on the benthic communities and algae populations of lakes is required to fully develop these as parameters of water quality. Research is needed also on the ecology of the stream biota in relation to heavy metals and pH levels but particularly on the effects and interactions of industrial and sanitary wastes on the biota and chemistry of receiving waters.

The Sudbury area contains many valuable lakes and streams and has a large and growing population. It is fitting, within tae modern conceits of public health, that the environment be protected and, furthermore, restored to some semblance of its former attractive and useful character. The Wanapitei River below Coniston and Moose Creek and the Onaping River in and below Levack are waters which require attention most urgently. The Vermilion River appeared to be in reasonably good condition, but an improvement in water quality throughout Junction Creek, particularly through the lake chain, is needed. Additional surveys will be required as corrective measures are implemented.



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Biological Survey of Streams and Lakes in the Sudbury Area: 1965

INTRODUCTION

Aquatic communities are affected by pollution and their property of reflecting past adverse environmental conditions, even of brief duration, makes therm valuable in the assessment of water quality. In this survey emphasis has been placed on the invertebrate community. Generally, the community in organically polluted waters is composed of lame numbers of a reduced number of species which are tolerant of low concentrations of oxygen and high concentrations of the gases of decomposition. Toxic pollutants may have both acute and sub-lethal effects, which together alter the community towards decreased numbers of a small number of species. The heavy metals, particularly copper and nickel, are of primary concern in the Sudbury area. Disturbance of the pH of the naturally poorly buffered waters also may exert toxic effects.

Sampling of the community is carried out above as well as below a source of waste water, and sampling sites are selected in a typical habitat in relation to hydrologic characteristics, including the nature of the bottom materials. Biological data and physical-chemical data are complementary and the latter are used in the interpretation of possible causes for observed changes in the community.

Operations in mining, milling and refining of copper, nickel and other base and precious metals in the Sudbury area cover an extremely large area. An area of about 200 square miles includes the mines and other mining developments between Levack and Skead. The effects of atmospheric and river contamination probably spread beyond this area.

The Sudbury area has one of the greatest concentrations of people north of the southern counties of Ontario. There are many valuable lakes and streams in the area that are subject to pollution from municipal and complex industrial waste sources. Therefore, this preliminary survey of the biological condition of lakes and streams was undertaken. Additional work must be carried out, both in the field and in the laboratory, to determine the extent and significance of the destruction of water resources in the Sudbury area.

GENERAL DESCRIPTION OF THE AREA

The area is characterized by Precambrian bedrock hills and ridges and drift-filled valleys containing clay, silt, sand and gravel deposits. The drainage is disordered and consists of many lakes and meandering streams. Two major rivers drain the mining area. The Vermilion River flows in a southwesterly direction to the Spanish River which in turn flows into the North Channel of Lake Huron. The Wanapitei River flows in a southerly direction to the French River and Georgian Bay (Figure 1).

Industrial development in the area consists of 12 underground nines, two major open-pit mines, six copper-nickel mills, three smelters, one copper refinery, three iron-ore mills and two sulphuric acid-sulphur dioxide plants. INCO, CIL, Falconbridge Nickel Mines and Lowphos Ore are the principle industries. CIL produces by-product acid and liquid sulphur dioxide in cooperation with INCO. The Lowphos iron-ore mill and open-pit mine are independent of other industry and are located about 15 miles north of Capreol.

A thorough description of the municipalities, industries, population, water supplies and supply problems and waste treatment facilities, for both sanitary and industrial wastes, is provided in two Commission reports "Water Resources Survey of the District of Sudbury, Part 1: A Survey of Water Resources and Stream Pollution with Recommended Programs" and "Part 2: A Survey of Industrial Water Use and Waste Disposal." The reader should refer to these reports for additional descriptive information.

The mining and related activities including residential developments occur in six smaller watersheds (or parts of watersheds) tributary to the two major rivers. The Roberts River, Onaping River (including Moose Creek), Whitson River and Junction Creek are tributaries of the Vermilion River. Emery Creek and Coniston Creek are tributaries of the Wanapitei River. All mining wastes are confined to these six watersheds with the exception of a mina presently under development at Skead which has discharged mine wastewater to Massey Bay of Lake Wanapitei. Also, most of the sanitary wastes are discharged to the six watersheds, though two exceptions include treated sanitary sewage from the Burwash prison farm, some of which is discharged to the lower Wanapitei River, and treated sewage from the Ontario Government buildings south of Sudbury which goes to McFarlane Lake.

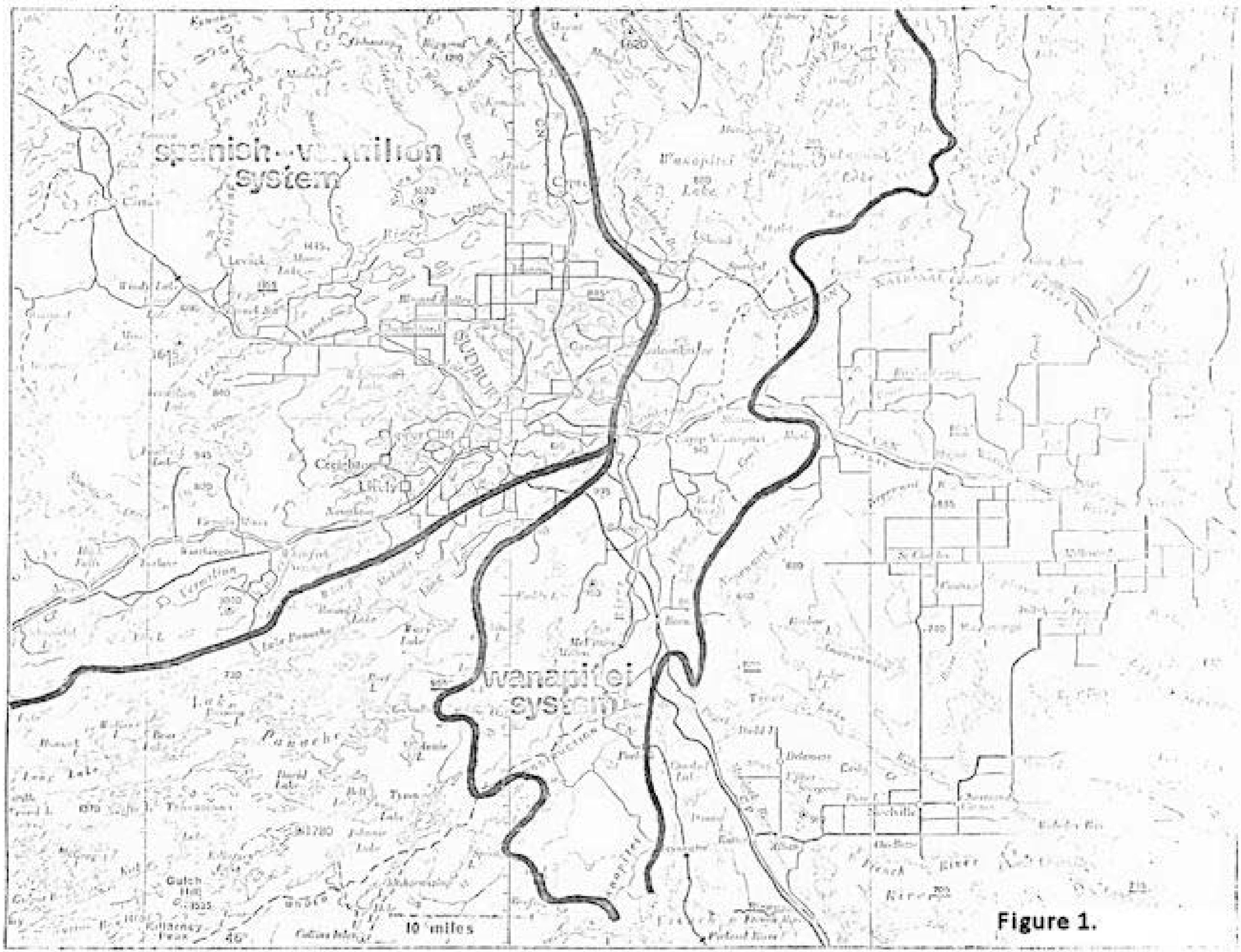


Figure 1.

METHODS

The survey was carried out in June, 1965. A total of 74 stream stations was selected and visited, three of which were dry at the time of the survey. Invertebrates were collected, as well as fish, whenever possible. One composite sample of water was collected at each stream station. Also, lakes were examined and samples of the bottom fauna and composite samples for chemical analysis and algae enumeration were collected at each lake. Bioassays were performed on the water from five obviously polluted streams, Copper Cliff Creek, Moose Creek, Junction Creek, Emery Creek and Coniston Creek.

Bottom fauna of streams

One 20-minute collection of invertebrates was made from each of a variety of habitats at each station. The collections were examined in the laboratory and the number of individuals of each selected taxa was noted (mainly each genera but tubificids, midges, two other families of flies and corixid larvae were each considered as one).

Fish

Fish were readily available only from the smaller streams, except the many small streams where fish were absent. Larger streams ware either not examined at all or not fished adequately to determine the relative abundance of the common species therein.

Bottom fauna of lakes

Several Ekman-dredge (9 x 9 inch) collections of bottom deposits were made at each lake; invertebrates were sorted and removed from the sediments and subsequently examined in the laboratory.

Lake phytoplankton (free-floating algae)

One sample of near-surface water was collected in June at each of 21 lakes for enumeration of phytoplankton. Phytoplankton was concentrated and enumerated in the laboratory. The sampling was repeated in September by personnel of the Sudbury District of the Department of Lands and Forests.

Water samples

A composite water sample was prepared throughout the period that the survey team, spent at each stream station and from several points at each lake in both June and September. The following analyses were performed by the Chemistry Branch of the commission:

- pH (at laboratory)
- Alkalinity
- Total solids
- Calcium
- Sulphate
- Turbidity
- Total Kjeldahl nitrogen
- Total copper
- Total nickel
- Total iron

Kjeldahl nitrogen was considered a general index of enrichment of waters by organic wastes and was used in preference to BOD (Biochemical Oxygen Demand) because of the time that would have lapsed until the analysis could be made and the presence of heavy metals in many samples suppress bacterial decomposition of organic matter.

Analyses for copper, nickel and iron included acid digestion. Therefore, these results measured both the dissolved and colloidal metal and that adsorbed or combined by particulate matter. Several samples were filtered (0.45 µ MPF) and analysis of metals was made on the filtrate as well as whole sample. These result are presented at this point to illustrate the variable relationship between solid and dissolved fractions.

	Copper		Nickel		Iron	
watercourse	Diss.	Part.	Diss.	Part.	Diss.	Part.
Copper Cliff Creek	0.17	0.01	1.2	5.4	0.3	3.7
Junction Creek	0.00	0.08	0.5	3.8	1.0	0.0
Moose Creek	0.00	0.01	1.1	1.9	1.8	1.2
Coniston Creek					0.1	0.9
Emery Creek	0.02	0.00	0.7	2.1	4.8	2.1

Suspended solids were determined as 71 ppm in Copper Cliff Creek, 77 ppm in Junction Creek, 3 ppm in Moose Creek, 5 ppm in Coniston Creek and 13 ppm in Emery Creek. No relationship was evident between the proportion of these metals which was associated with particulate matter and the concentration or suspended solids. Probably between 15% and 30% of the total nickel was soluble but the two iron and copper fractions showed no proportionate relationship. Therefore, the analyses of copper, nickel and iron must be used with caution in the interpretation of biological affects of these heavy metals.

Bioassay of stream water

Each sample was diluted serially with Toronto tap water. Fathead minnows were introduced and observe for 36 hours. The 96 hour TLm values which ware calculated indicate the concentration of tested material in diluent at which just 50% of the test animals survived for 96 hours.

INTERPRETATION OF BIOLOGICAL DATA

Development of biotic index for streams

Analyses of data on stream bottom fauna obtained in the survey of the Sudbury area was a difficult task because of the many stations on many streams of varied character. Atmospheric pollution, which may spread from Copper Cliff, Falconbridge and Coniston over a considerable distance, adds further to the problem of interpretation. In addition, the interpretation must be made in a precise and clear manner if the results are to be of value to other workers.

Therefore, the approach in this analysis has been to compare the number of taxa at each station to a series of “control" stations. Eleven control stations were selected at distances of 10 and 20 miles from the nearest smelter which were apparently not affected by waste discharges. However, some atmospheric contamination may have occurred, particularly at the 10-mile range. Also, the relative abundance (few, common, abundant) of 14 selected groups, mainly orders and families, was used to provide a general description of the composition of each invertebrate community.

Table 1 illustrates the means of describing communities and serves to develop a general biotic index with the data from control stations. An average of 12 taxa was

Table 1. Development of data on stream bottom fauna at 11 control cations for interpretative purposes. Explanation is included in text.

	Invertebrate groups														Number
Station	1	2	3	4	5	3	7	6	9	10	11	12	13	14	of taxa
10-1			F	F	F			F	F						8
10-2		F		F	C			F	F	C			C	F	13
10-3			F	F	F			F	C	F	F	F			12
10-4		C	F	F	F				C		F				9
10-5			F	F	F			F	F	F	F	F			11
10-6		C		F	F				C	F					10
20-1		F	F	C	F	F	F	F	F			F			18
20-2		F	F	C	F			F	F	F	F	F	F		16
20-3		F		F	F			F	F						5
20-5		C			C	F		F	C				F	C	15
20-5	F	C	F		F	F									17

Invertebrate groups are as follows:

1. Stonefly nymphs
2. Mayfly nymphs
3. Caddis larvae
4. Damselfly and dragonfly nymphs
5. Midge larvae
6. Other fly larvae
7. Fish fly larvae
8. Beetle larvae
9. Bugs
10. Amphipods (scuds)
11. Leeches
12. Sludgeworms
13. Snails
14. Fingernail clams

F indicates 1-9; C, 10-99: A, 100+ individuals taken per unit of effort.

found at the control stations. A high frequency of occurrence was characteristic of the groups, mayflies, caddisflies, damsel and dragonflies, bugs, midges, amphipods and beetle larvae. Leeches, sludgeworms, fingernail clams and snails were taken much less frequently, and only one or two of these groups might be expected at any station. Stoneflies, which emerge as adults early in the year, were seldom taken.

Based on this examination of data from control stations, collections at most stations (with a great deal of latitude for size, velocity, etc.) should have contained seven to ten of the 14 general groups of invertebrates and a total of about 12 taxa as defined for the purpose of this survey.

A marked reduction in the number of taxa present at any station indicated impairment of water quality. Whether this impairment was due to mining wastes or domestic wastes or both was determined on the basis of: 1. presence of industrial and/or residential development, 2. water chemistry, and 3. nature of the variation in composition and size of the aquatic community.

The invertebrate community subjected to heavy organic contamination consists of large numbers of sludgeworms, midge larvae, bugs and often leeches. Some amphipods, snails, fingernail clams, beetle larvae and other fly larvae occur in the presence of moderate organic pollution. Often a very few species may be present in extremely large numbers, usually sludgeworms and midge larvae.

In the case of contamination by heavy metals some differences from invertebrate communities in organically polluted waters will be evident. The greatest difference will be in the smaller numbers of the tolerant organisms in the presence of heavy metals.

The amphipods, snails, clams and leeches which are high concentrations of heavy metals (in excess of 0.10 ppm copper and 1.0 to 5.0 ppm nickel). Midges, sludgeworms, dragonflies and some caddisflies appeared to be tolerant of higher concentrations of heavy metals. Midges are known to be tolerant of metals, but sludgeworms are intolerant.

Possibly the presence of sludgeworms at high concentrations of metals may have been due to the presence of organic wastes, in which case metals may have been in a much less toxic form (e.g. chelated). A detailed examination of the data, not presented here, indicated that this hypothesis was probably quite true.

Development of biotic indices for lakes

Two groups, the bottom fauna and phytoplankton, were examined in 21 lakes in the Sudbury area. Data on the number of genera of phytoplankton and number of species of bottom macroinvertebrates in control lakes were compared with data on lakes which were potentially polluted. The use of the bottom fauna of lakes as a parameter of water quality is similar to the use of stream invertebrates. Apparently, less is known of the tolerance of phytoplankton to various levels and combinations of mining and domestic wastes. The data obtained in the present study will be used to develop the further use of phytoplankton to indicate the presence an effects of wastes of the type found in the Sudbury area and will be reported elsewhere. Of course, the reservations pointed out previously, in applying measurements of total concentrations of heavy metal to size and composition of aquatic communities, apply to lakes as well as streams.

WATER QUALITY AT CONTROL STATIONS

Control stations were selected on the basis of absence of industrial and, wherever possible, domestic outfalls of all types upstream. Atmospheric contamination may produce changes in water quality, probably particularly after rainfall and depending on ambient wind conditions. Station 10-6 certainly was affected by contaminated runoff; this conclusion is based on water quality (Table 2) and its location which was about 10 miles east (leeward) of Coniston.

The pH of control waters varied from. a approximately 6 to 8 and alkalinity from 7 to 145 ppm, which probably reflects the natural range between somewhat acid streams draining coniferous bogs and alkaline streams draining till plains.

With the exception of Station 10-6, the sulphate concentration was 100 ppm or less and the calcium concentration was less than 36 ppm. Higher levels of sulphate are probably indicative of the addition of mining or milling or smelting wastes. Tie turbidity of control waters was generally less than 10 ppm, and organic nitrogen varied between 0.4 and 1.6 ppm.

Iron was present at concentrations between 0.3 and 4.5 ppm, copper was found at concentrations up to 0.18 ppm (but was not detected at one-half of the stations) and nickel was detected rarely and then in vary small amounts.

This brief description of water quality at control stations may be used, by comparison, as a general guide to determine the extent of contamination of other waters. The drainage basin of each stream should be considered, because the nature of the rock, overburden and vegetation nay exert a very significant influence on the chemical characteristics of the surface water.

Table 2. Results of chemical analyses made on samples collected at 11 "control" stations on several streams at points ten miles and twenty miles from the closest smelter in the Sudbury area in June, 1965. All results, except for pH and turbidity are expressed in ppm.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
20-1	7.2	8	53	5	4	-	0.33	0.00	0.0	1.00
20-2	6.8	20	114	11	49	1.5	1.70	0.18	0.1	1.50
20-3	7.0	19	30	10	0	1.0	0.43	0.00	0.0	0.32
20-5	7 .1	41	158	14	60	12.0	1.60	0.00	0.O	2.10
20-3	5.8	7	34	5	19	-	0.40	0.01	0.0	0.30
10-1	8.3	9	90	8	120	4.5	0.84	0.00	0.2	3.30
10-2	7.6	103	220	36	80	4.0	1.30	0.00	0.0	0.62
10-3	6.2	7	98	6	71	2.6	1.10	0.06	0.0	0.93
10-4	6.5	43	614	15	80	2.3	1.10	0.02	0.0	0.75
10-5	7.0	14	123	8	70	5.5	1.60	0.08	0.3	4.50
10-3	6.9	145	1022	88	630	12.5	1.80	0.02	0.0	3.00

RESULTS AND CONCLUSIONS

Results and conclusions are presented by watershed, under which the sources of municipal and industrial wastes are described, survey findings are presented and conclusions drawn.

ROBERTS RIVER

Sources of domestic and industrial waste

Sanitary sewage from Moose Mountain Mine (Lowphos Ore Limited) in Hutton Township is disposed of by percolation in gravel deposits. All industrial wastes from the plant are discharged to a series of four tailings ponds which total 300 acres in area. The decant is re-used in the mill.

Biological assessment of water quality

The Roberts River was examined at points above and below the operation of Lowphos Ore Limited (Figure 2) . A total of 13 taxa was collected above and 17 below; the composition of the bottom fauna community was almost identical at the two stations. Therefore, there was no evidence of contamination of the Roberts River by this operation over the previous several months.

Chemical characteristics

Most of the materials analysed were present in low concentrations both above and below the mill (Table 3, following page 14) but, for some unknown reason, a relatively high concentration of nickel was found above. The quality of water was quite satisfactory below.

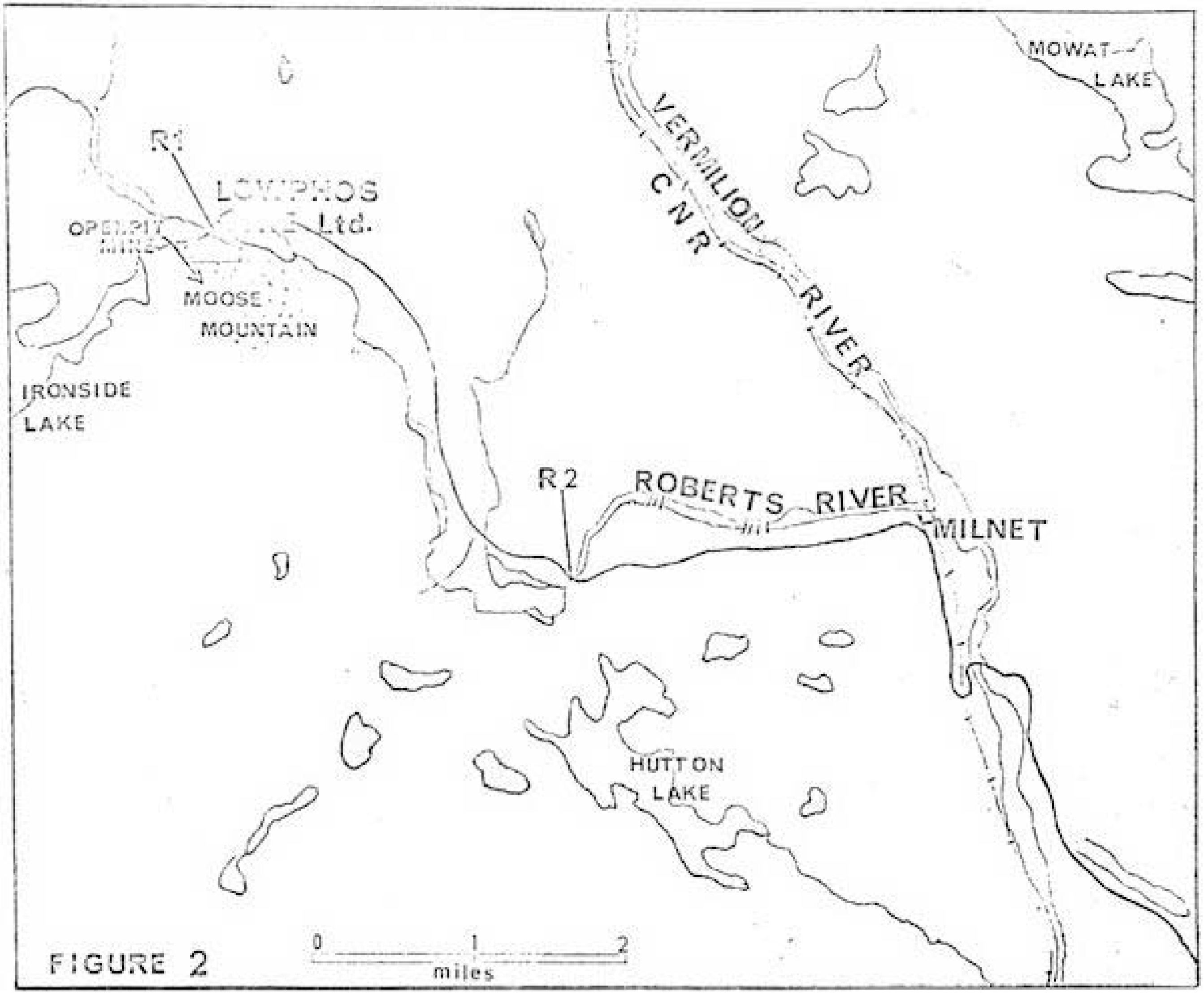

MOWAT
LAKE
VERMILION
CNR
RIVER
R1
Ltd.
MOOSE
MOUNTAIN
IRONSIDE
LAKE
R2
ROBERTS RIVER
MILNET
HUTTON
LAKE
0
1
2
miles

FIGURE 2

Conclusions

Both biological and chemical parameters showed that the Roberts River was in good condition.

WHITSON RIVER

Sources of domestic and industrial wastes

Township of Hammer, Blezard, Balfour and Rayside Domestic wastes are treated in most cases in septic tanks. However, a small activated sludge treatment plant serves a hotel in Hammer and the effluent goes to a ditch tributary to the Whitson River. Most of the Whitson watershed is flat and poorly drained; therefore, in many areas, particularly in the spring and following heavy rains, septic tanks may overflow resulting in pollution of ground and surface waters.

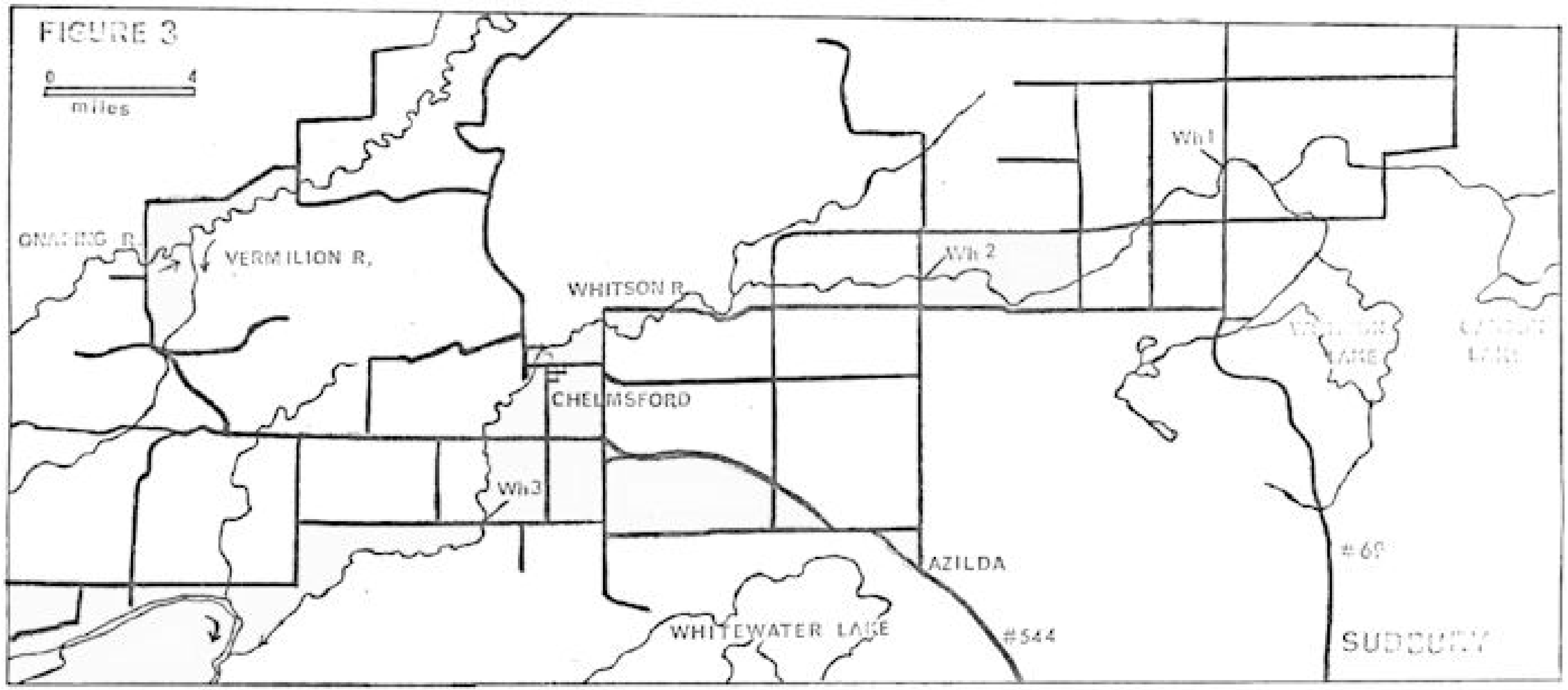
Town of Chelmsford

Sanitary waste from Chelmsford (population 2,605) is discharged to a 10-acre lagoon located in Balfour Township, which apparently has produced a satisfactory effluent. The outfall is to McKenzie Creek, which flows directly to the Vermilion River.

No industrial waste effluents enter the Whitson River.

Biological assessment of water quality

The three collections taken from the Whitson River were indicative of good water quality. A total of 12, 7 and 19 taxa were obtained at Stations 1, 2 and 3 respectively.


0
4
miles
VERMILION R.
WHITSON R.
Wh 1
Wh 2
Wh3
CHELMSFORD
AZILDA
WHITEWATER LAKE
#544
FIGURE 3

No indication of organic enrichment was evident, because midge larvae and sludgeworms were present. in low numbers and several species of mayfly were present.

Chemical characteristics

The three samples were very similar and each indicated the relatively more fertile nature of the Whitson River which meanders through an extensive area of till deposits (Table 3) . The pH was relatively high at 7.5 to 8.0 as was alkalinity at 64 to 92 ppm and total solids at 174 to 244 ppm. Iron was found at concentrations less than 1 ppm, but no copper or nickel were detected. Also, the organic nitrogen concentration was relatively low, about 0.5 ppm. The magnitude of these concentrations and similarity among stations are further evidence that water quality in the Whitson River is reasonably good. (Note, however, that no microbiological studies were carried out, which could reveal undesirable aspects of quality in an otherwise "clean" stream).

Conclusions

The Whitson River appeared to be in good condition as indicated by a bottom fauna consisting of moderate numbers of a variety of taxa and by chemical analyses.

ONAPING RIVER

Sources of domestic and industrial wastes

Town of Levack

Sanitary waste in Levack (population 3,000) is collected in sanitary sewers which direct the flow to several tanks. Sanitary waste from the Levack mine and mill is treated by septic tank; the effluent is mixed with mine water and discharged to Moose

Table 3. Results of chemical analyses made on samples collected at 5 stations on the Roberts River and Whitson River in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
R1	7.3	14	64	7	2	1.7	0.26	0.0	2.2	0.31
R2	6.5	17	26	9	0	1.8	0.18	0.0	0.0	0.40
Wh1	7.5	54	174	32	28	1.8	0.58	0.0	0.0	0.90
Wh2	7.5	89	200	44	47	2.1	0.52	0.0	0.0	1.70
Wh3	8.0	92	244	38	25	1.5	0.45	0.0	0.0	0.79

Creek. Tailings from the mill are discharged to Grassy Lake located north of the site and the decant from the tailings area is directed to Grassy Creek, which joins Moose Creek within Levack (Figure 4.

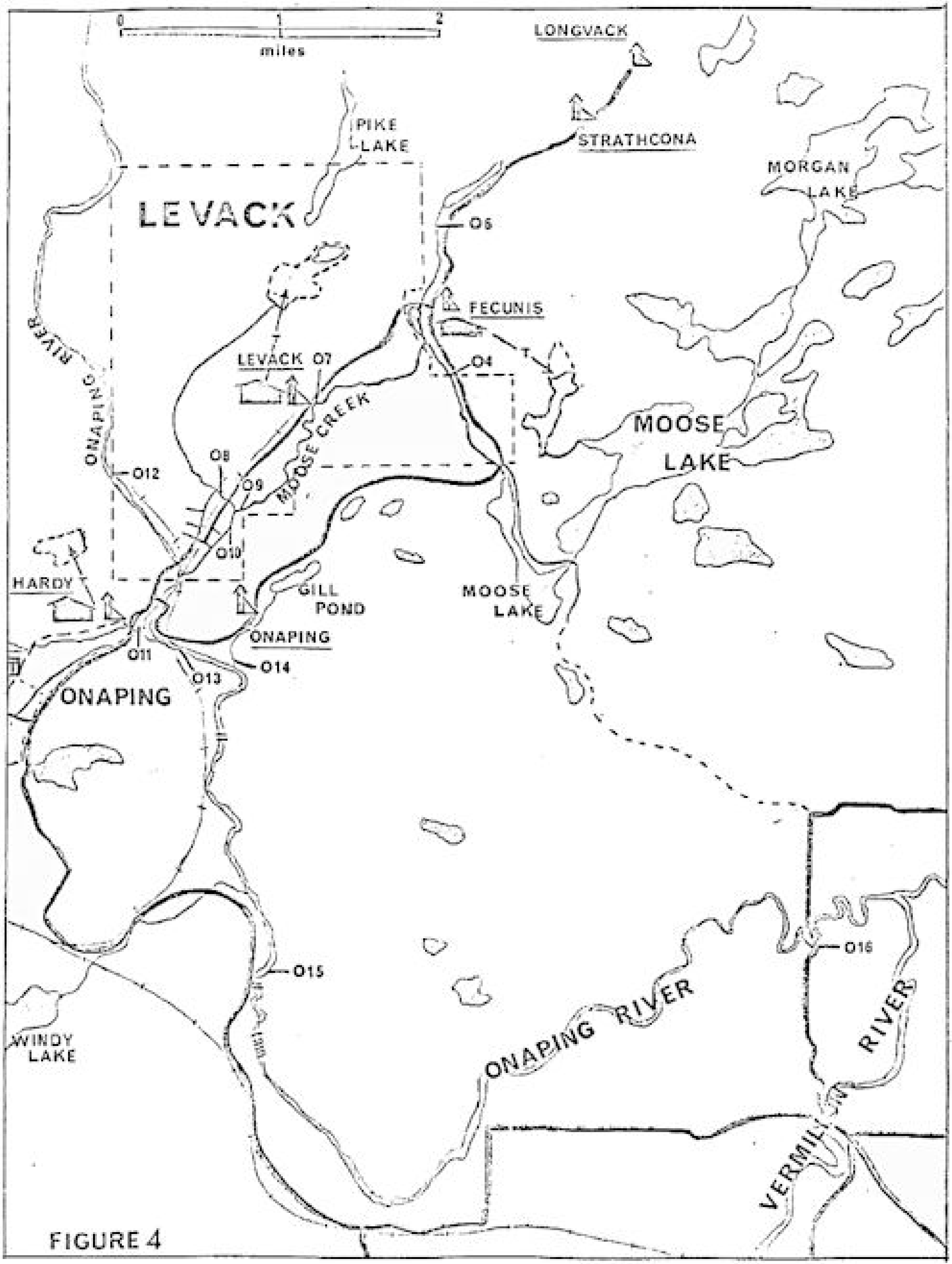
Onaping Improvement District

Sewage from the Onaping townsite (population 1,100) is collected by sewers and treated in a mechanically aerated, activated-sludge plant. The effluent is discharged to a swampy area which drains to High Cliff Lake, thence to the Onaping River.

Mine water is pumped from the shafts of the Hardy-Boundary mines into the Onaping River. Onaping mine water is directed to Gill pond, while Fecunis Lake mine water is pumped into Fecunis Lake. Tailings from the Hardy Mill, which processes ore fro the Hardy, Boundary and Onaping mines, are moved hydraulically to a 50-acre disposal area north of the mill which has no apparent outfall. Pyrrhotite concentrate is stockpiled near the Hardy mill and significant surface drainage occurs from the area. The Fecunis Lake mill processes ore from the Onaping and Fecunis Lake mines and tailings are directed to Cranberry Lake from which the decant flows into Moose Lake.

Township of Levack

Two mines are located in the township, the Strathcona mine which is under development and the Longvack mine which is closed. Septic tank overflow and mine water pumpage are directed to a swampy area tributary to the north branch of Moose Creek.



0
1
2
miles
LONGVACK
PIKE
LAKE
STRATHCONA
MORGAN
LAKE
LEVACK
O6
FECUNIS
LEVACK
O7
O4
MOOSE CREEK
MOOSE
LAKE
ONAPING RIVER
O12
O8
O9
O10
HARDY
GILL
POND
MOOSE
LAKE
ONAPING
O11
O13
O14
ONAPING
O16
O15
ONAPING RIVER
RIVER
WINDY
LAKE
VERMILION

FIGURE 4

Township of Dowling

The settlement at Larchwood, located in the sandy valley of the lower Onaping River (population 900), has proceeded with septic-tank treatment of sanitary sewage. Apparently, no problems have been posed attributable to waste disposal from this community.

Biological assessment of water quality

Moose Creek was examined first at Station 04 near the outlet of Moose Lake, a decidedly contaminated lake which will be discussed subsequently in this report. An intermediate number of eight taxa, comprised mainly of very small numbers of organisms, indicated impairment of water quality by toxic materiel. Similar conditions were found on the northern branch of Moose Creek at Station 06 between the Strathcona and Fecunis mines. Only two taxa were collected. One species of fish (the brook stickleback, a species tolerant of low pH and characteristic of bog streams) was found, while no fish had been caught or seen at Station 04. No improvement was noted at Station 07 where fish were absent and six taxa were found in the invertebrate collection, nor at Station 09 which lacked fish and had only three invertebrate taxa. The presence of very low numbers of a few insects indicated toxic conditions. Sludgeworms were present at Station 07, possibly because of the interaction between industrial and sanitary wastes rendering the combined effluents Grassy creek less toxic than might be expected.

Grassy creek enters Moose Creek in Levack carrying wastes from the tailings area and residential development. It is a foul, uninhabited stream, obviously heavily contaminated by both organic and toxic industrial wastes. Moose Creek below Grassy Creek is heavily polluted. No fish and only two invertebrate taxa were collected. It is in this deplorable condition that Moose Creek enters the Onaping River. Station 011 was examined on High Cliff Creek and, although three species of fish were taken, small numbers of only three invertebrate taxa were recorded, these being tolerant of toxic conditions. Water quality appeared to be reasonably good at the time of sampling but obviously toxic conditions had prevailed earlier.

At Station 014, the stream which drains Gill Pond appeared to be in a clean state. Brook trout were taken and the stream bottom fauna consisted of eight taxa, all insects.

The Onaping River above Levack was examined at Station 012, which served also as a control station (20-6). Below Levack, at Station 013, fewer taxa were found and these occurred in much reduced numbers. A total of 17 taxa was found at 012 and seven at 013. Some impairment in water quality was evident, certainly not due to organic wastes from Levack and surroundings, but likely because of decreased productivity associated with toxic conditions. Because the animals collected ware insects, which are generally wore tolerant of heavy metal poisoning than fish, particularly young fish, the possibility of damage to the fishery must not be overlooked.

Further downstream at Stations 015 and 016 a total of 10 and 16 taxa respectively were recorded, indicating improved conditions. Sludgeworms were present at both stations and, in the absence of heavy organic enrichment which would counteract the effects of metals, their presence apparently indicated that only low levels of heavy metals had reached those points.

Unfortunately, fish populations could not be examined in the Onaping River during the 1965 survey. Obviously additional studies on the fish of the larger streams in the Sudbury area are required.

Chemical characteristics

The outflowing water of Moose Laze is characterized by a depressed pH, while the heavy metal content is similar to that at control stations (Table 4). Probably the lake acts efficiently in providing for the settlement of metals together with the Cranberry Lake tailings area. The toxic effect on the aquatic community probably is the results of a depression in productivity because of the acidic nature of the water. The branch which received drainage from the Strathcona mine was similar, although at the time of the survey the pH was less depressed and nickel was present (2.9 ppm) in the sample.

Metal concentrations increased at Station 07 (0.27 ppm copper, 2.8 ppm nickel), the pH remained low and a greater concentration of nitrogen indicated some organic enrichment. The heavily polluted condition of Grassy Creek was verified by the following chemical analyses: 1256 ppm total solids, 2.00 ppm organic nitrogen, 7.2 ppm iron and pH of 4.9. Moose Creek was quite acidic above and below Grassy Creek. The high total solids and metals at Station 09 (1146 ppm total solids, 1.88 ppm copper and 8.7 ppm nickel) was caused mainly by effluents from the Levack mine and mill and to a much lesser degree by discharges from the Fecunis mine and mill which are upstream from Station 07. Station 010 was similarly contaminated.

High Cliff Creek water appeared to be of normal composition at the time of the survey while the creek from Gill Pond showed greater concentrations of nickel (3.5 ppm) and sulphates (193 ppm) than normal. Both streams ware inhabited by fish but the bottom fauna was restricted, particularly in the former. Both streams may carry mine wastes to the Onaping River periodically, but their effect certainly must be an insignificant one compared to that of Moose Creek.

Table 4. Results of chemical analyses made on samples collected at 12 stations on the Onaping River and tributaries in the Levack area in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
04	4.3	0	106	20	49	-	0.46	0.00	0.0	0.49
06	6.1	8	156	22	50	-	0.33	0.00	2.9	0.11
07	4.2	0	230	38	137	-	1.60	0.27	2.8	0.89
03	4.9	7	1256	232	-	-	2.00	0.06	0.0	7.2
09	3.9	0	1146	124	321	-	2.50	1.88	8.7	0.01
010	4.9	5	1060	189	-	-	2.40	0.03	14.0	4.40
011	6.0	11	64	98	22	-	0.84	0.01	0.0	0.3
012	5.8	7	34	5	19	-	0.40	0.01	0.0	0.3
013	6.2	8	66	11	35	-	0.40	0.00	< 1	0.4
014	6.4	11	500	78	193	-	0.23	0.01	3.5	0.1
015	6.1	6	76	16	29	-	0.40	0.00	4.4	0.3
015	7.2	10	106	24	9	1.8	0.78	0.00	0.3	0.4

The chemistry of Onaping River water is altered at Levack. The results of chemical analysis of water from Stations 012, 013, 015, 016 indicate that organic enrichment and industrial wastes together had increased the nickel concentration in the Onaping River (but not copper or iron) and doubled the concentration of total solids (calcium and sulphate ion concentration were both approximately doubled). The dilution of Moose Creek water is considerable in the Onaping River, about 30 to 40 times, based on flows measured by the Water Quality Surveys Branch. This ratio of flows also is evident in comparing the data on total solids and calcium at Station 010 on Moose Creek and Stations 012 and 013 on the Onaping River above and below the entry of Moose Creek.

Conclusions

The data on water chemistry indicated that considerable quantities of heavy metals, iron and nickel particularly, were discharged from. Moose Creek to the Onaping River. The extremely poor condition of Moose Creek indicated by these as well as by earlier evaluations of water chemistry was verified by the biological data obtained in June, 1965. Also, some changes in the biota in the Onaping River were detected which must be due to periodic contamination by metals. Organic wastes appeared to present no problems in the Onaping River. Probably some damage to the biota may occur periodically immediately below Levack because of contamination by metals. However, the condition of the Onaping River above its confluence with the Vermilion River appeared to be reasonably good and water quality in the Vermilion River appeared to be little affected by the Onaping River. Nonetheless, the Onaping River itself is an important river and definitely has been impaired by industrial activities at Levack and the immediate vicinity.

JUNCTION CREEK AND TRIBUTARIES

Sources of domestic and industrial waste

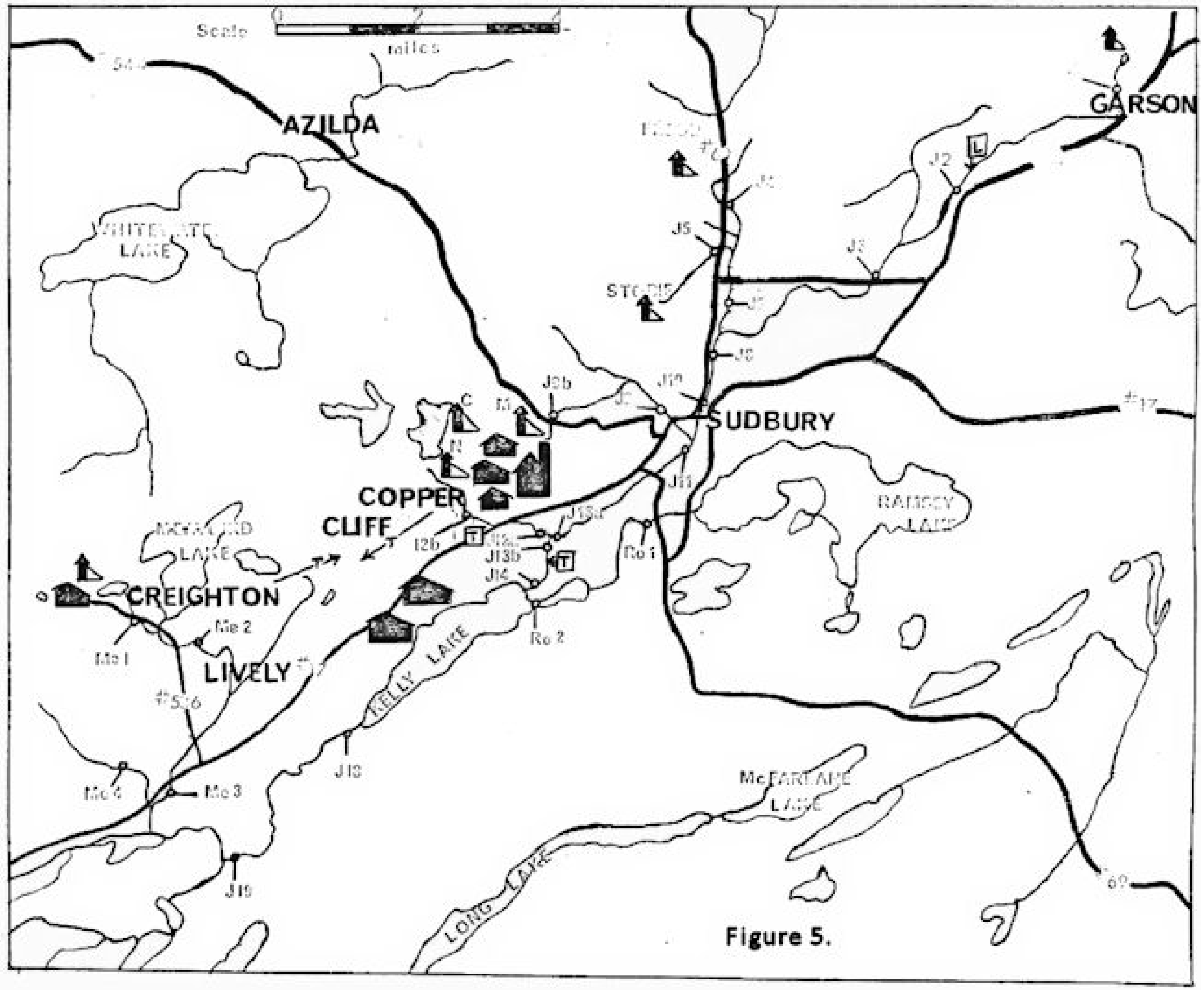
Townships of Neelon and Garson

The main development in the united townships of Neelon and Garson (population 5,350) is around the community of Garson and the Garson Mine townsite, with scattered development in the outlying area (figure 5). Carson and the townsite (population 3,000) are served by sanitary sewers, an Imhoff tank and a four-cell oxidation pond. The lagoon effluent goes to Junction Creek.

All mine drainage is pumped to the surface on the mine property and flows to Junction Creek.

City of Sudbury

Sudbury (population 78,000) is tile source of much of the domestic and industrial waste in the Junction Creek watershed. Although the outlying areas are served by private sewage disposal systems, much of the city's sanitary waste is collected in sewers, including a 5-mile tunnel excavated in the rock, and discharged to Junction Creek immediately below the entry of Copper Cliff Creek. The Sudbury and Algoma Sanatorium is served by an activated-sludge sewage treatment plant; the effluent is chlorinated and discharged to Pike Lake. Sanitary waste from the Murray Mine and townsite is treated in a septic tank; the effluent goes to a swamp, thence to Nolin Creek and Junction Creek. The Frood and Stobie Mines are served by septic tanks which discharge to the Frood Branch of Junction Creek. Sanitary waste from the Copper Cliff North Mine and Clarabelle open pit mine, which are now within the City of Sudbury, are treated in tile Copper Cliff sewage treatment plant.



Scale
miles
AZILDA
GARSON
SUDBURY
COPPER
CLIFF
CREIGHTON
LIVELY
KELLY LAKE
LONG LAKE
J2
J3
J5
J8
J9b
J14
J16
J19
Me 1
Me 2
Me 3
Me 4
Ro 1
Ro 2

Figure 5.

Mine water from the Frood and Stobie Mines is discharged to the Frood Branch of Junction Creek mine drainage from, the Murray Mine goes to Junction Creek via Nolin Creek. Copper Cliff North Mine pumps mine water to Copper Cliff Creek.

Town of Copper Cliff

The municipality (population 3,600) is served by an activated sludge treatment plant; the effluent is chlorinated and discharged to Copper Cliff Creek. A small plant serves most of the refinery, while the sulphur dioxide plant and the remainder of the refinery are served by septic tank. The effluents go to a tributary of Copper Cliff Creek.

Tailings from the mill are delivered to the large tailings area west of the town. The overflow goes to Copper Cliff Creek. All wastes from the smelter are discharged via sewer south of tile plant to Copper Cliff Creek. Refinery industrial waste are discharged with treated sanitary sewage to a tributary of Copper Cliff Creek. CIL's sulphur dioxide plant discharges waste to an INCO slag disposal area, thence it flows to Copper Cliff Creek.

Township of Waters

Most residences have septic tans disposal systems, which apparently have operated in a satisfactory manner. Domestic sewage from. INCO's iron ore recovery plant and CIL's acid plant is treated in septic tanks and discharged to a swampy area which drains to Kelly Lake.

Tailings and process and cooling water from the iron recovery plant are delivered to the Copper Cliff tailings disposal area north of Highway 17. Cooling water from the acid plant flows with the septic tank effluent to Kelly Lake. Process water is delivered to the iron recovery plant.

Town of Lively

The Town of Lively (population 3,100) is served by two septic tank-leaching pit systems which discharge to a tributary of Meatbird Creek.

Townships of Creighton and Snider

Septic tank effluents from the Creighton townsite mill and part of the mine are discharged to a tributary of Mud Lake at the source of one branch of Meatbird Creek. One shaft discharges septic tank effluent to Whitewater Lake.

Mine drainage is pumped to Mud Lake, while mill tailings are pumped to the Copper Cliff tailings area.

Biological assessment of water quality

Junction Creek rises in the Garson area and at the first station examined, J1, evidence of toxic conditions was found; only two invertebrate taxa were taken, both tolerant of heavy metals.

Invertebrate collections at Stations J2 and J3 below the Garson lagoon were similar and also indicated organic enrichment five and six taxa, all insects, occurred at the two stations in substantial numbers.

The Frood and Stobie branches were both heavily contaminated. Two taxa were taken at J4, one at J5, and one at J6. Midge larvae tolerant of both organic enrichment and heavy metals were taken at the last two stations.

However, invertebrate collections indicated somewhat better water quality at Stations J8 and J10 on Junction Creek than that indicated on the Frood-Stobie tributary. The eight taxa at Station J8 and six at J10 were similar to those at Stations J2 and J3 upstream.

Below the entry of Nolin Creak, along which no animals at all were taken, water quality was extremely poor because no animals were collected at Station J11. A slight improvement was noted at Station J13a immediately above the confluence of Junction Creek and Copper Cliff Creek. Only three taxa were collected, but worms were abundant indicating most likely the neutralization of toxic components from Nolin Creek by organic wastes in Junction Creek and additional wastes contributed downstream.

Fish were taken in Junction Creek only at Stations J2 and J3 and these were all of one species, the brook stickleback. Because the creek at most stations could be seined easily, most of Junction Creek apparently lacks fish. Data on fish and invertebrates indicated that water quality in Junction Creek progressively deteriorated from its source downstream through Sudbury.

Copper Cliff Creek was heavily polluted and no significant aquatic invertebrate community existed at Stations J12a and J12b on Copper Cliff Creek, at Station J13b on Junction Creek below the confluence but above the Sudbury sanitary sewage outfall and at Station J14 below the outfall.

Robinson Creek, which flows from. Ramsey Lake through Robinson Lake to Kelly take, was examined at two stations. The creek at Stations R01 And R02 appeared to be in good condition, although there was some evidence of moderate organic enrichment. The eight taxa taken at Station R01 included one mayfly species, while nine taxa were collected at Station R02.

Little improvement in water quality in Junction Creek was indicated below Kelly Lake, as only midge larvae were collected at Station J16 and few additional animals were taken at Station J19. The large numbers of midge larvae and absence or very small numbers of sludgeworms in an apparently suitable habitat is strong evidence of heavy organic enrichment together with substantial amounts of heavy metals below Kelly Lake.

Meatbird Creek drains the Creighton-Lively area. It is polluted at its source by both sanitary and industrial wastes. The typical invertebrate community of streams in the presence of considerable organic enrichment and metals, large numbers of midge larvae, was present at Station Me1. Some improvement was indicated at Station Me2, possibly because of dilution of wastes by the tributary from Meatbird Lake. Six taxa were collected, all insects tolerant of moderate toxic pollution. Further downstream. at Station Me3 the invertebrate community indicated that toxic conditions had occurred without any evidence of organic enrichment. Another tributary was examined at Station Me4 and was diagnosed as unpolluted. Meatbird Creek joins the Junction Creek system at Mud Lake.

Junction Creek joins the Vermilion River at McCharles Lake below Simon Lake. Because water quality in Junction Creek was extremely poor even below Kelly Lake, some measurable effect on the Vermilion River was expected and will be examined in the next section. Conditions in Kelly Lake and Simon Lake will be described in a section to follow.

Chemical characteristics

The results of chemical analyses are presented in Table 5. With few exceptions these data substantiate the findings of the biological survey that Junction Creek and

Table 5. Results of chemical analyses made on samples collected at 24 stations on Junction Creek and its tributaries in the Sudbury area in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
J1	7.2	38	1356	234	650	1.1	4.10	0.1	2.2	0.10
J2	7.3	53	1148	187	580	1.8	0.84	0.3	5.0	0.17
J3	8.5	69	692	114	320	3.3	0.98	0.1	2.4	0.32
J4	4.0	-	1256	182	830	11.5	7.30	0.8	27.0	0.50
J5	6.6	17	1462	174	830	1.1	4.50	0.3	14.0	0.15
J5	4.9	6	1332	173	870	1.4	5.30	0.4	24.0	0.18
J8	6.6	24	1026	142	675	4.0	2.80	0.3	11.0	0.30
J9A	5.5	33	1320	156	765	48.0	5.90	1.4	11.0	12.00
J9B	3.4	-	1662	199	1330	59.0	10.50	2.2	18.0	12.00
J10	6.6	28	928	124	545	3.5	1.80	0.3	5.5	0.30
J11	6.6	28	950	123	500	4.0	2.30	0.2	11.0	1.40
J12A	6.2	24	1476	80	750	53.0	85.80	2.80	7.7	15.00
J12B	5.5	4	5176	1000	1770	-	115.00	320.00	32.0	1.60
J13A	9.9	39	966	122	410	-	3.00	0.01	6.8	1.42
J13B	6.8	35	1208	108	900	-	66.00	3.40	5.7	9.70
J14	7.2	114	1016	65	570	-	61.00	1.70	2.8	5.70
J18	6.7	11	696	66	455	9.5	29.70	0.30	2.6	1.00
J19	7.2	13	746	66	455	10.0	26.40	0.30	0.0	0.60
R02	6.7	19	156	18	29	1.0	0.58	0.00	0.3	0.35
R01	7.2	37	164	21	32	2.5	1.05	0.00	0.0	0.72
ME1	4.4	-	1076	108	560	2.6	1.50	34.25	25.0	0.21
ME2	4.2	-	932	94	465	5.5	2.00	1.66	22.0	0.53
ME3	3.5	-	1676	246	2325	3.8	4.80	0.20	3.3	3.00
ME4	7.1	37	124	12	97	11.5	1.40	0.00	0.2	4.20

its tributaries were in an exceptional polluted state. Both organic enrichment and pollution by heavy metals were found in the upper reaches at Garson, in the Frood-Stobie branch in Nolin Creek, in Copper Cliff Creek and in Meatbird Creek. Chemical analyses demonstrated only moderate to organic enrichment in Robinson Creek, as was indicated also by biological parameters .

Stations of particular interest are J14 immediately above Kelly Lake and J16 below the lake. The concentration of organic nitrogen below was one-half of that above Kelly Lake, 61 and 30 ppm respectively. Also, the copper concentration was 2.3 ppm above and 2.6 ppm below, while there were 6.7 ppm of iron above and 0.6 ppm below. Kelly Lake probably has a considerable assimilative capacity but substantial all counts of organic materials, heavy metals and inorganic salts (mainly calcium and sulphates) passed beyond Kelly Lake.

Conclusions

Junction Creek and four of its five major tributaries were found to be heavily polluted by both sanitary and industrial wastes on the basis of selected chemical and biological parameters. Kelly Lake reduced the waste load in Junction Creek, but the condition of the creek below the lake retained very poor.

VERMILION RIVER

Sources of domestic and industrial wastes

The potential sources of waste are located on the Roberts River (Lowphos Ore Limited), the Onaping River including Moose Creek in the Levack area, the Whitson River in the Hammer - Chelmsford area and Junction Creek in the Sudbury- Copper Cliff- Creighton area. The sanitary-waste disposal systems and industrial developments have been described previously. However, Capreol is directly on the Vermilion River and will be described at this point.

Capreol

Sanitary sewage from Capreol (population 2,973) flows in combined sewers to a large septic tank which discharges to the Vermilion River. The CNR yards are served by separators to remove oil. Boiler and cooling water are discharged to the Vermilion River.

Biological assessment of water quality

The upper Vermilion River was examined at Station V1 and V2 (Figure 6), where four and eleven taxa were collected from the stream bottom, fauna. In spite of the small number of forms taken at Station V1, the water was apparently of excellent quality.

No evidence of impaired water quality was revealed at Station V3. Moderate numbers of eight taxa were collected. At Station 4, about 5 miles below Capreol, one of the most varied collections (23 taxa) of the total of 71 collections was obtained. Stoneflies, mayflies, caddisflies, dragonflies, midges and related flies, amphipods,

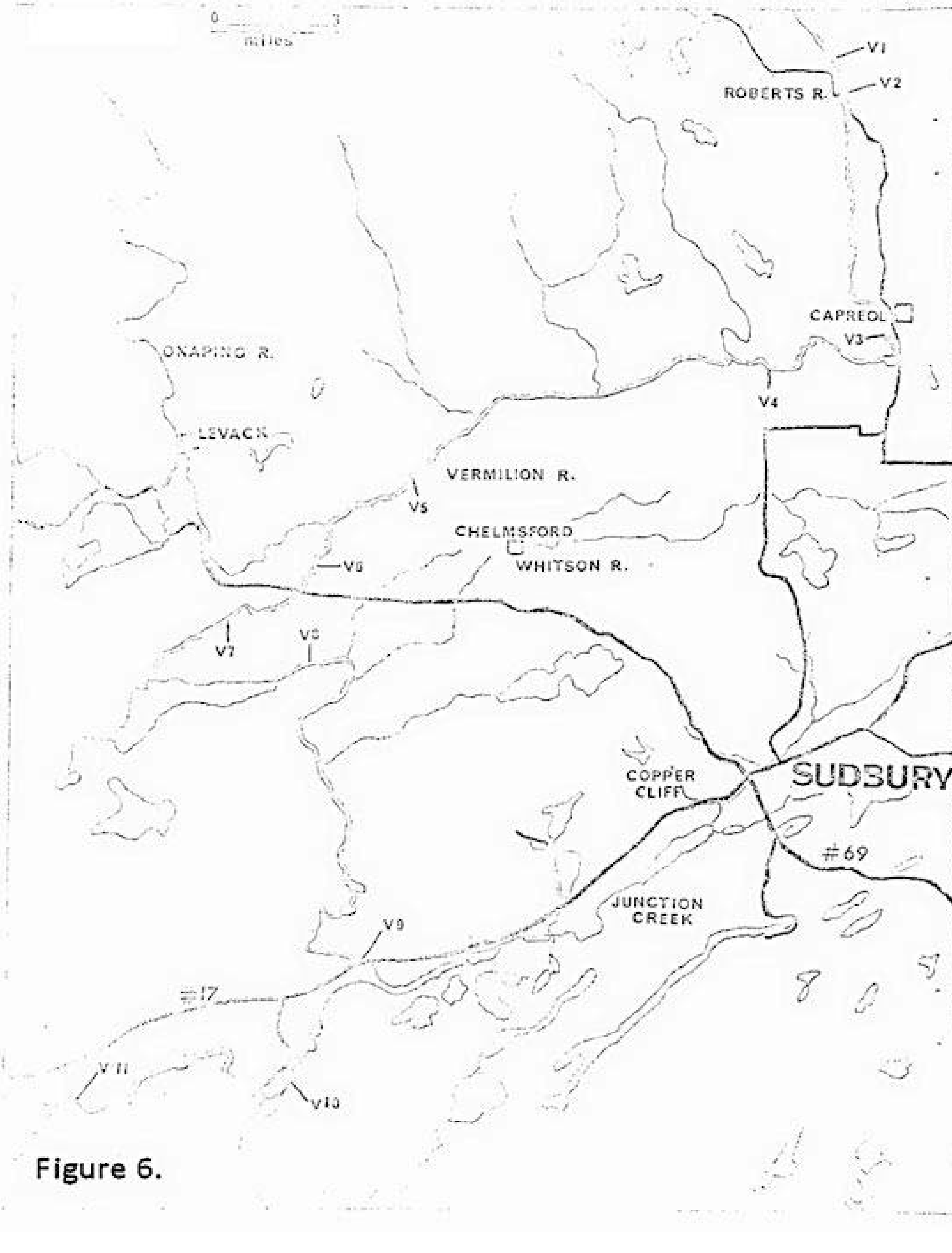

0
3
miles
V1
V2
ROBERTS R.
CAPREOL
V3
ONAPING R.
V4
LEVACK
VERMILION R.
V5
CHELMSFORD
WHITSON R.
V7
COPPER
CLIFF
SUDBURY
#69
JUNCTION
CREEK
V9
#17
V11
V10

Figure 6.

snails and clams were collected.

At Stations V5 and V6, above and below the confluence of the Onaping River, a varied bottom fauna was observed. A total of 12 taxa was taken above and 17 below. No effects of the Onaping River on the Vermilion River were evident.

Stations V7 and V8 above and below Vermilion Lake also yielded good collections of bottom invertebrates. Ten taxa were taken at Station V7 and 17 at Station V8. Further downstream: at Station V9, the last station above the entry of Junction Creak, similar evidence of good water quality was obtained. Fourteen taxa including mayflies, caddisflies, amphipods and clams were collected.

Station 10 was about 4 miles below McCharles Lake and, although devastating effects of Junction Creek on the Vermilion appeared to be a distinct possibility, the bottom fauna was indicative of fair water quality. A moderate number of taxa (eight including amphipods and snails, both relatively sensitive to heavy metals) and normal numbers of animals apparently indicated that detention of wastes carried by Junction Creek in Mud Lake, Simon Lake and McCharles Lake, and dilution by the Vermilion River, markedly improved water quality.

Actually the dilution is between 10 and 15 times when Junction Creak meets the Vermilion River, and fortunately, the four lakes, Kelly, Mud, Simon and McCharles certainly must act to stabilize the quality of water entering the Vermilion River as well as acting in an assimilative capacity. However, moderate organic enrichment was indicated by the absence of mayflies at Station V10 and at Station V11, about seven miles further downstream. The latter station yielded a varied collection of invertebrates, 13 taxa in all, and provided further evidence that water quality in the Vermilion River was not severely impaired by wastes from the Sudbury -Copper Cliff-

Creighton area.

A description of fish populations will not be attempted because of the large size of the Vermilion River, which limited fishing efforts considerably.

Chemical characteristics

The upper five stations on the Vermilion River were very similar with respect to water quality which was good (Table 6) . These waters were neutral, low in alkalinity at 18 to 24 ppm and relatively low in total solids at 30 to 70 ppm. Neither copper nor nickel was detected and the concentration of iron did not exceed 1 ppm.

A small amount of nickel, 0.2 ppm, was found at Station V6 below the entry of the Onaping River and more calcium and sulphates were present than at upstream. stations. The dilution factor was approximately four.

No significant differences in water quality ware observed above and below Vermilion Lake at Stations V7 and V8 or at Station V9 above the entry of Junction Creek.

Below McCharles Lake, where the Vermilion River and Junction. Creek mix, sulphates, organic nitrogen and nickel were higher than above that lake. The concentration of sulphates was 21 ppm at Station V10, the organic nitrogen concentration was 0.84 ppm and 0.1 ppm of nickel was determined.

Table 6. Results of chemical analyses made on samples collected at 11 stations on the Vermilion River in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
V1	7.0	19	30	10	0	1.0	0.43	0.0	0.0	0.32
V2	7.1	18	30	11	0	0.3	0.33	0.0	0.0	0.94
V3	7.1	20	52	14	0	2.6	0.40	0.0	0.0	0.68
V4	6.9	19	70	10	0	1.1	0.52	0.0	0.0	0.21
V5	7.4	24	68	8	11	0.8	0.25	0.0	0.0	0.31
V6	6.7	18	64	17	18	1.1	0.33	0.0	0.2	0.50
V7	7.4	15	110	14	18	2.3	0.71	0.0	0.2	0.39
V3	6.9	19	64	10	13	1.4	0.18	0.0	0.1	0.38
V9	7.0	22	92	14	14	1.1	0.33	0.0	0.0	0.21
V10	7.0	21	112	14	27	1.0	0.84	0.0	0.1	0.49
V11	7.0	21	74	16	16	1.4	0.71	0.0	0.2	0.22

Conclusions

The Roberts River, Town of Capreol and Onaping River apparently did not affect the Vermilion River adversely. Even the entry of the extremely Polluted Junction Creek had not altered the biota and water quality of the Vermilion River to any marked degree, although some evidence of moderate organic enrichment was indicated. The large flow n the Vermilion River diluted Onaping water about four times and Junction Creek water about fifteen times. Adequate dilution was obviously responsible for preservation of good water quality in the Vermilion River, together with the moderating influence and assimilative capacity of the Junction Creek lake chain.

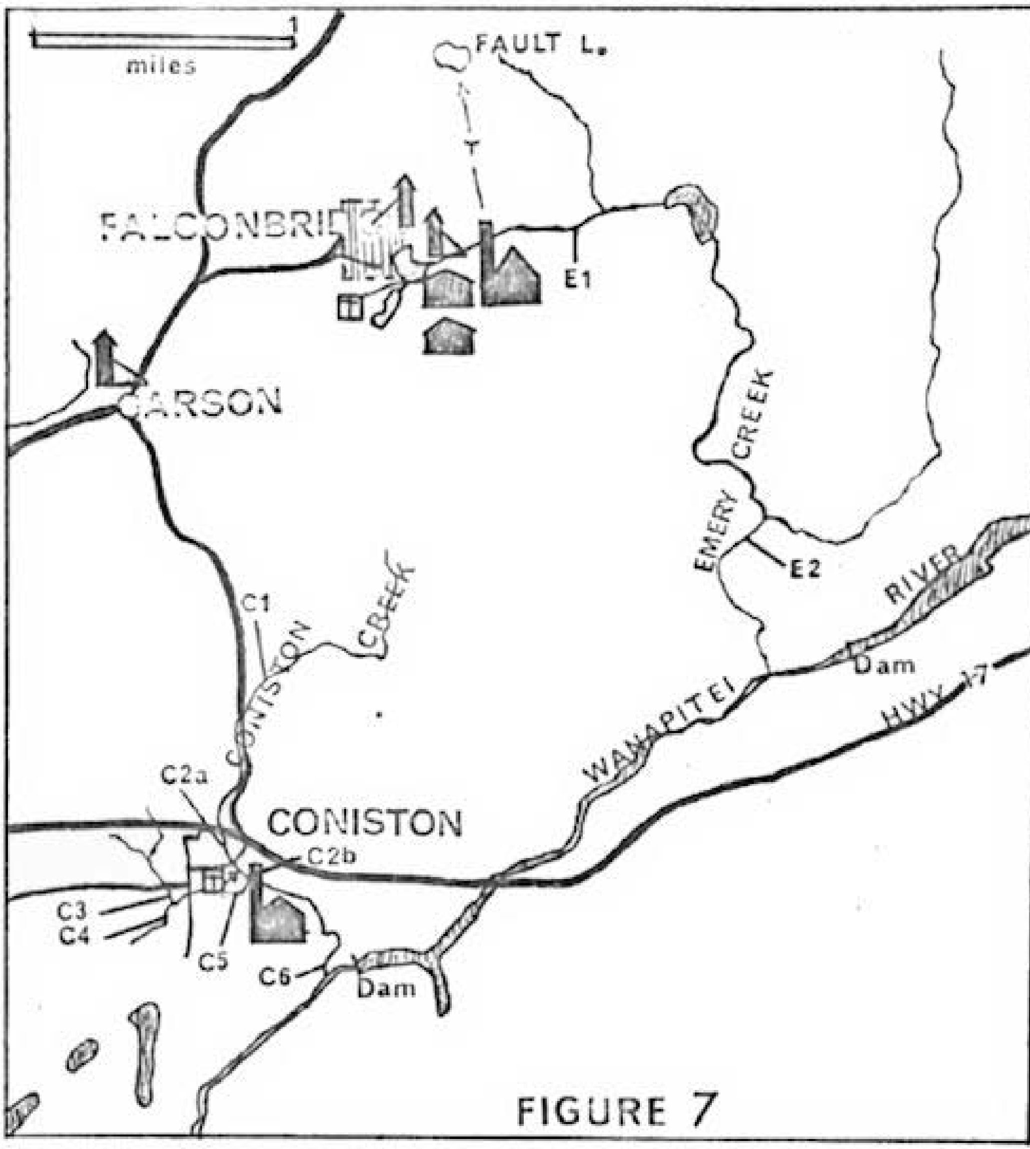
EMERY AND CONISTON CREEKS

Sources of domestic and industrial waste

Township of Falconbridge

Sanitary sewage from the Falconbridge townsite (population 1,200) and parts of the industrial complex nearby is treated in two parallel septic tanks and trickling filters. The affluent is discharged to Emery Creek. Other plant domestic wastes are treated in septic tanks and dis-charged to both the new and old tailings areas and adjacent swampland.

Mine drainage is pumped from the Falconbridge and East Mine to swampland which drains to Emery Creek. Tailings from the concentrator are pumped to Fault Lake which has no visible outfall. Cooling water from the swelter is discharged to Boucher Lake, while wastewater from the pyrrhotite plant is discharged to the old tailings area.


1
miles
FAULT L.
FALCONBRIDGE
E1
CARSON
EMERY
CREEK
E2
RIVER
Dam
HWY 17
WANAPITEI
C1
CONISTON
CREEK
C2a
CONISTON
C2b
C3
C4
C5
C6
Dam
FIGURE 7

Town of Coniston

All sanitary sewage in Coniston (population 2,600), including sewage from the smelter, is discharged to the municipal separate sewer system and provided primary treatment in an activated sludge treatment plant operated by the OWRC. The effluent is chlorinated during the summer months and is discharged to Coniston Creek.

The smelter, which processes ore from the Creighton and Levack mines, yields spent cooling water to Romford Creek, a tributary of Coniston Creek.

Biological assessment of water quality

Only three taxa were found in the stream bottom fauna of Emery Creels and, because these ware midges and beetle larvae, and the former group was present in large numbers, toxic together with organic pollution was indicated.

Similarly, the invertebrate fauna indicated toxic conditions in Coniston Creek. No animals were taken at Stations C2b and CS and only midges were present at Station C6 at a point immediately above the confluence with the Wanapitei River. The creek at all other stations indicated in Figure 7 was dry at the time of the survey.

Chemical characteristics

Considerable impairment of water quality was evident in Emery Creek. Iron in particular but also nickel were present in large concentrations (Table 7). Also, organic enrichment was evident at Station E1. The very high concentrations of calcium, sulphate and total solids indicated the presence of a great amount of industrial wastes, comparable, in fact, with Junction Creek just above Kelly Lake.

Coniston Creek water also contained considerable amounts of the heavy metals, particularly nickel and copper, but much lass calcium and sulphates than Emery Creek (Table 7). Organic enrichment was obvious in the very high concentration of organic nitrogen at Station C2b.

Conclusions

Both Emery Creek and Coniston Creek were heavily polluted by industrial wastes. Undesirable concentrations of heavy metals were detected chemically and their toxic effects were indicated in each case by an impoverished bottom fauna.

Table 7. Results of chemical analyses made on samples collected at 5 stations on Emery and Coniston Creeks in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
E1	6.9	145	1022	88	630	12.5	1.80	0.02	0.0	3.00
E2	-	230	1154	93	723	-	0.77	0.02	3.4	6.90
C2b	7.3	135	388	40	198	-	26.50	0.00	0.8	1.40
C5	6.1	7	152	21	61	9.0	0.64	0.80	6.2	2.80
C6	6.8	17	202	30	82	4.0	1.95	0.30	2.4	1.40

WANAPITEI RIVER

<u>Sources of domestic and industrial waste</u>

The main sources of wastes from Falconbridge and Coniston have been described. Descriptions of three other less significant sources outside of the Emery Creek and Coniston Creek watersheds are provided here.

Township of MacLennan

A new underground mine was being developed by Inco near Skead in 1965. Mine water was pumped to a small lake which drained to Massey Bay of Lake Wanapitei.

Township of Dryden

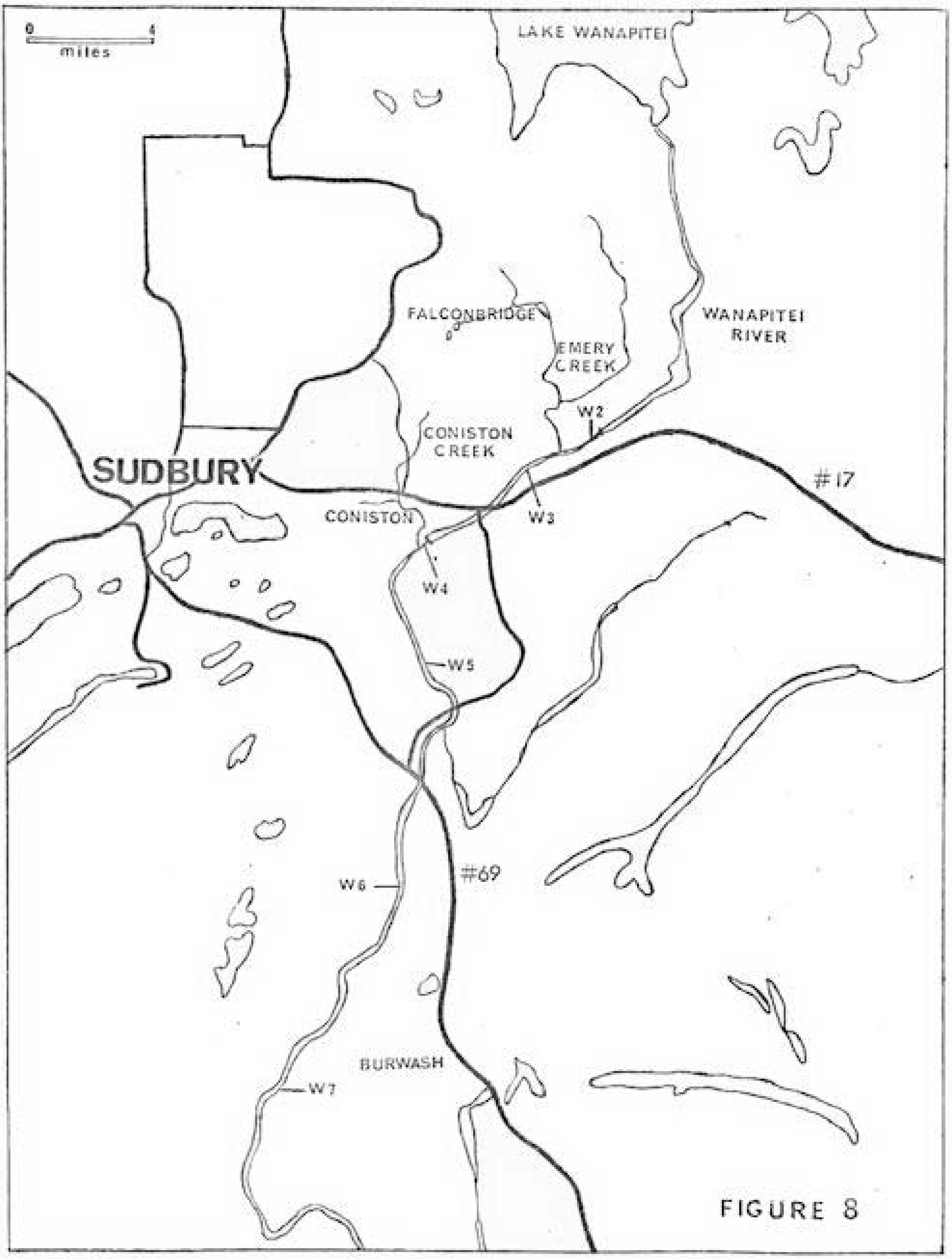
The community is served by septic tanks and leaching pits, many of which function poorly, resulting in pollution of roadside ditches.

Township of Laura

The Burwash Industrial Farm is served by two activated-sludge treatment plants and several septic tank installations. One treatment plant discharges its effluent to the Wanapitei River, while the other discharges to a pond.

<u>Biological assessment of water quality</u>

Good water quality was indicated by the biological collections made at Stations W2 and W3 above and below the entry of Emery Creek (Figure 8). A total of 10 and 12 taxa respectively were taken at these two stations. Amphipods, which are not tolerant of heavy metals, were common at Station W3. Emery Creek is diluted approximately 25 times in the Wanapitei River.


0
4
miles
LAKE WANAPITEI
FALCONBRIDGE
EMERY
CREEK
WANAPITEI
RIVER
W2
CONISTON
CREEK
SUDBURY
#17
CONISTON
W3
W4
W5
#69
W6
BURWASH
W7
FIGURE 8

Poorer water quality was indicated at both Stations W4 and W5 above and below the entry of Coniston Creek. Only five and six invertebrate taxa were collected, consisting mainly of groups tolerant of heavy metals. Deterioration of water quality above the entry of Coniston Creek must be because of the leeward proximity to the Coniston smelter. Poor water quality indicated below the entry of Coniston Creek may be caused partly by the extremely polluted state of Coniston Creek, although about 40-times dilution occurs.

No improvement was noted at Station W6 where low numbers of only four tolerant taxa were collected. However, at Station W7 about 18 miles below Coniston improved water quality was indicated by the presence of greater numbers of individuals of nine taxa, including mayflies.

Chemical characteristics

Concentrations cf total solids, calcium and sulphates in the Wanapitei River increased through that length of river between Stations W2 and W7 (Table 8). Copper was present in small amounts in only two samples, nickel in small amounts in three, while the concentration of iron from Station W3 to Station W6 was greater than at control stations.

Conclusions

At the time of the survey water in the Wanapitei River was of fairly good quality, although biological data indicated otherwise at several stations. The Wanapitei River passes very close to the Coniston smelter through land which is devoid of vegetation over large areas.

Table 8. Results of chemical analyses made on samples collected at 5 stations on the Wanipitei River in June, 1965.

Station	pH @ lab	Alkalinity	Total solids	Calcium	Sulphate	Turbidity units	Total Kjeldahl nitrogen	Copper	Nickel	Iron
W2	6.6	18	74	12	0	1.0	0.84	0.01	0.0	0.21
W3	7.4	17	80	14	2	3.5	0.20	0.00	0.0	1.30
W4	7.1	15	80	16	23	2.S	0.26	0.00	0.I	1.10
W5	7.2	4	72	14	22	2.9	0.40	0.00	0.1	0.80
W6	6.9	13	108	13	23	3.8	0.26	0,02	0.0	1.10
W7	7.4	15	110	14	18	2.3	0.71	0.00	0.2	0.39

Unlike the Vermilion River, the Wanapitei River is not protected by lakes on the Coniston and Emery systems, which would serve to moderate the level of pollutants in the way that the Junction Creek lakes must do. Therefore, it is quite likely that during dry weather, pollutants are concentrated in the watershed near Coniston and then are washed into the Wanapitei River during short-duration, high-intensity rainfalls. The Wanapitei River was periodically contaminated as indicated by biological sampling, and the preceding hypothesis should be examined in future studies.

BIOASSAY EXAMINATION OF STREAMS

The toxicity of water in Moose Creak, Copper Cliff Creek, Junction Croak, Emery Creek and Coniston Creek was investigated. Samples were obtained on July 1, 1965 near the mouth of each stream, returned to the Commission laboratory and fathead minnows were exposed to serial dilutions of stream water with Toronto tap water.

The 96-hour TLm values were as follows:

	% by volume
Moose Creek	75.0
Copper Cliff Creek	12.5
Junction Creek	Non-toxic
Emery Creek	24.0
Coniston Creek	75.0

The chemical analyser of the Emery Creek sample indicated that toxicity was due to the low pH and the high concentration of iron. Although the rusty-red precipitate which developed in all concentrations suggested that considerable amounts of iron came out of solution, the sample was much more toxic than that from Moose Creek which had a similarly low ph. Some toxicity from the iron in Emery Creek is indicated. Apparently the mortality in the Moose Creek sample was caused by pH alone.

The toxicity of the sample from Copper Cliff Creek can be accounted for by the concentrations of copper (14 ppm) and ammonia (82 ppm N). Similarly the 1.0 ppm copper in the water from Coniston Creek would have been toxic.

Although Junction Creek water was not acutely toxic, it would not be expected that the stream could successfully support fish populations for any length of time due to its pH of 10.1.

These results demonstrate that the heavy metal concentration and pH disturbance are indeed toxic to fish at the levels found in the five streams in the Sudbury area which were judged to be most polluted. Furthermore, the data indicate that in some cases considerable dilution is required to render the wastes non-toxic in laboratory tests. Considerably greater dilution would be requires to minimize effects on fish under stream conditions of continuous exposure.

These tests serve to support the field data in pointing out the prevalence of toxic levels of pH and concentrations of heavy metals.

LAKES OF THE SUDBURY AREA

Of the many lakes within 25 miles of Sudbury 21 ware selected and their bottom fauna, phytoplankton and chemical characteristics were examined. Four of the lakes which do not receive liquid wastes are about 20 miles from the closest smelter Windy Lake, Little Panache Lake, Frenchman Lake and Rock Lake. Another four lakes, Ashigami Lake, Red Deer Lake, Elbow Lake and Whitefish Lake are approximately 10 miles from the nearest smelter. A group of eight lakes, including Whitewater Lake, Garson Lake, Long Lake, Meatbird Lake, Ramsey Lake, Lady Macdonald Lake, Clarabelle Lake and Robinson Lake are within 5 miles of the nearest smelter. These lakes receive little or no fluid wastes but their proximity to smelters makes them susceptible to atmospheric contamination.

A group composed of Vermilion Lake, Kelley Lake, Simon Lake, Moose Lake and Norway Lake receive streams containing fluid wastes. Of these five, considerable atmospheric contamination as well must occur in Kelley Lake and Norway Lake at least.

Although only a preliminary examination of these waters was made, nonetheless some of the information is quite revealing and will guide future surveillance programs. The observations on phytoplankton, bottom fauna and chemical characteristics are as follows:

<u>Chemical characteristics</u>

The four lakes 20 miles from the nearest smelter had average total solids concentrations which averaged 60 ppm and varied between approximately 30 and 100 ppm (Table 9). These lake waters were close to neutral in pH except the acidic Frenchman Lake. Calcium and sulphate concentrations were relatively low; the average

Table 9. Chemical characteristics of the near-surface waters of 21 lakes in the Sudbury area in June (upper line) and September (lower line) in 1965. Where only one line of data is presented, these are June data.

Lake	Total solids	Ca	SO_4	Alkalinity	pH	TKN	Metals		
							Cu	Ni	Fe
Windy	20	4	14	8	6.0	0.77	0.01	0.0	0.10
	38	4	25	6	7.1	0.20	0.02	0.0	0.09
Panache	58	13	<5	23	7.2	0.39	0.00	0.0	0.10
	36	13	17	25	6.9	0.33	0.01	0.0	0.50
Frenchman	80	9	<5	5	5.3	0.07	0.00	0.0	0.15
Rock	114	9	<5	15	6.9	0.07	0.00	0.0	0.20
	92	9	20	15	6.9	0.20	0.00	0.0	0.01
Ashigami	84	9	<5	5	6.2	0.07	0.00	0.1	0.15
Red Deer	70	10	44	15	6.8	0.39	0.00	0.1	0.20
	102	9	21	14	6.6	0.43	0.02	0.0	0.50
Elbow	86	10	133	13	7.0	0.52	0.00	0.0	0.18
	68	10	24	11	6.0	0.20	0.04	0.0	0.30
Whitefish	72	10	10	7	6.3	0.07	0.00	0.1	0.15
	80	10	34	10	6.5	0.40	0.02	0.0	0.02
Whitewater	128	18	30	31	7.6	0.40	0.00	2.4	0.44
	132	19	59	35	7.3	0.84	0.20	0.0	0.11
Carson	60	14	<5	5	4.9	0.46	0.00	1.7	0.30
	76	7	30	3	5.0	0.84	0.04	0.1	0.40
Long	86	13	16	18	7.1	0.32	0.00	0.3	0.40
	130	17	37	19	6.9	0.20	0.03	0.0	0.04
Meatbird	278	30	210	5	4.8	0.13	0.31	2.6	0.24
	312	*24*	164	2	4.5	0.26	0.30	6.0	0.08
Ramsey	144	18	35	19	7.1	0.20	0.10	0.2	0.16
	170	13	51	13	6.8	0.46	0.02	0.3	0.09
Lady	270	41	139	7	6.1	0.55	0.40	4.0	0.13
Macdonald	310	41	171	4	6.0	0.33	0.50	3.5	0.02
Clarabelle	236	38	118	22	7.2	0.39	0.10	2.0	0.20
	322	46	147	23	7.5	0.26	0.30	1.5	0.10
Vermilion	68	10	10	18	7.1	0.33	0.00	0.1	0.22
	86	12	25	19	6.5	0.40	0.01	0.2	0.19
Moose	130	21	60	0	4.0	0.77	0.00	0.5	1.31
(upper)	190	29	117	0	3.8	1.00	0.03	0.1	0.47

Table 9. (continued)

	Total solids	Ca	SO_4	Alkalinity	pH	TKN	Metals		
							Cu	Ni	Fe
Robinson	143	20	29	17	7.0	0.71	0.00	0.2	0.19
	178	18	14	13	7.0	0.46	0.07	0.4	0.20
Vermilion	68	10	10	18	7.1	0.33	0.00	0.1	0.22
	86	12	25	19	6.6	0.40	0.01	0.2	0.19
Moose	130	21	60	0	4.0	0.77	0.00	0.5	1.31
(upper)	190	29	117	0	3.8	1.00	0.03	0.1	0.47
Moose	114	20	60	0	4.2	1.00	0.00	0.0	0.62
(lower)	160	22	88	0	4.2	0.60	0.20	0.0	0.12
Kelly	766	71	440	9	7.2	33.00	0.40	4.0	0.70
	880	82	549	0	4.3	21.00	2.50	5.8	8.30
Simon	568	60	320	5	5.9	6.10	0.26	0.1	0.38
	686	66	403	8	6.2	19.00	0.40	4.5	6.40
Norway	308	17	160	0	3.2	0.33	0.00	5.0	5.90

calcium concentration was 9 ppm and the sulphate concentration averaged 13 ppm. Organic nitrogen did not exceed a concentration of 0.77 ppm while most analyses showed less than half that amount. Copper was present in only three of seven analyses and in trace amounts, nickel was not detected and the average concentration of iron was 0.16 ppm.

The second set of four lakes, those at the 10-mile range, were not markedly different in chemical characteristics than the lakes at the 20-mile range. The average concentration of calcium was 10 ppm and of sulphate, 22 ppm. The pH varied between 6 and 7 and total solids concentration averaged 80 ppm. Copper was present in only three of seven analyses and in trace amounts. Traces of nickel were found in three samples. The average concentration of iron was 0.21 ppm.

The third set of lakes, from Whitewater Lake to Robinson Lake in Table 9, occur within 5 miles of the nearest smelter and is included in an area of about 250 square miles surrounding the smelters. In general, these eight lakes are much higher in dissolved solids. The average total solids concentration was 190 ppm, about three times the concentration 2.4 ppm in Whitewater Lake in June, 2.6 and 6.0 ppm in Meatbird Lake in June and September, 4.0 and 3.5 ppm in Lady Macdonald Lake and 2.0 and 1.5 ppm in Clarabelle Lake.

No evidence of organic contamination was found in these eight lakes, as assessed by considering total Kjeldahl nitrogen concentrations. Most pollution was of industrial origin and the degree may be assessed by an examination of concentrations of calcium, sulphates, total solids, copper and nickel in relation to the first two groups of lakes.

Five other lakes were examined and their chemical characteristics will be discussed in turn. Moose Lake, which receives some mill tailings from Cranberry Lake, has been contaminated as evident in abnormal concentrations of calcium and sulphates and high total solids. Of particular significance from, a biological viewpoint, the pH has been seriously depressed probably as a result of the continuous hydrolysis of heavy-metal compounds derived from the tailings area. The pH averaged 3.9 in the upper basin and 4.2 in the lower basin.

Water quality in Vermilion Lake did not appear to be seriously impaired. Concentrations of calcium, sulphates and total solids were not abnormally high, only trace amounts of metals were detected and the water was approximately neutral.

Kelly Lake and Simon Lake in tile Junction Creek Lake chain were examined. The total solids concentration in Kelly Lake was approaching 1,000 ppm, of which sulphates made up about one-half. Kelly Lake water was neutral in June but quite acidic in September. The high concentration of organic nitrogen, 33 and 21 ppm, demonstrated the presence of large amounts of domestic wastes, while abnormal levels of copper and nickel (0.4 and 2.5 ppm of copper, 4.0 and 5 ppm of nickel) indicated the seriousness of the industrial waste problem. Simon Lake was in little better condition with about 600 ppm total solids, 360 ppm sulphates, pH about 6.0, average organic nitrogen concentration of 12.5 ppm and high levels of copper, nickel and, in September, iron also.

These two lakes and certainly Mud Lake between therm, and probably McCharles Lake too, were in an unsatisfactory condition. As pointed out previously this lake chain may moderate the flow of wastes to the Vermilion River but its assimilative capacity is limited by the extremely large amounts of wastes which are delivered to Kelly Lake and Mud Lake. Furthermore, the assimilation of organic wastes may be impeded by the presence of levels of heavy metals which are toxic to many organisms.

Norway Lake, close to the Falconbridge mill, was inspected and found in a very polluted condition based on the following analyses: 308 ppm total solids, 160 ppm sulphates, pH of 3.2 and high concentrations of nickel and iron.

Lake Wanapitei was not sampled in June but a sample was submitted by the Department of Lands and Forests in September. The chemical characteristics are as follows: 75 ppm total solids, 10 ppm calcium, 19 ppm sulphates, pH 7.0 and alkalinity of 18 ppm, 0.46 ppm organic nitrogen, 0.02 ppm copper, 0.08 ppm iron and no nickel detected. Because some mine drainage nas been introduced into the lake and greater amounts may be added in the future, surveillance of Lake Wanapitei should be continued on a regular basis.

Phytoplankton

The lake groups at the 20-mile and 10-mile ranges had phytoplankton populations which were comprised of at least 8 genera in June and at least 9 genera in September (Table 10). Diatoms were common in these lakes, particularly in June when between one-third and one-half of the genera were diatoms. A considerable range in size of the standing crop of near-surface phytoplankton was observed, but was not unexpected.

Some differences in the phytoplankton populations of lakes near the 5-mile range are apparent. Although several lakes had as many genera in June as in the first two groups, for example Whitewater Lake, Long Lake and Ramsey Lake (all rather large lakes), the rest of the group showed fewer genera. Only five genera were present in Garson Lake and Meatbird Lake and only four in Lady Macdonald Lake. These three

Table 10. Summary of data on Phytoplankton collected at 21 lakes in the Sudbury area in June (upper line) and September (lower line) in 1965. Where only one line of data is presented, these are June data.

Lake	Diatoms	Number of Genera					Areal standard units/ml.
		Yellow-green	Blue-green	Green	Others	Total	
Windy	5	1	1	4	-	11	43
	2	-	7	8	2	14	29
Lake	4	-	3	4	-	11	185
Panache	3	1	2	5	-	11	
Frenchman	3	-	1	2	2	8	35
Rock	6	1	2	5	-	14	581
	4	2	3	2	2	13	297
Ashigami	5	1	1	6	-	13	37
Red Deer	7	1	2	3	1	14	4408
	2	1	2	6	-	11	347
Elbow	9	1	2	6	2	20	2512
	3	2	2	1	1	9	200
Whitefish	7	1	-	8	-	16	355
	7	1	3	1	-	12	249
Whitewater	4	1	2	8	-	15	557
	3	-	2	9	1	16	194
Garson	2	-	1	2	-	5	416
	2	-	1	2	1	6	173
Long	8	1	1	3	0	13	16
	4	1	3	4	1	13	91
Meatbird	2	1	-	1	1	5	40
	1	1	-	2	1	5	96
Ramsey	6	-	2	3	-	11	5538
	1	1	2	4	-	8	557
Lady	2	1	-	1	-	4	2
Macdonald	3	-	-	1	-	4	2
Robinson	3	1	-	2	1	7	245
	1	-	3	9	1	14	1917
Clarabelle	3	1	1	3	1	9	415
	1	-	1	1	-	3	8

Table 10. continued

Lake	Diatoms	Number of Genera					Areal standard units/ml.
		Yellow-green	Blue-green	Green	Others	Total	
Vermilion	8	1	1	4	1	15	300
	5	1	3	4	-	13	322
Simon	4	-	-	3	-	7	74
	-	-	2	4	-	6	28
Kelly	2	-	1	5	-	8	988
	-	-	-	4	-	4	14
Moose	3	-	-	5	1	7	29
(upper)	1	-	-	2	1	4	21
Moose	2	-	-	3	2	7	31
(lower)	-	-	1	3	1	5	20
Norway	2	-	-	1	2	5	49

lakes were noted in the previous section as having depressed pH levels. Also, the latter two lakes had copper concentrations of 0.3 and 0.40 ppm in June. The volume of phytoplankton was depressed in most samples where the heavy metal concentration was high and the pH was low. Similar results were obtained from the samples taken in September.

The phytoplankton population in Vermilion Lake resembled those in the lakes in the first two groups. Kelly Lake arc Simon Lake had reduced numbers of genera in both spring and fall. That these lakes are populated by phytoplankton at all is surprising, in view of the high concentrations of copper which have been observed, for example, 0.40 and 2.50 ppm in June and September in Kelly Lake and 0.26 and 0.40 ppm in Simon Lake. However, considerable organic matter was present and much of the copper could have been in less toxic form tan the ionic state.

Moose Lake and Norway Lake both receive mill tailings and have shown depressed pH values and abnormal heavy metal concentrations. Both lakes had phytoplankton populations which appeared to be limited in both size and number of genera.

Bottom fauna

The bottom fauna of precambrian lakes is neither abundant nor varied. Midge larvae predominate, and few representatives of other groups are usually taken. Therefore, an examination of the number of genera would provide little useful information; the number of species of the few common groups should be much more informative. Such data have been prepared and presented in Table 11.

Table 11. Summary of data on bottom fauna collections made at 21 lakes in the Sudbury area in June, 1965. The number of Ekman-dredge collections made at each lake is shown in parentheses.

Lake	Number of Species							Mean No. collected/ sample
	Midges	Sludge-worms	Caddis	Molluscs	Chaoborus	Other groups	Total	
Windy (4)	5	1	-	1	-	-	7	8
L. Panache (4)	6	1	-	-	-	1	8	7
Frenchman (2)	6	-	-	-	-	2	8	28
Rock (3)	2	1	1	1	1	2	8	5
Ashigami (3)	8	2	-	1	1	-	12	19
Red Deer (4)	2	1	-	-	1	2	6	18
Elbow (4)	2	3	-	-	1	-	6	35
Whitefish (3)	5	2	-	-	1	-	8	100
Whitewater (3)	6	1	2	4	1	3	17	40
Garson (2)	3	2	1	-	-	1	7	36
Long (4)	5	2	-	-	1	1	9	21
Meatbird (3)	4	-	1	-	-	1	6	26
Ramsey (7)	3	1	-	-	-	-	4	13
Lady Macdonald (4)	-	-	-	-	-	1	1	<1
Clarabelle (3)	-	-	-	-	1	-	1	1
Robinson (3)	-	-	2	-	1	-	7	39
Vermilion (4)	3	2	2.	3	1	1	12	19
Kelly (8)	3	4	1	-	-	1	9	20
Simon (3)	2	-	1	-	1	-	4	249
Moose (upper) (6)	1	2	-	-	-	1	4	25
Moose (lower) (2)	-	-	-	-	-	-	-	0
Norway (3)	-	-	-	-	-	-	-	0

Six to twelve species were found in the bottom fauna of the first two lake groups. Most of these, of course, were midges. No great differences were evident in most of the lakes at the 5-mile range. Whitewater Lake had a considerable number of species probably because of its shallow character.

Only one species was taken from Lady Macdonald Lake and one from Clarabelle Lake. Impairment of water quality in these two lakes has been demonstrated by chemical analyses and phytoplankton counts.

The bottom fauna in Vermilion Lake was similar to that found in uncontaminated lakes. Kelly Lake yielded as many species as control lakes but other differences were apparent. For example, while the sludgeworm *Rhyacodrilus montana* was found in control lakes, sometimes with the ubiquitous *Limnodrilus hoffmeisteri*, Kelly Lake contained *Tubifex tubifex* and several species of *Limnodrilus* which are found in greatest numbers in organically enriched lakes. Simon Lake had large numbers of midge larvae but only four species of bottom animals. Finally, lower Moose Lake and Norway Lake had few, if any, bottom animals whatsoever, while the bottom fauna in upper Moose Lake was composed of very few species.

Conclusions

No evidence of contamination, atmospheric or from surface discharge, could be detected in eight lakes 10 to 20 miles from the nearest smelter. Eight lakes within five miles of smelters showed some evidence of impaired water quality, particularly Lady Macdonald Lake and Clarabelle Lake, where high heavy metal concentrations and low pH levels restrict the number of taxa and individuals in both the phytoplankton and bottom fauna populations. Vermilion Lake appeared to be in good condition, but Kelly Lake, Simon Lake, Moose Lake and Norway Lake were considerably polluted. Because only a small number of lakes was visited and minimal sampling was carried out, these data are of limited value. However, it should be apparent that lakes, even those of considerable size, can be damaged by inadequately treated waste dischargers. Also, the value of phytoplankton samples and bottom fauna collections should be useful in the surveillance of water quality in these and other lakes in the Sudbury area. However, research on the phytoplankton and benthic communities is required to fully develop the two groups as parameters of water quality.

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D. Pugh, D. Osmond, R. Hunsinger and G. Westlake collected water samples, fish, invertebrates and phytoplankton. Y. H. Swabey carried out bioassays. Chemical analyses were made by the Chemistry Branch of the Commission and the Water Quality Surveys Branch measured flows in the major streams in tie summer of 1965. The Industrial Wastes Division of the Commission and the Department of Lands and Forests provided considerable assistance.

APPENDIX

Table 1. Specimens collected at 11 stations on uncontaminated streams in the Sudbury area at ranges of 10 and 20 miles from the closest smelter. Collections were made in June, 1965, and methods are outlined in text of report.

	Ten-mile range						Twenty-mile range*				
Taxa	1	2	3	4	5	6	1	2	3	5	6
STONEFLIES											
Isoperla											2
Acroneuria											1
MAYFLIES											
Caenis		3		7		9	3	6		3	
Cloeon		1		1		1				6	
Centroptilum		6		4		7	2			2	
Ephemerella							4			2	22
Heptagenia									2		4
Hexagenia										2	4
Baetis											
Callibaetis											3
Pseudocloeon											1
Stenonema											1
Baetisca											1
Arthroplea											1
CADDISFLIES											
Trianenodes			1				2	6			
Polycentropus	7			1							
Limnephilus			1		1						
Pycnopsyche											5
Hydropsyche							2				2
Banksiola							1				
Mystacides							1				
Athripsodes							1				
Lepicostoma											1
Chimarra											2
DRAGONFLIES											
Gomphus							1				
Cordula							1				
Erpetogomphus									1		
Aeshna			1		1	7					
Sympetrum					1	1					
DAMSELFLIES											
Enallagma	1	3		1			1	15			
Lestes	4							9			
Ischnura	2				1						
FISHFLIES											
Sialis							1				

Table 1 - continued

	Ten-mile range						Twenty-mile range				
Taxa	1	2	3	4	5	6	1	2	3	5	3
FLIES											
Tendipedidae	3	63	4	1	3	4	9	4		11	9
Palpomyia							1			1	1
Pseudolimnophila										3	
BEETLES											
Oreodytes		6						1		1	
Laccophilus			1								
Coptotomus								4			
Gyrinus							2				
Dytiscus								1			
Galerucella									1		
Rhantus	1										
Tropisternus			2								
Hydroporus					1						
Unidentified adults	2	14	4	6	4	2	5	5		2	
BUGS											
Notonecta		2	1	3	1	1		1		1	
Corixidae	4	2	14	15	7	17	5	7		38	
Ochtaridae									1		
Trepobates	1										
AMPHIPODS											
Hyallela		18				2	8	14		5	
Crangonyx			1		1						
LEECHES											
Genus B			2								
Genus C				3							
Genus D					1						
Genus E								2			
MOLLUSCS											
Physa		1						2			
Amnicola		15								1	
Pisidium		1									
Sphaerium										29	
CRAYFISH											
Cambarus										11	1
SLUDGEWORMS											
Unidentified			3		6		1	1			
MITES											
Unidentified		6	1			5		9			

* Station 4 at 20-mile range was not examined.

Table 2. Specimens collected at five stations on the Roberts River and Whitson Creek in June, 1965. Sampling methods are outlined in the text of the report.

	Roberts River		Whitson Creek		
Taxa	R1	R2	WH1	WH2	WH3
MAYFLIES					
Caenis	1				1
Stenonema	1	10			2
Heptagenia	1				
Hexagenia					1
Baetis	1	3	16	12	12
Centroptilum			7		
Ephemerella		2			
CADDISFLIES					
Cheumatopsyche	13	5			
Hydropsyche	2	8			1
Leptocella					1
Lepidostoma					1
Oecetis	1				
Chimarra		7			
Wormaldia		1			
Polycentropus		2			
Anabolia			5	1	
DRAGONFLIES					
Lanthus		2			
Aeshna					1
Ischnura					1
FLIES					
Tendipedidae	12	9	29	23	48
Tipulidae		1	3		
Simulium	58	2			
Atherix		1			
Pseudolimnophilia				3	
Chrysops			3	4	4
Palpomyia	2				2
FISHFLIES					
Chauliodes					1

Table 2. continued

Taxa	Roberts River		Whitson Creek		
	R1	R2	WH1	WH2	WH3
BEETLES					
Galerucella	1				
Oreodytes			2		
Stenelmis					2
Unidentified adults			22	1	1
BUGS					
Notonecta		1			
Trepobates			2		
Corixidae			4	21	
AMPHIPODS					
Hyallela			3		
Crangonyx		.			1
LEECHES					
Unidentified genus A	1				
MOLLUSCS					
Pisidium		14			18
Sphaerium					15
Campelloma					54
CRAYFISH					
Unidentified		4			
SLUDGEWORMS					
Unidentified	3	5	2	1	95
MITES					
Unidentified			6		

Table 3. Specimens collected at 12 stations on the Onaping River and tributaries in the Levack area in June, 1965. Sampling methods are outlined in the text of the report.

Taxa	04	06	07	08	09	010	011	012	013	014	015	016
STONEFLIES												
Isoperla								2				
Acroneuria									1			
Allocapnia									1	6		
MAYFLIES												
Ephemerella								22	1		2	36
Baetis								4	2			
Callibaetis								3				101
Pseudocloen								1				
Heptagenia								4				
Stenonema								1	4			
Caenis												1
Baetisca								1				
Arthroplea								1				
Paraleptophlebia									2			
CADDISFLIES												
Hydropsyche								2			1	
Parapsyche										3		
Polycentropus	1		35									1
Lepidostoma								2		1		
Pycnopsyche								2			1	
Chimarra								2			1	
Limnephilus			1					5		24	1	
Wormaldia											1	
Mystacides												2
DRAGONFLIES												
Aeshna	1				1							
Leucorrhinia			1									
Perithemis												1
Cordulegaster												1
DAMSELFLIES												
Enallagma	2											1
Lestes			12		2							
Nehalennia			1									
FLIES												
Tendipedidae	7	1					46	9	20	36	5	87
Palpomyia	1							1				
Simulium		70					5			4	2	
Eristalis						1						
Atherix											1	
Chrysops												3

Table 3. continued

	Stations											
Taxa	04	06	07	08	09	010	011	012	013	014	015	016
FISHFLIES												
Sialis										1		22
BEETLES												
Rhantus	1											
Hydrotrupes										2		
Oreodytes												1
Gyrinus												1
Unidentified adults					10		1			1	1	2
BUGS												
Notonecta	1											1
Corixidae					3							
MOLLUSCS												
Physa							1					
CRAYFISH												
Cambarus								1				
TUBIFICIDS												
Undentified	23		26			28					2	5
MITES												
Undentified												1

APPENDIX

Table 5. Specimens collected at 11 stations on the Vermilion River in June, 1965. Sampling methods are outlined in the text of the report.

	Stations										
Taxa	V1	V2	V3	V4	V5	V6	V7	V3	V9	V10	V11
STONEFLIES											
Acroneuria				4							
Isoperla						1	1				
Unidentified genus A		4									
MAYFLIES											
Heptagenia	2		1								
Stenonema		7		3							
Ephemerella			1	14				1			
Baetis		1		13							
Centioptilum			19	4	3				2		
Ephemera		3		1							
Pseudocloeon?				25							
Hexagenia		3			5	1					
Baetisea					1						
Callibaetis					1	3	1	4			
Caenis						1		4	4		
CADDISFLIES											
Hydropsyche				1							
Chimarra		2									
Neureclipsis											1
Pycnopsyche		1		2	2	2		3	7		
Oecetis						1	1	2	3		6
Polycentropus						4	1				
Leptocella					1				7		1
Triaenodes								1			
Mollana									1		
Mystacides									1		
Cheumatopsyche							1				
Helicopsyche				1							
DRAGONFLIES											
Erpetogomphus	1										
Ophiogomphus				5							
Gomphus						1	4				
Aeshna										1	
DAMSELFLIES											
Hyponeura		1									
Agrion						2	1				
Enallagma								10	14	1	2

Table 5. continued

Taxa	Stations										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
DAMSELFLIES											
Ischnura								1			
Teleallagma								2			
FLIES											
Tendipedidae		2	2	1	20	41	34	4	8	4	10
Tipulidae			1	4	1						
Atherix				1							
Chrysops				2		5					
Palpomyia					4	11					1
Simulium											127
FISHFLIES											
Sialis				1							
BEETLES											
Galerucella	1								1		
Oreodytes						1					4
Rhantus								2		1	1
Laccophilus								1			
Gyrinus											1
Coptotomus											1
Unidentified adults				5	2	3	3	16	7	17	3
HEMIPTERA											
Corixidae				4	13	2	5	13	11	3	6
Ochteridae	1										
Notonecta								1			
Rhagevelia											17
AMPHIPODS											
Hyallela				21		1		55	3	10	
LEECHES											
Unidentified genus A			1				1				
MOLLUSCS											
Pisidium			1	2	8	6					
Sphaerium									2		
Campelloma				2							
Physa				2	1			4		1	
CRAYFISH											
Orconectes		2	1								
SLUDGEWORMS											
Undentified		2	5	1		17			2		
TRICLADS											
Phagocata				1							
MITES											
Unidentified								1		1	

APPENDIX

Table 6. Specimens collected at 10 stations on the Wanipitei River and tributaries in the Falconbridge and Coniston areas in June, 1965.

	Stations									
Taxa	W2	W3	W4	W5	W6	W7	E1	C2b	C5	C6
MAYFLIES										
Centroptilum	4					28				
Éphemorella	1	13								
Stenonema	3									
CADDISFLIES										
Hydropsyche	9		2							
Cheumatopsyche	12									
Chimerra	1		1							
Neureclipsis	1									
Pycnopsyche		7								
Molanna		2								
Mystacides		6			3	4				
Oecetis						1				
Leptocella				2						
FLIES										
Simulium		2	399							
Palpomyia		1		1		1				
Teridipedidae	1	24		5		2	137			4
BEETLES										
Oreodytes										
Berosus					1	2				
Dytiscidae							1			
Unidentified adults		11		4	1	13	3			
HEMIPTERA										
Corixidae		2	2		1	9				
AMPHIPODS										
Hyallela		14								
MOLLUSCS										
Pisidium			2							
Sphaerium	5									
SLUDGEWORMS										
Unidentified		1		1						
MITES										
Unidentified		1		1						
TRICLADS										
Phagocata	1									

Table 4. Specimens collected at 20 stations on Junction Creak and tributaries in the Sudbury area in June, 1965. No animals were collected at stations J9a, J9b, J11 and J14. Collecting methods are outlined in the text of the report.

	Stations																			
Taxa	J1	J2	J3	J4	J5	J6	J8	J10	J12a	J12b	J13a	J13	J18	J19	R01	R02	ME1	ME2	ME3	ME4
MAYFLIES																				
Caenis															13					
Centroptilum																				4
CADDISFLIES																				
Polycentropus		1																		
Trianenodes															17					
Cheumatopsyche																				57
Limnephilus																				1
Pycnopsyche																		26		
DRAGONFLIES																				
Gomphus								1												
DAMSELFLIES																				
Enallagma						12														
Ischnura						2	1													
Nehalennia						1														
FLIES																				
Dixa																				1
Tendipedidae	9	47	76			5	68	74			27		65	522	18	28	138	46	1	10
Palpomyia			1											1						
Ephydridae	1		1																	
Tipulidae			1																	1
Chrysops																				2
BEETLES																				
Oreodytes		25	42	1			1	3						6		5		3		
Hydroporus		3														1				
Dineutus			1																	
Rhantus							2	5								2				
Unidentified adults	1	3	45			1	1	10			3		2		2	11	3	6	2	
Laccophilus																1				
Agabus																2				
Loptotomus																3				
Cyphon																		1		
Graphoderus															3					

Table 4. (continued)

Taxa	Stations																			
	J1	J2	J3	J4	J5	J6	J8	J10	J12a	J12b	J13a	J13	J18	J19	R01	R02	ME1	ME2	ME3	ME4
BUGS																				
Notonecta		1						1							2					
Corixidae		2					16								254			49	2	
Saldidae																		7		
MOLLUSCS																				
Pisidium											2									
Sphaerium															75					
CRAYFISH																				
Orconectes																				4
SLUDGEWORMS																				
Unidentified				29	7		1		1	4	266	2		7		17				
MITES																				
Unidentified																10				