



INLAND WATERS BRANCH

DEPARTMENT OF THE ENVIRONMENT

A Hydrological-Metal Pollution Study

Heath Steele Mines Area, New Brunswick, Canada

J.E. CHARRON

TECHNICAL BULLETIN NO. 43



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OTTAWA, CANADA, 1972

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Abstract

Two streams in the Heath Steele Mines area of New Brunswick were determined to be affected by metal pollution (Zn and Cu). These streams and the springs of the area are not polluted in their natural environment because the sulphide ore in its natural unbroken state was unoxidized and, therefore, insoluble. The pH of these natural waters ranged from 6.0 to 8.0 while the value of total dissolved solids was low as indicated by specific conductance values of less than 100 micromhos/cm. Therefore, the metal pollution in the Northwest Miramichi must be caused by the Heath Steele mining operation at the head of the Tomogonops River basin.

On the mining property, the extreme values obtained for pH, specific conductance and copper were 5.0, 3,650 micromhos/cm and 72.0 ppm. Metal pollution was seen to increase appreciably after heavy precipitation, due mainly to the lack of facilities for transmitting these polluted waters to the tailing pond. If the capacity of pumping and transmitting facilities or the storage capacity were increased immediately, metal pollution resulting from heavy precipitation could be reduced by 85 per cent.

This report draws attention to the fact that, once the mining operation ceases at No. 2 and No. 3 shafts, more polluted water will be discharged to the Little South Tomogonops River to further aggravate the situation presently caused by polluted water released from "A" pit.

A Hydrological-Metal Pollution Study

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INTRODUCTION

A hydrogeological study was carried out in the summer of 1967 to determine if groundwater contributed to the metal (Cu and Zn) pollution which is a threat to the salmon in the Northwest Miramichi River. The study served a dual purpose: (1) to discover the main sources of pollution and (2) to establish the chemistry of ground and surface waters in their natural state so that the data obtained could be used as a basis for future pollution control studies in similar regions.

Early in the study it became evident that groundwater, in its natural environment, was not the source of metal pollution. Thus, the study became a hydrological one that consisted mainly of sampling most of the streams and springs within a limited area, as well as the groundwater in the mine at the Heath Steele property.

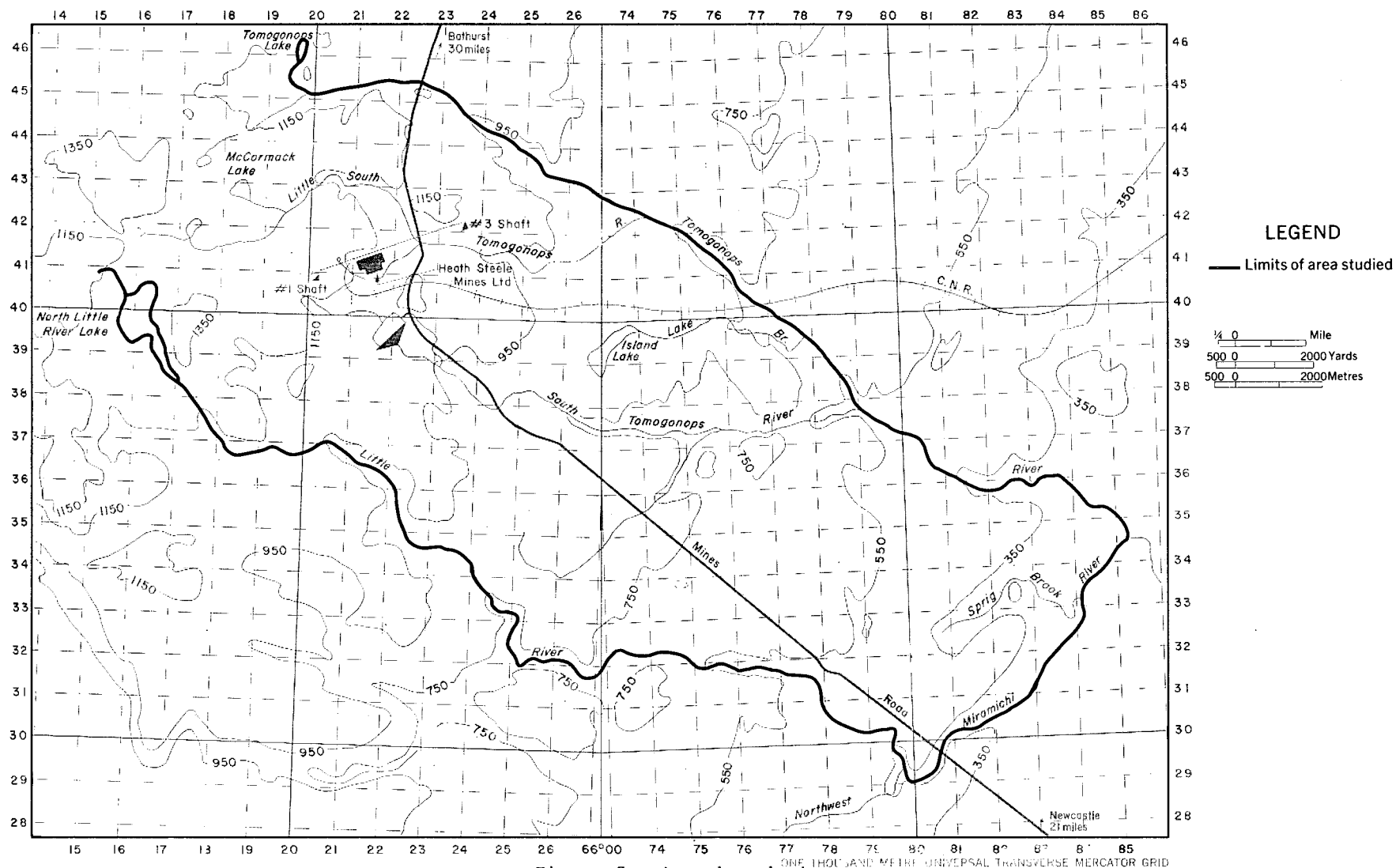
The data gathered for this report confirmed the opinion of the Department of Fisheries that the metal pollution in the Northwest Miramichi River is due to the Heath Steele mining operation situated at the head of the study area and give rise to the recommendations herein that certain immediate measures be taken at the mine to alleviate heavy-metal pollution.

Levels of 48 ppb Cu or 600 ppb Zn, or one half of each level (if they occur together) are defined by the Fisheries Research Board of Canada as toxic to fish. These toxic concentrations have a definite temperature dependence and apply only at a pH of 7 and a water hardness of approximately 14 ppm CaCO_3 .

A number of papers dealing with metal pollution in the Northwest Miramichi River has already been published by the Canada Department of Fisheries, the Fisheries Research Board of Canada and the Water Authority of New Brunswick.

Location

The study area is 22 miles northwest of the town of Newcastle New Brunswick, (Figure 1, index map) and encompasses approximately 65 square miles. The area, which has an oblong shape (Figure 3), lies on a north-westerly-southeasterly projection, and is bounded on three sides by rivers - the Little River to the south, the Tomogonops River to the north and the



Northwest Miramichi River to the east. The fourth side is formed by the Heath Steele Mines property.

From the mining property, the area slopes downward towards the Northwest Miramichi River. The maximum elevation, 1,400 feet above mean sea level, is east of North Little River Lake, with the average elevation at the mine site itself being 1,150 feet. The minimum elevation is 200 feet at the other extremity of the map-area near the junction of the Tomogonops and Northwest Miramichi Rivers. The hydraulic gradient of the area is less than 1 per cent.

The limits chosen for the area were such that if the metal pollution was caused by the Heath Steele Mines, it would be readily discernible within these limits (Figure 3).

Sampling

Because the area is entirely forested and not inhabited except at the mine site, well data were not available, although many diamond-drill holes have been drilled in the past by various mining companies. Therefore, the hydrogeological part of the study consisted of analysis of the springs in the area. The surface waters were also included in the sampling program.

A portable Hach Kit was available for field analyses and a simple analytical-chemical procedure was necessary if many samples were to be collected and analysed. The Fisheries Research Board had earlier established the fact that high toxicity in the Northwest Miramichi River was due to dissolved copper and zinc. Therefore, it was thought that analysis of the mine water might indicate the best procedure to use. The mine water analysis showed that if the water had a relatively high dissolved copper content (1.0 ppm or more), it also had a low pH (6.0, 5.0 or 4.0) and a relatively high specific conductance value (100 - 3,000 micromhos/cm). Consequently the field laboratory tests were limited in most cases to these three tests.

First, the pH value of a water sample would be determined. If it proved to be low, a specific conductance test was performed; if this gave a high value, the copper content of the water sample was determined. In this manner, twenty pH and specific conductance tests could be made in a relatively short time.

Field analyses were carried out on water samples from 421 different locations. The results are given in Table I for the locations shown on Figure 1. The Universal Transverse Mercator grid system is used to indicate each location.

Thus the basic part of the field work consisted of traversing the area and collecting samples from springs, streams, lakes and rivers. In many locations samples were collected repeatedly at different intervals. Details of these are shown in Table II.

Streamflow Data

In August and early September, 1967, a total of 21 streamflow measurements (Table III) were made in the area by the Halifax District Staff of the Water Survey of Canada; the locations of these measurements are shown on Figure 4. The August measurements can be considered as representative of base flow. The September measurements show the effect of heavy precipitation (approximately 2 inches), but because of rapid runoff, one day's delay can make a considerable difference in the measurement of any stream. Therefore, these values have to be used with care, especially if comparison between different locations is to be made.

The variation in streamflow is well demonstrated by location No. 19 on the Little South Tomogonops River (Figure 4). At base flow the streamflow was only 1.5 cfs on August 18, 1967. The heavy rainfall of early September increased the flow to 5.4 cfs on September 8, 1967. Yet, early in June, the same stream had a flow of 77 cfs, fifty times the baseflow value.

FIELDWORK

The limits of the study area were defined by the position of Heath Steele mine; nevertheless, when the work was begun it was assumed that the metal pollution came from other sources. For this reason, the work was begun on the Northwest Miramichi River, the part of the area furthest from the mine; progress in the field work carried the work northwestward, progressively closer to the mine area (Figure 1).

Little River

The stream was found to be free of pollution throughout its entire length (Figure 5). The pH and specific conductance values were 8.0 and 89 micromhos/cm at the mouth, 7.5 and 35 micromhos/cm some ten miles upstream from the mouth, and 6.8 and 20 micromhos/cm at the source, at North Little River Lake. This implies that the river water goes through a natural evolution with the value of total dissolved solids increasing gradually from source to mouth. This gradual increase also demonstrates that there were no polluted tributaries on either side of this river.

Northwest Miramichi River

At the Mines Road Bridge, sample No. 17 (Figure 5) had pH and specific conductance values of 7.5 and 45 micromhos/cm on July 29, 1967. These values correspond approximately to the values in the Little River, halfway between its source and its mouth. Consequently, the stretch of the Northwest Miramichi that we are concerned with in this study, between Little River on one side and the Tomogonops on the other, was found to be clean and not polluted. This fact was demonstrated initially by the Department of Fisheries' study.

Only two of the boundary streams have so far been described as pollution free. The other main streams will be discussed later. However, it should be mentioned at this time that all the springs and streams within the confines of the Little River and the Tomogonops River in one direction, and the Northwest Miramichi and the South Tomogonops River in the other, were

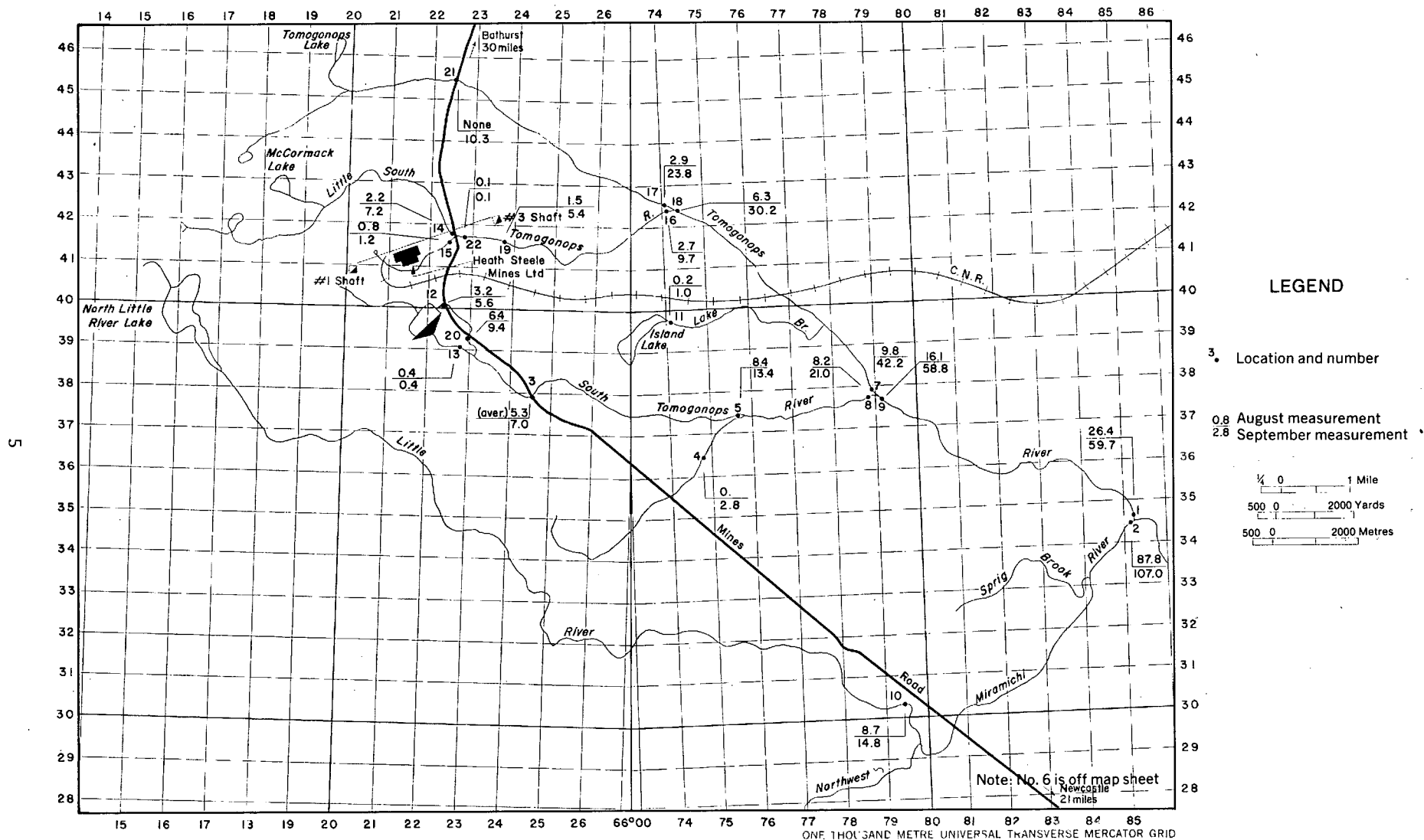


Figure 4 - Streamflow measurements and location.

found to be unpolluted. The pH and specific conductance values of the streams were about 7.5 and 90 micromhos/cm while those of the springs were about 6.5 and 40 micromhos/cm. In general, the spring water was more acidic than the stream water. Some streams had a pH of 4.5 (e.g. Sample No. 94) but this was attributed to organic acid. No copper values were discernible even in the most acidic streams and springs within these confines and the low specific conductance value obtained was in complete agreement with the findings of others.

Tomogonops River

This river is one of the main tributaries of the Northwest Miramichi River. At the mouth of the Tomogonops, the pH and specific conductance values were 7.5 and 215 micromhos/cm (Figure 5), while at the source, those same values were 7.5 and 35 micromhos/cm. The high pH value combined with the relatively low specific conductance value prevented the field analysis from showing any copper values. However, the Department of Fisheries has been taking periodic samples at the mouth of the Tomogonops for many years and their data for the years 1963-1966 show the metal (Cu and Zn) toxicity value of the river at this point to be high, even during the period from June to September.

The Tomogonops River has only four major tributaries, all on the southwest side of the river. Two of these tributaries, the South Tomogonops River and the Little South Tomogonops River run through the Heath Steele mining property. Both streams contain metal pollution and will be dealt with in detail later on. The third, Lake Brook, was found to be clean with a pH of 8.0 and a specific conductance of 55 micromhos/cm (Sample No. 177) at its source at Island Lake and a pH of 7.5 (Sample No. 242) one mile downstream from the source. The fourth is a stream immediately to the southeast of the South Tomogonops (Figure 1) and its pH value was 7.0 (Sample No. 97) at the mouth, 6.5 (Sample No. 259) two miles upstream, and 6.0 (Sample No. 219) at the source, indicating an unpolluted stream.

The analyses taken along the Tomogonops River indicated no discrepancies that could be associated with the tributaries coming in from the northeast side of this river. This plus the fact that the total discharge of these tributaries is extremely low did not warrant their sampling.

Having eliminated all the groundwater and all but two of the tributaries of the Tomogonops River as the source of pollution, it was decided to carry out a detailed study of these two streams that showed pollution - the South Tomogonops River and the Little South Tomogonops River. Upstream from the mining operation, these two streams were found to be unpolluted. Because they flow through the Heath Steele mining property, it was assumed that any pollution in them would be related directly to the mining operation, since no other stream in the area, in its natural state, was found to be polluted.

South Tomogonops River

This river rises one-half mile south of Heath Steele Mines shaft No. 1. It is not polluted at the source where it has a pH and specific conductance of 7.0 and 183 micromhos/cm (Sample No. 382, Fig. 2). Nevertheless,

the value of 183 micromhos/cm is considered relatively high and abnormal at the source of such a stream. It is probably due to the mine waters of No. 1 shaft that, after being pumped out of the mine, flow to an area only a thousand feet away from the source of the South Tomogonops.

Some 3,500 feet downstream from the source, the South Tomogonops River receives the mine and mill waters that have been pumped through pipelines to the old tailing pond. Before mixing, the pH and specific conductance values were 9.5 and 3,650 micromhos/cm (Sample No. 319) for the mill water, and 5.0 and 1,250 micromhos/cm (Sample No. 1) for the mine water. (The latter includes the water from No. 2 and No. 3 shafts as well as the water from Camp Brook and the Clean Water Channel, the latter at base flow only). After mixing, the mixture of mine and mill water was periodically limed; a sample of this mixture (Sample No. 320) tested out to have pH and specific conductance values of 9.5 and 1,850 micromhos/cm. Again, because of the high pH values, a copper value could not be observed during field analysis.

After the South Tomogonops River is joined by the limed mixture of the mine and mill waters, it flows to the present tailing pond where the heavy metals in suspension settle. At the dam's No. 1 outlet the pH and specific conductance values have decreased to 8.0 and 950 micromhos/cm (Sample No. 49 on July 24, 1967). Two miles downstream, where it crosses the Mines Road, a pH reading taken on June 12, 1967 gave a value of 7.5 (Sample No. 51). Readings taken still farther downstream (Sample No. 222 on June 29, 1967 and No. 252 on July 5, 1967) yielded pH values of 7.6 and 7.9 respectively. It was, therefore, assumed that the water of the South Tomogonops River remained basic throughout its entire course. But on July 24, 1967 a pH of 5.0 was obtained where the South Tomogonops crosses the Mines Road and it became evident that the basic water flowing down the South Tomogonops from the present tailing pond, had become acidic along the way. This phenomenon had previously been observed at Brunswick Mines by the Department of Fisheries. Therefore, the stretch of the South Tomogonops River that lies between the present tailing pond dam and the Mines Road was studied more carefully.

One thousand feet downstream from the No. 1 outlet at the present tailing-pond dam, the South Tomogonops River encounters two relatively acidic tributary streams with pH values of 4.0 and 5.0 (Samples No. 342 and No. 277). The combined flow of these two streams is only one-tenth that of the South Tomogonops, but their effect is quite extensive in that they reduce the pH of the South Tomogonops to 7.0 (Sample No. 323 on August 2, 1967), from a value of 8.3 (Sample No. 344 on August 2, 1967) only 50 feet upstream. The stream then flows through a bog (Figure 2) which also seems to continue this acidifying process so that by the time it comes out of this bog, the stream's pH value is reduced to 6.9. All this time the specific conductance value has remained fairly constant at about 940 micromhos/cm (Sample No. 345 on August 2, 1967). The river then receives water that reeks of hydrogen sulphide (H_2S) from a marsh that extends some 2,000 feet to the north. It must be said here that at one time the overflow of the water behind the dam of the present tailing pond was at No. 1 outlet and this was then taken by a round-about way (Figure 2) through this marshy area. In its natural state, this marsh with its many springs is a discharge area for the groundwater situated north of it.

Because the tailing pond water passed through this marsh, two layers with a pungent smell of H_2S are found at its surface. One layer is white and the other, black. During the course of the 1967 field season,

No. 1 outlet was again used because of some construction being carried out at No. 2 outlet. This flushed out the marsh so that the pH and specific conductance values of the water coming from it were about 6.7 and 408 micromhos/cm. This marsh area is considered by the writer to be a possible source of pollution to the South Tomogonops. One thousand feet downstream from the point where the marsh water enters the South Tomogonops River, the pH and specific conductance values drop to 5.5 and 875 micromhos/cm (Sample No. 324 on August 2, 1967). Then the stream goes through a second bog from which it emerges with a pH of 5.0 and a specific conductance of 850 micromhos/cm (Sample No. 349). It then passes through a third bog but the pH and specific conductance values remain relatively unchanged. (Sample No. 350). By the time it reaches the Mines Road, the pH and specific conductance values are 5.0 and 825 micromhos/cm (Sample No. 51 on August 2, 1967). This change in pH is illustrated on Figure 6. For approximately one mile downstream from the Mines Road, the pH of the South Tomogonops remains the same until it passes through a fourth bog. At this point, it reverts to a neutral pH of 7.0 (Sample No. 352) while the specific conductance value decreased considerably to 685 micromhos/cm. For the remainder of the course, the pH value of the river remains near 7.0 but always on the high side, while the specific conductance value slowly decreases to approximately 500 micromhos/cm. Figure 6 shows clearly the sharp rise in the specific conductance value of the stream as soon as it encounters the mine and mill waters, followed by a continuous subsequent decrease all the way to the mouth of the South Tomogonops River.

The physical characteristics of this river are the same as those of most streams in the region. It is a narrow, shallow stream with rocky or bouldery bed. There the resemblance with streams in their natural state ends. From the time the South Tomogonops mixes with the mine and mill waters, it acquires a peculiar smell that persists all the way downstream to the mouth, and the bed of the stream takes on a greenish-yellow appearance. In their natural environment, the streams of the region have a black bottom, that is, the rocks and boulders making up the river beds normally have a black coating while the rocks and boulders in the South Tomogonops are coated by a greenish-yellow scum that, once out of the water, appears almost white.

During the base flow period (late July and August), the South Tomogonops and the Tomogonops Rivers cleared somewhat and lost the yellowish appearance and both streams seemed to take on a brown colour. It was during this period that fish were seen in the Tomogonops as far upstream as the mouth of the South Tomogonops River. Until then, no fish life had been seen in this stream during the course of the study.

An interesting phenomenon also occurred at the junction of these two rivers. The difference between the level of the two river beds at the mouth of the South Tomogonops River is about two or three feet, resulting in small falls being formed. However, as soon as the waters of the South Tomogonops come in contact with the Tomogonops River, the boulders and rocks that form the river bed take on a rust-brown colour and appear to be coated with an iron-oxide precipitate. This rusty brown colour can be seen for more than a quarter of a mile downstream from the junction of the two rivers. At the point where these two rivers meet, (Figure 5) the pH of the Tomogonops is 7.0 while that of the South Tomogonops is slightly higher at 7.5. The main difference is in the specific conductance value which is 87 for the Tomogonops and 350 micromhos/cm for the South Tomogonops.

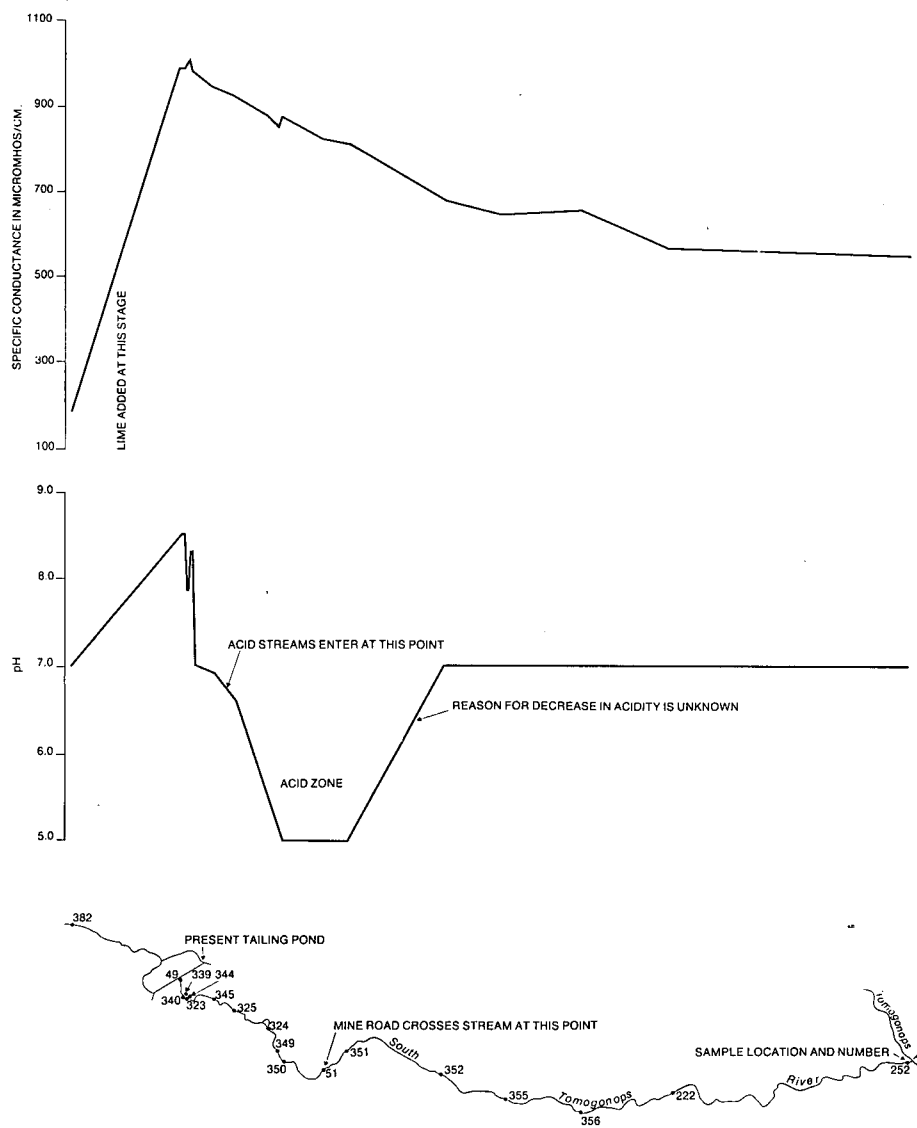


Figure 6 - pH and specific conductance values downstream along the South Tomogonops River.

Calcium sulphate forms the largest part of the total dissolved solids in the South Tomogonops River. The high sulphate value is due to the oxidation of the sulphide ore while the high calcium value is derived from the lime that is added to neutralize the acidity of the mine and mill water. Even though these waters are not saturated in sulphates and both rivers have a very low iron content (0.01 ppm), the precipitation of iron oxide is probably associated with a sulphate hydrolysis phenomenon. As for streamflow values at low flow, the two streams at that point have similar discharge rates (August 16, 1967) of approximately 9 cfs (Figure 4 and Table III). However, at high flow, the Tomogonops can have twice the flow of the South Tomogonops, 42.2 cfs versus 21.0 cfs. (Figure 4, Table III). A chemical analysis in September 1967 revealed a copper value of 0.021 ppm. This is in agreement with the results obtained previously by the Department of Fisheries which indicated copper content in the South Tomogonops to be less than 0.04 ppm. This low value is attributed to the efficiency of the present tailing pond treatment in removing the heavy metals and is acceptable to the Department of Fisheries. However, the writer firmly believes that this stream with its odour and colour is definitely not that of a stream in its natural evolution. There must be some unknown toxic compound apart from metal pollution that prevents fish from living in its waters. This unknown toxic compound was mentioned in the report of the Department of Fisheries (1965) which emphasized that the unknown commodity should be examined as soon as possible. This study has not solved this particular problem. The toxic compound could be related to the metallurgical process used in the mill, to bacterial action or simply to lack of oxygen. It could also be directly related to the marsh area, located between the intersection of the South Tomogonops with Mines Road and the present tailing pond (Figure 2), that reeks of H_2S . However, the nature or source of this toxic compound, which in itself could possibly be a serious cause of non-metal pollution, was not pursued in this study.

Little South Tomogonops River

This river has its source in the northwestern part of the mining property. At the source it is similar to Little River. The pH and specific conductance values are 7.5 and 35 micromhos/cm. Fish can be seen in this stream at the source.

Some three miles from the source, the Little South Tomogonops River enters the Heath Steele Mine area (Figure 2). From that point on, it is joined by many small affluents. At low flow, the streamflow of the Little South Tomogonops River as it enters the mine property is very low (only 2.2 cfs on August 17, 1967) while at the mouth of the river, during the same low flow period, it has increased only to 2.7 cfs, which is about 1/3 to 1/4 the flow at the mouth of the South Tomogonops. Therefore, the small affluents mentioned previously only contribute 0.5 cfs to the total. However, what they lack in quantity, they contribute in toxicity. These little rivulets can have pH values as low as 4.5, specific conductance values as high as 2,060 micromhos/cm and copper values of 112 ppm. Some occur on the south side of the Little South Tomogonops River but most are on the stream's north side. There are also many uncontaminated springs producing water of low specific conductance, 50 micromhos/cm, and a pH of 6.0. These springs occur all along the Little South Tomogonops River, down to the mouth (Figure 2). On the other hand, the toxic rivulets extend only from the Mines Road for about a mile downstream, or as far as the operational area of the mine presently exists (No. 3 shaft and "B" pit). Therefore, it appears that the toxicity of these rivulets is due to the mining operation.

The main sources contributing to the contamination of these rivulets are the oxidized ore and wastepiles between No. 2 and No. 3 shaft and oxidized wastes which are used as fill and which form the bed for part of Camp Brook and Clean Water Channel between the Mines Road and the plant. Three other areas contributed more at specific times to the pollution of the Little South Tomogonops River than all the ore and waste piles combined. They are 1) "A" pit, 2) the south branch of the Clean Water Channel and 3) the marsh area south of No. 3 shaft. Later in this report, these three areas are discussed individually.

Although the Little South Tomogonops River water is basic (pH of 7.5) at the source, it becomes slightly acidic, (pH of 6.8) some 700 feet upstream of the Mines Road Crossing. It reaches a low pH of 6.0 at the mining area, after which it reverts to a pH of 6.8 by the time it reaches the mouth. The specific conductance value increases from a low of 24 micromhos/cm at the source to 120 micromhos/cm some 1/2 mile downstream of the Mines Road Crossing, and it only slightly increases from there to 160 micromhos/cm by the time it reaches the mouth of the Little South Tomogonops River. Therefore, the variations of the pH and specific conductance for this stream are not as large as those for the South Tomogonops River.

Physically, the Little South Tomogonops River is similar to the South Tomogonops in that it is narrow and shallow with a stony bed. Before entering the mining property, the stream has a black bottom but, downstream of the Mines Road Crossing, it develops a rust-brown bottom. Once again, iron oxide appears to be precipitated on the rocks that form the stream bed.

The field analysis did not detect any high copper toxicity in the Little South Tomogonops River itself until August 21, 1967. Thus, until that date, no proof of metal pollution in the main streams coming from the mining property had been established by this study, which corroborates a similar statement made by the writer at a joint Federal-Provincial meeting held in Fredericton, N.B. on July 28, 1967.

During their five years of study, the Department of Fisheries noticed that when heavy precipitation occurred, metal pollution increased noticeably, particularly in the Little South Tomogonops, the Tomogonops and downstream in the Northwest Miramichi River. Therefore, in the course of the writer's field work two rain gauges were set up, one at the base camp and one in the area studied. Throughout the summer, rain fell an average of once every three days, but only in small amounts (Table IV). The first significant rainstorm in the map-area occurred on August 21, 1967 when 0.94 inch was registered. Also in a period of four days, September 1 to September 4, a total of 2.30 inches of precipitation fell. With that last mentioned heavy rainfall, it became obvious that the lack of pumping and transmitting facilities at the mine water's settling pond was the principal cause of the increase in metal pollution at a time of heavy precipitation. The large flow brought about by heavy precipitation includes an increase in mine water volume, an increase in "A" pit overflow (Camp Brook) and an increase in the Clean Water Channel volume. The main sources of pollution will now be discussed especially in relation to a heavy rainfall.

SOURCES OF METAL POLLUTION ON THE HEATH STEELE MINING PROPERTY

"A" Pit

"A" pit is an abandoned open pit, northwest of the mine plant, that has filled with water. The level at which the water stands in the pit is the piezometric level (approximately 1,150 feet) of the confined aquifer intercepted by the pit. The pH, specific conductance and copper content of the water at the surface of the pit are 5.0, 340 micromhos/cm and 5 ppm (Sample No. 291). At the 110-foot depth, these values are 5.0, 850 micromhos/cm and greater than 15 ppm (Sample No. 300). These figures were taken during a period of low flow.

The water of "A" pit overflows into a stream called Camp Brook. Therefore, "A" pit could be classified as an outsize flowing well. Camp Brook passes through a marsh (discharge area), flows south of the mill, and is finally collected in a settling pond along with the mine waters from No. 2 shaft. From there the combined waters are pumped via a 10-inch pipe-line to the old tailing pond where they are mixed with the mill water.

However, at low flow, the overflow of "A" pit is less than one Igpm. But after a steady rain such as occurred at the beginning of September, the flow was estimated to be approximately one cfs (373.8 Igpm). More important, the pH, specific conductance and copper values had changed to 4.0, 375 micromhos/cm and 25 ppm. This suggests that the effect of a barometric low not only raises the piezometric level of the water in "A" pit, but also stirs it up from top to bottom, thus increasing the copper concentration to 25 ppm. The fact that the water in a well becomes agitated because of a barometric low is a well-known phenomenon.

The stream bed of Camp Brook along the entire distance between "A" pit and the settling pond is either broken-up rock or wastefill. This permits some of the water to go underground to reappear at innumerable places as springs. One of these areas is immediately southeast of the settling pond where Camp Brook and the mine waters are collected. This area therefore contributes high metal pollution values to the Little South Tomogonops at times of heavy precipitation. One can only wonder at the high metal pollution occurring at times of spring runoff.

Finally, the piezometric level of the water in "A" pit is some 75 feet higher than the surface of the present tailing pond and the Little South Tomogonops at the point where it crosses the Mines Road. This is mentioned here to show that, because of the difference in head, groundwater flow is possible at the contact of the surficial deposit and bedrock, between "A" pit and these two points mentioned.

Mine Waters

This is the groundwater produced underground at No. 1 and No. 3 shafts and at the "B" incline.

At No. 1 shaft the acidic water (pH 5.0 to 7.0), specific conductance (518 to 635 micromhos/cm) and Cu (0.0 to 8.0 ppm) is merely pumped to a swamp area situated some 1,000 feet south of the No. 1 headframe. It would appear to be an almost ideal situation for pollution prevention. Yet,

the specific conductance of the South Tomogonops near that area is 183 micromhos/cm, which tends to indicate that some of the No. 1 shaft water may infiltrate the ground to the south of this disposal area. There are indications also that some of this water may directly (surface runoff) or indirectly (groundwater) reach the marsh that drains into the Clean Water Channel. Pumping all the water from No. 1 shaft directly to the South Tomogonops should eliminate all possible metal pollution from that source.

The water from No. 3 shaft is at present generally basic (Samples No. 397 - No. 407) and is pumped to a sump at the "B" incline. There, the water is mixed with the acidic waters of that part of the mine and limed. This mixture (pH 4.0, specific conductance 1,300 micromhos/cm and 5.0 ppm copper) is then pumped up No. 2 shaft to the surface where a flume takes it to the settling pond. Therefore, the present pollution control of this groundwater to the settling pond is adequate. Because of infiltration, heavy precipitation will increase the volume of water pumped out of the mine.

Clean Water Channel

The source of this stream is northwest of "A" pit, but that part of the stream up to where it crosses the pipe-line carrying the mill water was dry throughout July and August. What is being considered here as the source is a branch of that stream situated in the big bend in the railway track to the southwest of the Heath Steele Plant (Figure 2). The source is a marsh that is assumed to be a discharge area not only for the ground around No. 1 shaft but also a discharge area for the groundwater flow from "A" pit. This assumption is based on the topography of the area. After having crossed the track, the channel crosses the pipe-lines that carry the mill and mine waters to the old tailing pond. At that point the mill pipe-line has a relief valve. The valve must be opened periodically since the immediate surroundings are littered with tailings through which the Clean Water Channel flows. These tailings are identical to those found in the old and present tailing ponds. Some tailings are certainly carried downstream. At the old plant road, the Clean Water Channel flows parallel to and only a few feet from Camp Brook for a distance of some 2,000 feet until it reaches the flume. From there it goes to the Little South Tomogonops. However, at base flow during the summer of 1967, the mining authorities were diverting the water of the Clean Water Channel into Camp Brook so that the combined flow was being pumped with the mine water to the tailing pond. Nevertheless, as is the case with Camp Brook, the material on which the Clean Water Channel flows is broken-up rock and waste fill and, even though the precaution of a flume is added, some of the water filters underground and reappears as springs underneath the flume. These springs drain into a ditch that crosses the Mines Road and ends in a sump situated at the edge of the Little South Tomogonops. This water is pumped through 2-inch plastic lines into the flume that carries the mine waters from No. 2 and No. 3 shafts to the settling pond.

As was the case for "A" pit at low flow, the flow of the Clean Water Channel is usually negligible but, after a rain, it increases considerably. The pH, specific conductance and copper values obtained at the flume are 4.0, 650 micromhos/cm and 1.5 ppm (Sample No. 295). However, the ditch water that represents underground leakage from "A" pit and the Clean Water Channel has pH, specific conductance and copper values of 4.0, 2,800 micromhos/cm and 15 ppm (Sample No. 296). The writer placed iron rods and pieces of pyrite taken from the mine waste piles into the water of the ditch and, within a week, the replacement of the iron by copper, which is present in solution

in the water, was already noticeable. Some of the ditch water also infiltrated its porous bed and flowed directly to the Little South Tomogonops.

The main reason, however, for the high metal pollution in the Little South Tomogonops River after a heavy precipitation - pH 4.0, specific conductance 365 micromhos/cm, and copper 11.5 ppm. (Sample No. 301 on September 4, 1967) versus pH 7.0, specific conductance, 88 micromhos/cm and copper nil (Sample No. 301 on July 31, 1967) - is the fact that the pumping and transmitting facilities at the mine water settling pond are not adequate to handle the larger flows from 1) "A" pit through Camp Brook, 2) the Clean Water Channel and 3) the mine. Similarly the ditch water flow, derived from the underground flow of Camp Brook and the Clean Water Channel, is so increased by heavy precipitation, that the pumping station near the Little South Tomogonops River cannot handle all of it to the mine water flume. So the excess ditch, mine and "A" pit water as well as the Clean Water Channel water, all go directly to the Little South Tomogonops. It appears that the mine pumping and transmitting facilities to control the metal pollution of the Little South Tomogonops are strained beyond their capacities when two or more inches of precipitation occurs.

The solution seems simple enough. Larger pumping units and more transmitting pipes could be used to take care of the larger flows due to heavy precipitation assuming that the storage capacity of the mine water settling pond remains the same. Spring runoff would have to be considered here as the main factor affecting maximum cost. So far, all evidence of metal pollution in the Little South Tomogonops has been concentrated mainly in the area where the river crosses the Mines Road. But a 2-inch precipitation also activates all the small toxic affluents located along the river in the stretch from the Mines Road all the way to south of No. 3 shaft, where we come to another suspicious area concerning metal pollution in the Little South Tomogonops River.

Swamp Below No. 3 Shaft

At one time the company had settling ponds situated between No. 2 and No. 3 shafts that took care of the mine waters. Immediately to the south of No. 2 and No. 3 shafts exists a marsh that acts as a discharge area for the highland surrounding it. The water flowing through and from this swamp was so polluted that it has killed all the vegetation along its path. With the different pollution control set-up existing at the mine at the time of this field study, the old settling ponds were no longer used and, at low flow, the flow from the swamp was so small that none of the water flowing at the surface reached the Little South Tomogonops. Sample No. 326, taken at the old pump house situated at the lower end of the swamp, gave pH, specific conductance and copper values of 5.0, 2,060 micromhos/cm and 15 ppm on July 31, 1967. But, after the early September rain, the flow of water from the swamp was visible all the way down to the Little South Tomogonops and the pH, specific conductance and copper values had become 4.0, 2,800 micromhos/cm and 20.0 ppm.

With all these uncontrolled flows following a 2-inch rain, the pH, specific conductance and copper values of the Little South Tomogonops at a point some 2-1/2 miles downstream from the Mines Road were 4.0, 380 micromhos/cm and 15.0 ppm (Sample No. 304 on September 4, 1967). The streamflow at this date was approximately 10 cfs. At base flow, the corresponding values were 6.5, 118 micromhos/cm and nil (Sample No. 300 on July 29, 1967). This is shown graphically on Figure 7. However, one can only imagine what these

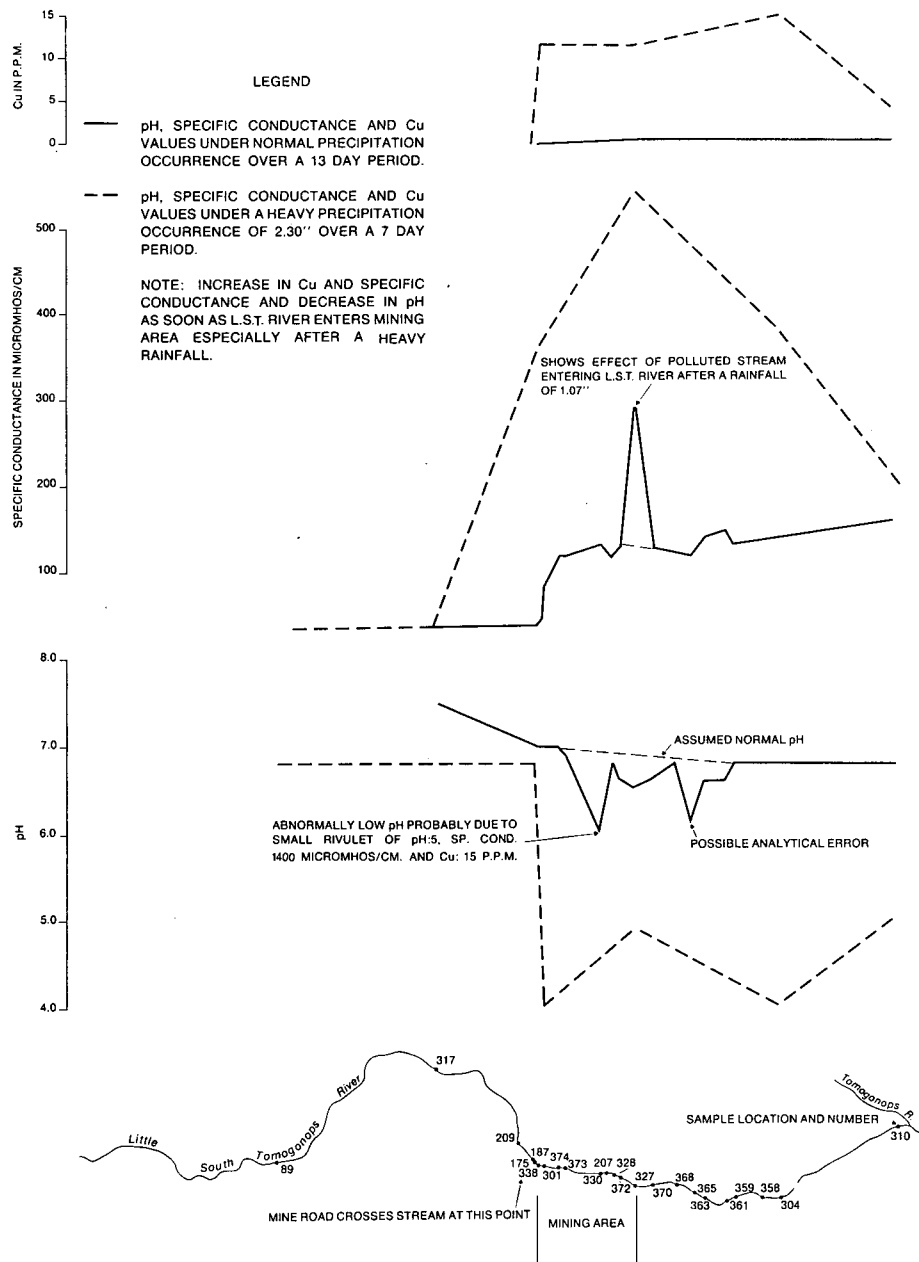


Figure 7 - pH and specific conductance values downstream along the Little South Tomogonops River.

values would be with the flow of 77 cfs measured on June 9, 1967.

One other main factor that should be taken into consideration is the oxidation of the ore and low grade waste piles.

Sulphide Oxidation

Through the courtesy of the Heath Steele mining management, the writer was allowed underground to collect water samples. The underground sampling brought out some interesting facts.

The first underground sampling was carried out at No. 3 shaft. Table I shows the field analyses of the 11 water samples (No. 397 - No. 407) and, generally speaking, the water was neutral to slightly basic. It is a known fact that sulphides are almost insoluble. The fact that No. 3 shaft is a development shaft proved that, since the ore had not yet been broken, the ore did not have the chance to become oxidized and the groundwater flowing through the sulphide zone remained basic. Only samples from the second level, (the level closest to the weathered zone near the surface) showed a tendency towards acidity, and also gave copper values in the field test. Therefore, the acidic waters pumped out of No. 2 shaft come from the old workings around No. 2 shaft that are not presently mined, that is, the broken ore has had time to become oxidized and this is reflected in the acidic waters. It can thus be predicted that the oxidation process will occur at No. 3 shaft when the development stage is terminated and the actual ore mining goes into full operation. Therefore, more acidic water can be expected to be produced when this occurs.

One other point of interest in the underground sampling was Sample No. 406. This was the most basic water (pH of 10.0) with the highest specific conductance value (over 10,000 micromhos/cm) encountered in this study. This water came from D.D.H. No. B226. Because the mine officials use a large amount of lime to neutralize the acidic mine water, it would be in their interest to check the amount of water available from this diamond drill hole (the water in DDH No. B226 is under artesian pressure) as well as the complete chemical composition of the water, as it possibly could be used instead of lime to neutralize the acid mine water.

Oxidation occurs not only underground but also on the surface. At the surface of the mining property, there are numerous ore and waste piles as well as many areas filled with waste from the mine. These rock piles are weathered and, between rains, the sulphides become oxidized. It is then a simple matter for heavy precipitation to dissolve the heavy metals and carry them in solution to the streams, principally to the Little South Tomogonops River. Consequently, two factors - the oxidation of the sulphide ores, and the inadequacy of the pumping and transmitting facilities for the waters containing metal pollution - are the principal reasons why the rate of metal pollution goes up so radically and was so noticeable in the data gathered by the Department of Fisheries after the occurrence of heavy precipitation.

Tailing Ponds

Old Tailing Pond: Geochemically, the "Old Tailing Pond" acts like an undiscovered ore body. The heavy metals settled there are insoluble because they

cannot be oxidized. But an exposure in this tailing pond demonstrated how quickly (because of the fine grain size of the settled particles) the heavy metals can oxidize if exposed and there is no doubt that erosion will do just that in time to come, especially once the mining operation closes. In this exposure the following strata could be observed from top to bottom:

<u>Material</u>	<u>Colour</u>	<u>Thickness</u>
copper sulphate	blue	6 inches
copper sulphate	rose	6 inches
slime	grey	12 inches
zinc sulphate	white	18 inches
pyrite	brown	60 inches

At present this tailing pond is not considered as an immediate problem but it has to be considered in the long-term pollution control planning.

Present Tailing Pond: The present tailing pond was studied closely especially at the base of the dam. It was discovered that many springs occur at the base of the dam, along with some leakage through it. The basis for distinguishing between springs and normal leakage through the dam was temperature. Due to its shallowness, the water temperature (top foot) of the tailing pond varied daily. The highest temperature recorded during the summer was 73°F. Subsequently, any water having a temperature of 50°F or less at the base of the dam was classified as a spring. These springs are shown on Figure 2. They are all found at the contact of the surficial deposits with bedrock. It is possible that the water from these springs also originates in the tailing pond, but having percolated farther (deeper), has a lower temperature.

This pond does an adequate job of retaining the heavy metals such as copper and zinc. However, lead and some arsenic have been found in the effluent (Dr. A. Watson, correspondence). This may be the unknown toxic compound already mentioned in previous Fisheries' studies. This, in itself, could be classified as an urgent problem depending on the amounts of lead and arsenic that were detected. As for future problems this pond is in the same class as the old tailing pond.

PRESENT METAL POLLUTION CONTROL AT THE HEATH STEELE PROPERTY

Having described the various areas considered to be sources of pollution, Figure 8 was drawn to illustrate diagrammatically that the source of pollution is the Heath Steele mining complex, including the four marshes, the two tailing ponds, the various ore and waste piles and "A" pit (Figure 2). Figure 8 also shows that the uncontrolled pollution (metal or other) is then carried by the Little South Tomogonops and the South Tomogonops to the Tomogonops and eventually to the Northwest Miramichi River. The mining company does attempt to control metal pollution, and as yet, has never rejected suggestions on the problem. The following is a brief description of the present pollution control at Heath Steele Mines.

The two main sources of metal pollution are mine water (pH 4.6, Cu 5.0 ppm) and mill water (waste in solution and suspension). Metal pollution control of the mine water consists of liming the water underground and then pumping this mine water up No. 2 shaft, into an open wooden flume, to a settling pond (Figure 2). It is then pumped via a 10-inch pipe to the site of the old

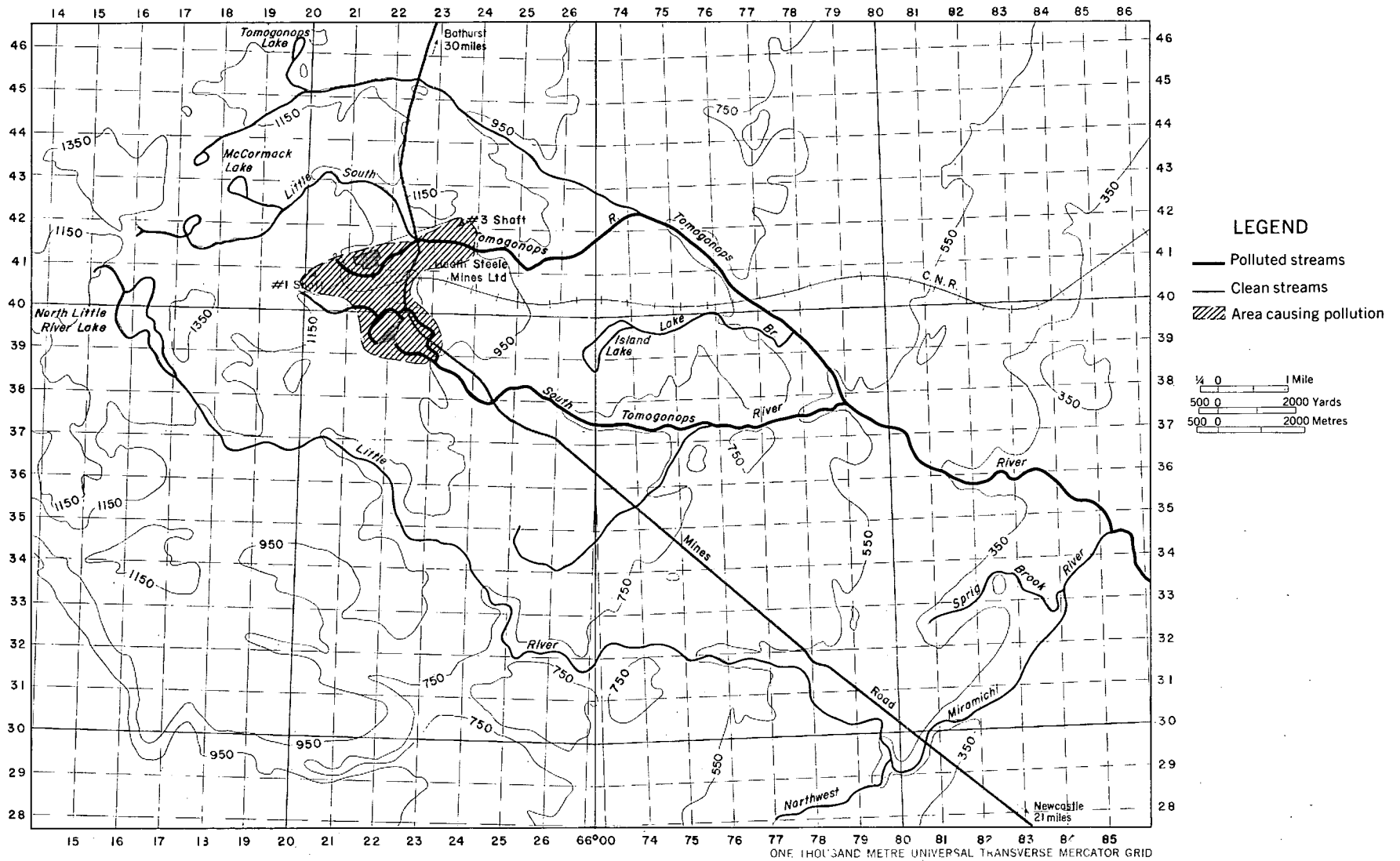


Figure 8 - Source of pollution and transmitting streams.

tailing pond. As for the mine water from No. 1 shaft, it is pumped into a marsh situated about one thousand feet to the south of the shaft (Figure 2).

The mill water is limed and pumped directly from the mill into a 10-inch pipe that takes it to the old tailing pond with the mine waters from No. 2 shaft. The two are periodically limed at the point and then flow together, following the topography, to the present tailing pond where most of the heavy metals settle.

The pollution control of the groundwater from "A" pit consists of letting the overflow of the pit flow into a partly natural and partly man-made channel called Camp Brook. This brook ends at the settling pond where the mine waters from No. 2 shaft are sent. From there it follows the same path as that previously mentioned for the No. 2 shaft mine waters.

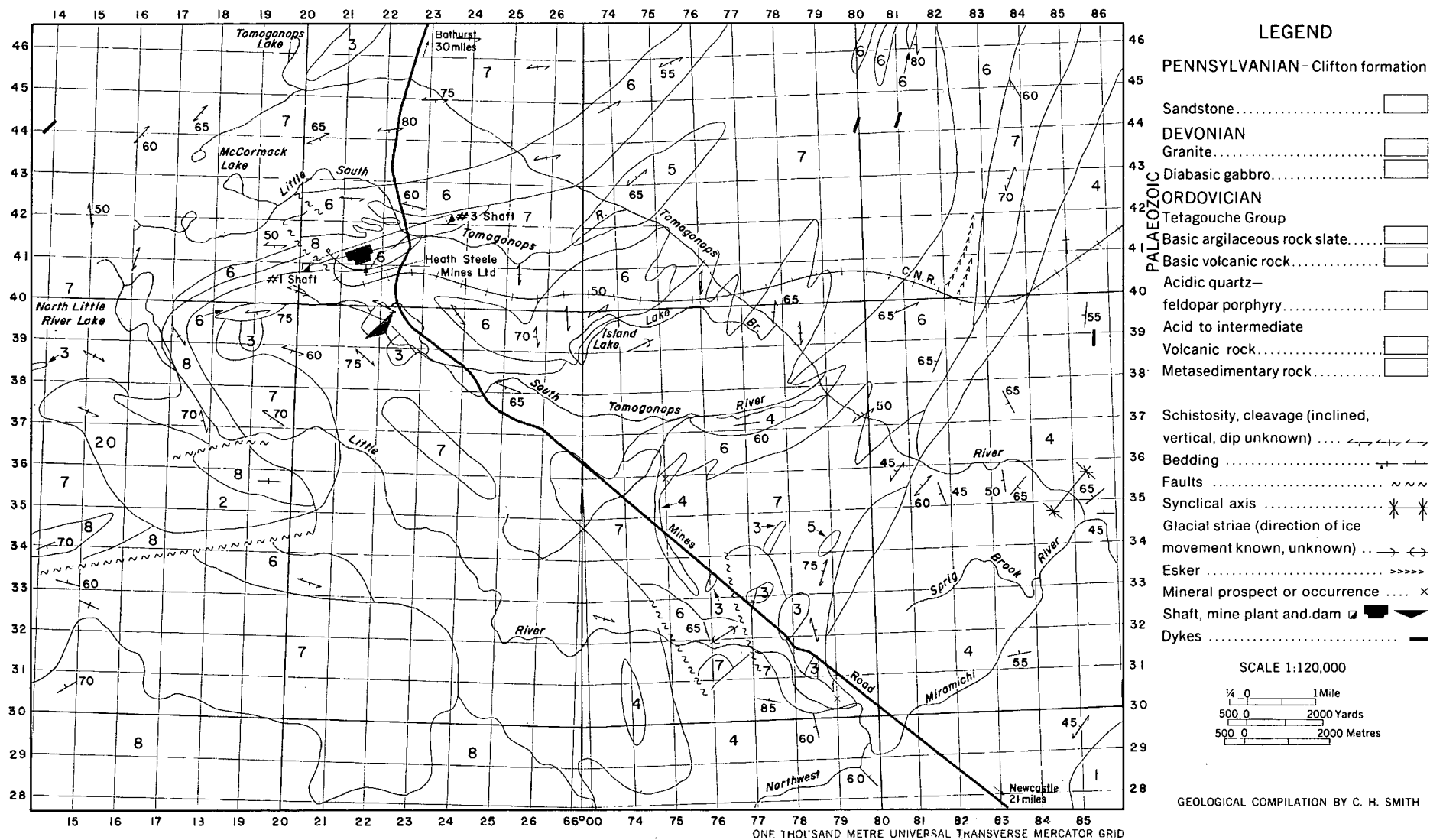
The Clean Water Channel pollution control is not as well defined. Because of its proximity to Camp Brook, its water is released into Camp Brook at base flow. In general, it flows directly into the Little South Tomogonops River. The last 200 feet of the Clean Water Channel consists of an open wooden flume; at a point approximately 100 feet from the end of the flume, seepage, probably derived from Camp Brook and the Clean Water Channel, is collected into a ditch that flows to the south bank of the Little South Tomogonops. This seepage is collected in a sump to be then pumped through two-inch plastic pipes into a flume carrying the mine waters of No. 2 shaft to the settling pond.

Therefore, except for the water from No. 1 shaft and that from the Clean Water Channel, the present tailing pond is the terminal for the pollution control. From there, two outlets are used independently to carry the overflow of the tailing pond to the South Tomogonops River.

GEOLOGY

The geology of the area (Figure 9) was not relevant to this study. The rocks consist of basic volcanic quartz-feldspar porphyry lava and tuffs that have been subjected to intense dynamic metamorphism. The area is almost entirely covered by a thin till layer. The very low hydraulic gradient combined with this type of rocks does not favour groundwater movement nor large quantities of groundwater. Figure 10 is a pH map of the water in the map area. Three zones are shown as having acidic waters and the acidity of the middle one is probably due to the presence of the mining operation. A fourth zone is basic. The fact that these acidic and basic zones coincide fairly well with the acidic and basic rocks underlying these zones is misleading in that acidic igneous rocks should yield water with a high pH (basic), while basic igneous rocks should give low pH (acidic) water. Therefore, it is possible that the thin till mantle is more important than the bedrock of the area in the control of the pH of these waters.

The specific conductance map (Figure 11) shows that the waters of the area in their natural state have low specific conductance values and, therefore, low values of total dissolved solids. Only in the vicinity of the mine area or along the streams leading from the mine area are the specific conductance values relatively high, which confirms what has already been said about metal pollution.



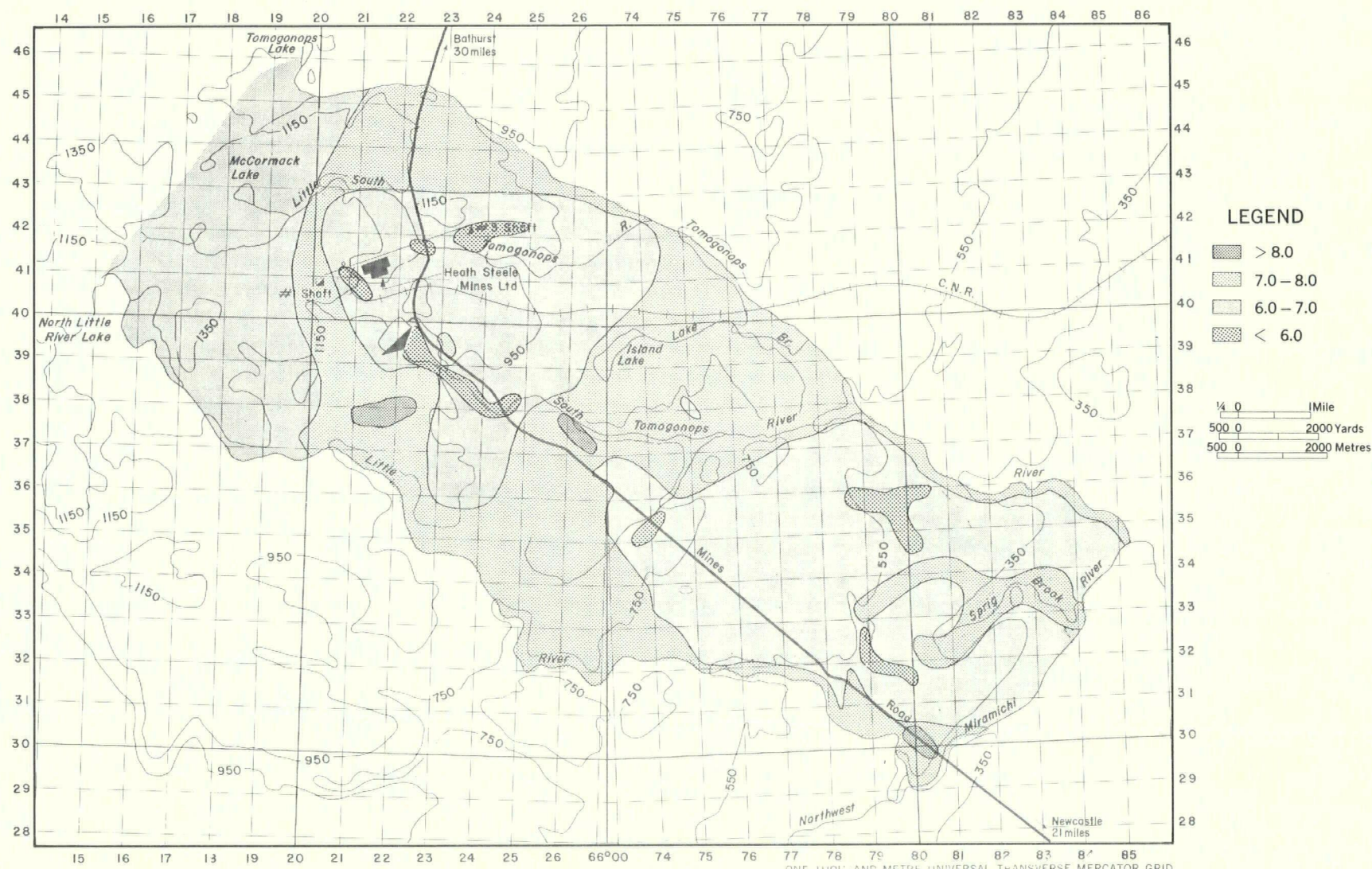


Figure 10 - pH map of the area.

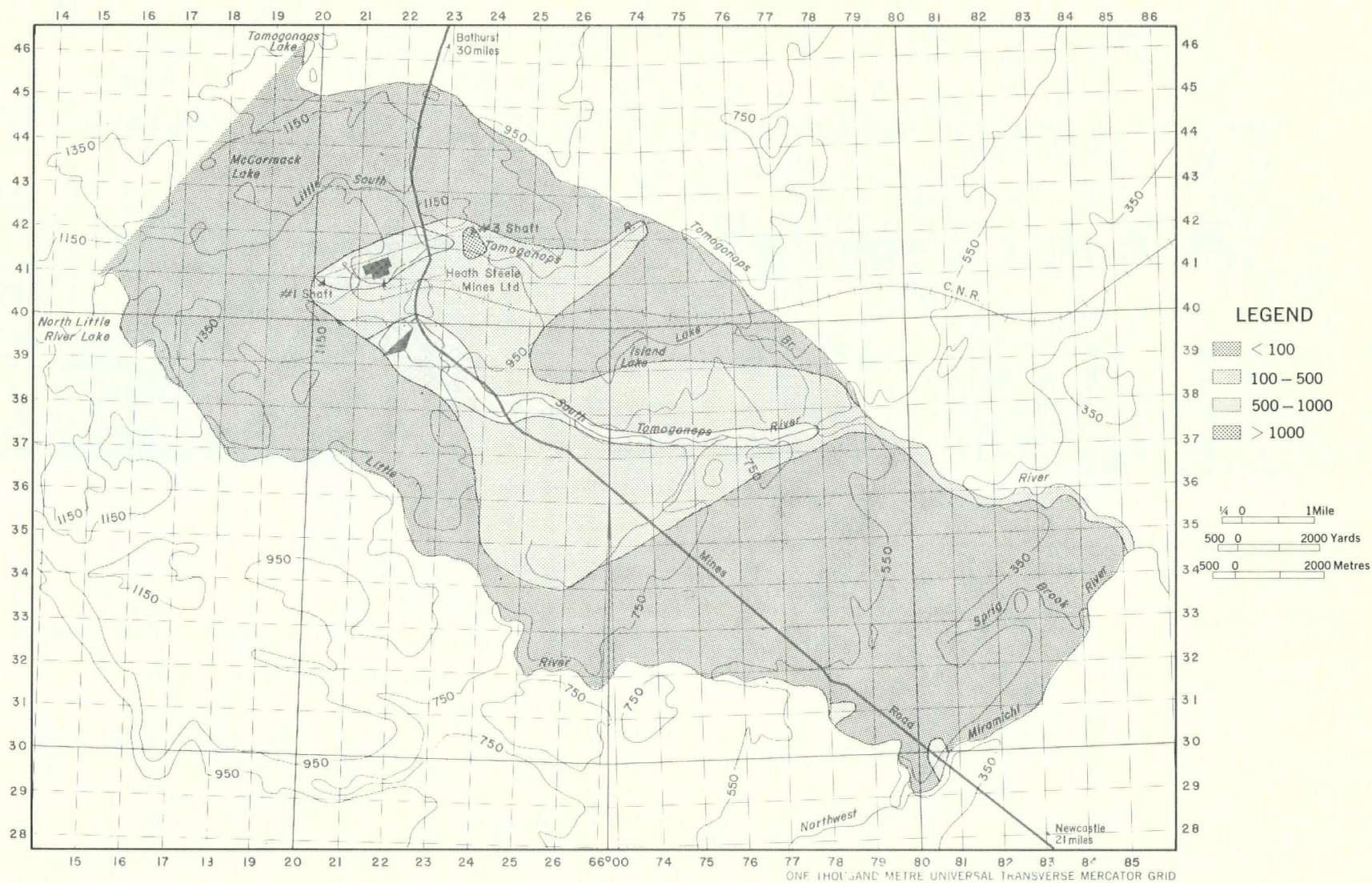


Figure 11 - Specific conductance map of the area.

RECOMMENDATIONS FOR FURTHER POLLUTION CONTROL

The metal pollution problem is not a continuous one, but one that occurs only during certain periods. It so happens that the fish make their move at these times (spring and fall) when heavy runoff occurs. With the present pollution control system, this means that the fish migration coincides with periods of heavy metal pollution.

The fact that the metal pollution control provided by the mining company is adequate at low flow is shown by the data gathered both by the Department of Fisheries and the writer. Further pollution control is desirable at periods of high runoff. The only immediate remedy applicable is to increase the storage capacity or the pumping and transmitting facilities at the mine water settling pond in order to dispose of the main sources of metal (copper and zinc) pollution, consisting of the water from 1) "A" pit, 2) the Clean Water Channel and 3) the mine. This pollution control improvement will take care of 85 per cent of the copper and zinc pollution that would otherwise reach the Little South Tomogonops River. The other 15 per cent is what the stream will pick up between the Mines Road and the point where it comes closest to the No. 3 shaft. Nevertheless, this improvement is of no value when a power failure occurs. Usually power failures are due to electrical storms that, in turn, are associated with heavy precipitation. Consequently, the size of standby units required to supply the power in case of a power failure will also have to be considered. The only data now missing pertain to the maximum amount of water that will have to be pumped to the tailing pond if this metal pollution control improvement is to be effective. The mine management may already have the answer to that.

However, the Department of Fisheries is quite satisfied with the present tailing pond treatment that regulates the copper and zinc pollution reaching the South Tomogonops River. What it deplures is the high copper and zinc pollution of the Little South Tomogonops River. Therefore, to satisfy the Department of Fisheries' request, the mining company would have to pump all the streamflow of the Little South Tomogonops River (from a point somewhere downstream from No. 3 shaft) to the present tailing pond. This more elaborate method of pollution control would almost completely eliminate the copper and zinc pollution, but it would not correct the pollution caused by the lead and arsenic which was detected by Dr. A. Watson and which may be the unknown toxic compound found in the South Tomogonops River system by the Department of Fisheries (1965).

This brings us to the problem of what to do about pollution control after the mining operation ceases. Only a cost-benefit study can truly evaluate this type of long-term pollution control.

To conclude, this study has not solved all the pollution problems concerning the Heath Steele mining operation. For instance, it did not look into the suspension phase (Brandon, 1966) of the streams as the solution phase seemed more important. It is suggested that the unknown toxic compound present in the South Tomogonops River may be associated with the suspension phase of the stream. Also, it did not take into consideration the metallurgy of the ore nor the composition of the milling waste. Future pollution studies should perhaps be orientated in these directions.

CONCLUSIONS

This report contains certain findings which are listed below and offers one immediate solution to the metal (Cu and Zn) pollution problem in the Heath Steele area:

(1) It demonstrated that in a natural state both, groundwater and surface water in this area have almost neutral pH values (6.0 to 8.0) and very low specific conductance values (100 micromhos/cm). These values indicate that natural metal pollution does not occur in these waters.

(2) It shows that the groundwater of this area in its natural state does not contribute metal pollution to the streams because of the relative insolubility of sulphides. However, a mining development can change these circumstances because it gives the sulphides an opportunity to become oxidized and, therefore, increases their solubility. The best example of that is "A" pit, the open pit filled with groundwater.

(3) It verifies the findings of the Department of Fisheries that the source of metal pollution (Cu and Zn) in the Northwest Miramichi River is caused by the Heath Steele mining operation and that most of this metal pollution is carried to the river system by the Little South Tomogonops River.

(4) It locates all main sources of metal pollution on the Heath Steele mining property.

(5) It explains why heavy precipitation is always accompanied by a noticeable increase in metal pollution. The reason for this being inadequate pumping and transmitting facilities to carry polluted waters ("A" pit, Clean Water Channel and mine waters) to the tailing pond.

(6) It predicts that after the mining operation at Heath Steele ceases, a substantial amount of polluted groundwater (pH 5.0 and high metal concentration) will flow from the present underground workings at No. 2 and No. 3 shafts, to the Little South Tomogonops River. This is based on the fact that the piezometric level of the groundwater in "A" pit is approximately 1,150 feet while the portal or adit opening of "B" incline is approximately 1,050 feet.

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TABLE I

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
1*	8-6-67	215 - 402	-	5.0	-	-	Mine water from line at old tailing pond. H:1710, Fe:1.5
2	8-6-67	811 - 315	54	6.5	-	-	Stream
3	8-6-67	811 - 315	55	6.5	-	-	Stream
4	8-6-67	799 - 311	52	6.5	-	-	Stream
5	8-6-67	801 - 316	47	5.5	-	-	Spring. H:34, Fe:0.1, NaCl:25
6	8-6-67	801 - 321	51	7.0	-	-	Stream
7	8-6-67	795 - 314	51	6.0	-	-	Stream
8	8-6-67	792 - 310	60	6.5	-	-	Stream
9	9-6-67	803 - 322	50	7.0	-	-	Sprig Brook. H:34, Fe:0.1, NaCl:12
10	9-6-67	800 - 324	52	6.0	-	-	Stream
11	9-6-67	804 - 321	50	7.5	-	-	Stream
12	9-6-67	805 - 317	60	6.8	-	-	Stream
13	9-6-67	788 - 306	47	7.5	-	-	Spring
14	9-6-67	787 - 306	45	8.0	-	-	Spring
15	9-6-67	786 - 306	46	7.5	-	-	Spring
16*	9-6-67	781 - 312	64	6.5	-	-	Gravel pit - H:51, Fe:0.1, NaCl:25
17*	5-6-67	806 - 298	-	6.9	-	-	Northwest Miramichi R., Mines Road Bridge. H:17, Fe:0.0
18	5-6-67	805 - 298	-	8.0	-	-	Stream in ditch. H:120, Fe:0.0
19*	5-6-67	805 - 299	-	8.5	-	-	Stream in ditch - Fe:0.0, NaCl:50
20	5-6-67	799 - 303	-	7.8	-	-	Ditch, Fe:0.0
21*	5-6-67	797 - 302	-	7.0	-	-	Little River. H:34, Fe:0.1, NaCl:37
22	5-6-67	791 - 310	-	6.1	-	-	Stream. H:34, Fe:0.0, NaCl:37
23	5-6-67	788 - 312	-	6.0	-	-	Stream
24	5-6-67	783 - 316	-	6.0	-	-	Marsh, organic brown water. H:34, Fe:0.2, NaCl:50
25	5-6-67	780 - 317	-	6.0	-	-	Stream
26	5-6-67	777 - 321	-	6.1	-	-	Stream
27	5-6-67	775 - 324	-	6.5	-	-	Stream
28	5-6-67	775 - 325	-	6.5	-	-	Stream
29	5-6-67	771 - 327	-	6.5	-	-	Stream
30	5-6-67	769 - 328	-	6.0	-	-	Stream
31	5-6-67	765 - 332	-	6.2	-	-	Stream
32	5-6-67	764 - 333	-	5.9	-	-	Stream
33	5-6-67	759 - 338	-	5.9	-	-	Stream

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
34	5-6-67	758 - 338	-	5.9	-	-	Stream. Good flow
35	5-6-67	757 - 339	49	5.9	-	-	Spring
36	5-6-67	755 - 341	-	5.9	-	-	Stream
37	5-6-67	754 - 342	-	6.0	-	-	Stream
38	5-6-67	751 - 344	-	5.9	-	-	Stream
39	5-6-67	748 - 348	-	6.0	-	-	Stream. Fe:0.0
40	5-6-67	746 - 348	-	6.0	-	-	Spring
41	5-6-67	741 - 353	-	5.8	-	-	Stream
42*	5-6-67	739 - 354	-	5.5	-	-	Stream
43*	5-6-67	738 - 355	-	6.9	-	-	Stream. Good flow. H:34, Fe:0.0, NaCl:25
44	5-6-67	738 - 356	-	6.5	-	-	Spring
45	23-8-67	199 - 371	58	7.0	40	-	Stream
46	10-6-67	782 - 334	58	6.5	-	-	Stream
47	10-6-67	785 - 318	52	7.5	-	-	Stream
48*	12-6-67	2338 - 4207	-	5.0	-	-	Mine water at No. 2 shaft H:>855, Fe:3.0
49*	5-6-67	221 - 392	-	9.0	-	-	Tailing Pond No. 2 outlet H:307, Fe:0.0, NaCl:25
50	23-8-67	200 - 369	50	6.8	35	-	Spring
51*	12-6-67	243 - 379	-	7.5	-	-	South Tomogonops at Mines Road. H:775 (smell)
52	23-8-67	213 - 378	53	8.0	99	-	Stream (trout)
53	23-8-67	223 - 379	53	8.0	78	-	Stream (trout)
54	13-6-67	795 - 335	51	7.4	-	-	Stream
55	13-6-67	802 - 346	53	5.8	-	-	Stream
56	13-6-67	802 - 356	46	6.9	-	-	Spring
57	13-6-67	795 - 358	58	5.6	-	-	Stream
58	13-6-67	789 - 360	52	5.2	-	-	Stream
59	13-6-67	789 - 361	60	6.9	-	-	Stream
60	13-6-67	790 - 361	62	6.9	-	-	Stream
61	13-6-67	802 - 362	66	5.9	-	-	Stream
62	14-6-67	854 - 254	-	7.5	-	-	Pat's Brook. Off map sheet
63*	14-6-67	864 - 289	-	7.5	-	-	Smoker's Brook. Off map sheet
64*	14-6-67	872 - 334	-	7.5	-	-	Portage River. Off map sheet
65*	14-6-67	853 - 347	50	7.5	-	-	Tomogonops River at Mouth
66	14-6-67	847 - 343	56	6.9	-	-	Spring

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
67	14-6-67	838 - 338	55	6.8	-	-	Spring
68	14-6-67	837 - 335	54	6.2	-	-	Stream
69	14-6-67	837 - 333	48	6.0	-	-	Spring
70	14-6-67	837 - 328	56	7.9	-	-	Sprig Book
71	14-6-67	829 - 321	-	6.9	-	-	Spring
72	23-8-67	225 - 382	50	8.0	95	-	Spring
73	26-8-67	261 - 360	49	7.0	115	-	Spring
74	15-6-67	839 - 350	55	6.8	-	-	Stream
75	15-6-67	840 - 352	56	7.2	-	-	Stream
76	15-6-67	842 - 351	58	6.9	-	-	Stream
77	15-6-67	845 - 349	54	6.0	-	-	Stream
78	15-6-67	849 - 349	52	6.0	-	-	Stream
79	1-9-67	257 - 344	43	7.2	125	-	Spring
80	16-6-67	840 - 353	51	6.4	-	-	Stream
81	16-6-67	830 - 357	51	7.3	-	-	Stream
82	16-6-67	828 - 360	46	7.3	-	-	Spring. Large flow
83	1-9-67	737 - 351	51	5.0	58	0.10	Stream. Cu value could be erroneous
84	10-6-67	790 - 318	48	7.5	-	-	Stream
85	10-6-67	789 - 327	48	5.8	-	-	Spring
86	9-6-67	737 - 330	51	7.8	-	-	Stream
87	9-6-67	786 - 332	42	7.5	-	-	Spring
88	9-6-67	787 - 332	55	7.5	-	-	Sprig Brook
89	2-9-67	185 - 416	-	6.8	35	-	Little South Tomogonops River at source
90	8-7-67	808 - 355	-	6.8	-	-	Spring
91	19-6-67	822 - 340	42	6.0	-	-	Spring
92	19-6-67	811 - 356	54	6.9	-	-	Stream
93	19-6-67	812 - 359	51	7.0	-	-	Stream
94*	19-6-67	807 - 361	54	4.5	-	-	Stream. H:342, Fe:0.6, NaCl:12
95	19-6-67	807 - 362	41	7.0	-	-	Spring
96	19-6-67	809 - 363	58	7.0	-	-	Tomogonops River above stream (sample 97)
97	19-6-67	809 - 363	57	7.0	-	-	Stream at junction with Tomogonops River
98	20-6-67	732 - 360	58	6.8	-	-	Stream
99	20-6-67	730 - 362	57	7.4	-	-	Stream
100	20-6-67	269 - 365	47	6.8	-	-	Spring
101	20-6-67	262 - 368	46	7.2	-	-	Spring

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu	Remarks
102	20-6-67	262 - 369	62	7.5	-	-	Stream
103*	20-6-67	252 - 373	46	7.8	-	-	Spring
104	20-6-67	251 - 374	63	7.8	-	-	Stream
105*	20-6-67	249 - 374	62	6.2	-	-	Stream
106	2-9-67	187 - 443	-	6.8	33	-	Tomogonops River at source
107	20-6-67	240 - 385	62	6.7	-	-	Stream
108*	20-6-67	236 - 388	60	6.8	-	-	Stream
109*	20-6-67	232 - 391	58	8.0	-	-	Stream. Smell H:204
110*	20-6-67	231 - 393	59	7.8	-	-	Stream. Smell H:204
111	20-6-67	825 - 337	52	7.8	-	-	Sprig Brook
112	20-6-67	815 - 339	52	6.2	-	-	Stream
113	20-6-67	810 - 339	60	7.2	-	-	Stream
114	20-6-67	807 - 333	51	6.5	-	-	Stream
115	20-6-67	797 - 310	53	6.5	-	-	Stream
116	21-6-67	849 - 246	60	6.5	-	-	Two Mile Brook. Off map sheet
117	21-6-67	845 - 260	52	6.0	-	-	Stream. Off map sheet
118	21-6-67	845 - 260	58	6.3	-	-	Stream. Off map sheet
119	21-6-67	843 - 265	60	6.2	-	-	Stream. Off map sheet
120	21-6-67	842 - 267	62	6.2	-	-	Stream. Off map sheet
121	21-6-67	839 - 269	60	6.8	-	-	Stream. Off map sheet
122	21-6-67	833 - 275	60	6.8	-	-	Stream. Off map sheet
123	21-6-67	820 - 286	62	6.0	-	-	Stream. Outside area studied
124	21-6-67	817 - 287	60	6.1	-	-	Stream. Outside area studied
125	21-6-67	818 - 288	58	6.0	-	-	Stream. Outside area studied
126	21-6-67	816 - 288	62	7.0	-	-	McLaughlin Brook. Outside area studied
127	21-6-67	812 - 282	61	6.1	-	-	Stream. Outside area studied
128	21-6-67	808 - 295	63	7.0	-	-	Stream. Outside area studied
129	17-8-67	2252 - 4161	-	4.8	3900	112.0	Spring. Probably seepage from clear water channel
130	21-6-67	841 - 272	52	6.8	-	-	Stream. Off map sheet
131	21-6-67	842 - 278	62	6.5	-	-	Stream. Outside area studied
132	21-6-67	844 - 283	60	5.7	30	-	Stream H:35, Fe:0.6. Outside area studied
133	21-6-67	820 - 331	55	7.3	-	-	Sprig Brook
134	21-6-67	817 - 335	47	7.3	-	-	Spring
135	21-6-67	815 - 330	55	7.3	-	-	Stream
136	18-8-67	224 - 394	65	4.5	790	-	Leakage below present tailing pond dam

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
137	18-8-67	225 - 395	67	4.5	835	-	Leakage below present tailing pond dam
138	18-8-67	225 - 394	60	5.0	825	-	Leakage below present tailing pond dam
139*	22-6-67	851 - 238	58	7.2	-	-	Northwest Miramichi at Wayerton bridge. Off map sheet
140	22-6-67	844 - 285	60	6.4	-	-	Stream. Outside area studied
141	22-6-67	844 - 286	61	6.0	-	-	Stream. Outside area studied
142	22-6-67	845 - 285	60	6.2	-	-	Stream. Outside area studied
143	22-6-67	844 - 287	58	6.5	-	-	Stream. Outside area studied
144	22-6-67	845 - 288	54	6.8	-	-	Stream. Outside area studied
145	22-6-67	845 - 289	52	6.8	-	-	Stream. Outside area studied
146	22-6-67	845 - 289	58	6.8	-	-	Stream. Outside area studied
147	22-6-67	845 - 290	52	6.3	-	-	Stream. Outside area studied
148	22-6-67	845 - 290	58	6.8	-	-	Stream. Outside area studied
149	22-6-67	749 - 319	52	7.5	-	-	Little River
150	22-6-67	750 - 320	48	6.0	-	-	Stream
151	22-6-67	749 - 320	44	6.2	25	-	Spring
152	22-6-67	745 - 323	49	7.3	-	-	Stream
153	22-6-67	745 - 326	49	7.2	-	-	Stream
154	22-6-67	748 - 328	47	6.0	-	-	Spring
155	24-6-67	846 - 293	58	7.2	-	-	McLaughlin Brook. Outside area studied
156	24-6-67	846 - 294	56	6.5	-	-	Stream. Outside area studied
157	24-6-67	846 - 292	56	6.8	-	-	Stream. Outside area studied
158	24-6-67	850 - 298	58	6.0	-	-	Stream. Outside area studied
159	24-6-67	850 - 298	56	6.0	-	-	Stream. Outside area studied
160	24-6-67	850 - 299	60	4.8	-	-	Stream. Outside area studied
161	24-6-67	851 - 300	58	5.0	-	-	Stream. Outside area studied
162	24-6-67	851 - 300	42	6.0	-	-	Spring. Outside area studied
163	24-6-67	853 - 292	58	5.7	-	-	Stream. Outside area studied
164	24-6-67	854 - 304	60	5.7	-	-	Stream. Outside area studied
165	24-6-67	855 - 307	58	5.5	-	-	Stream. Outside area studied
166	24-6-67	855 - 308	60	7.5	-	-	Stream. Outside area studied
167	24-6-67	856 - 309	60	7.2	-	-	Stream. Outside area studied
168	24-6-67	857 - 310	61	7.2	-	-	Stream. Outside area studied
169*	24-6-67	185 - 236	-	7.5	-	-	North Sevogle River. Off map sheet
170*	24-6-67	123 - 228	-	7.0	-	-	Sheephouse Brook. Off map sheet

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
171*	24-6-67	099 - 198	-	7.0	-	-	Clearwater Stream. Off map sheet
172	24-6-67	752 - 343	47	6.5	-	-	Spring
173*	24-6-67	096 - 197	-	6.5	-	-	Spring beside mining camp. Off map sheet
174*	27-6-67	2233 - 4166	46	5.0	645	-	Spring
175*	27-6-67	2233 - 4164	58	6.9	44	-	Little South Tomogonops at Mines Road
176	22-8-67	263 - 390	-	6.8	30	-	Spring
177	22-8-67	265 - 394	-	8.0	55	-	Island Lake
178	27-6-67	2245 - 3964	61	5.9	-	-	Stream
179	27-6-67	2246 - 3963	60	5.0	750	-	Stream. H:256, Fe:2.0, NaCl:25
180	27-6-67	2247 - 3961	60	5.0	665	-	Stream. H:391, Fe:3.0, NaCl:25
181	27-6-67	2248 - 3960	56	6.2	-	-	Stream
182*	27-6-67	2250 - 3965	58	5.8	-	-	Stream
183	17-8-67	2227 - 4175	49	5.5	195	0.4	Spring, at Boyle Brothers Camp. H:68
184	27-6-67	2226 - 4176	50	5.0	-	-	Stream
185	27-6-67	2225 - 4176	64	5.0	-	-	Stream
186	27-6-67	2228 - 4177	60	4.8	-	-	Stream
187*	12-6-67	224 - 417	-	6.5	-	-	Little South Tomogonops at dam. H ₂ S smell
188	27-6-67	2217 - 4177	62	6.8	-	-	Stream
189	27-6-67	2211 - 4200	48	6.0	-	-	Spring
190	27-6-67	2212 - 4188	46	6.2	-	-	Spring
191	27-6-67	2212 - 4182	54	5.5	-	-	Stream
192	27-6-67	2085 - 4125	68	6.5	-	-	Stream
193	27-6-67	2084 - 4123	62	5.0	360	-	Brook around "A" pit
194*	27-6-67	2162 - 4153	94	7.0	-	-	From Compressor
195	27-6-67	2179 - 4102	72	4.8	640	-	Stream. H:342
196	27-6-67	2178 - 4126	70	6.0	-	-	Stream
197	27-6-67	2178 - 4090	68	4.8	220	-	Stream
198	27-6-67	2178 - 4099	64	4.8	700	-	Camp Brook
199	27-6-67	2240 - 4170	65	5.0	-	-	Stream
200*	27-6-67	232 - 417	48	5.0	-	-	Spring. 250 feet from portal
201	27-6-67	740 - 335	55	6.8	-	-	Stream
202	27-6-67	736 - 336	48	7.8	-	-	Spring
203	27-6-67	735 - 323	46	7.8	-	-	Spring
204	27-6-67	734 - 322	63	7.8	-	-	Little River

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
205	27-6-67	738 - 324	42	7.8	-	-	Spring
206	27-6-67	740 - 325	48	7.8	-	-	Spring
207	28-6-67	2318 - 4160	64	5.0	142	-	Little South Tomogonops at portal. H:86, Fe:0.4, NaCl:13
208	28-6-67	2318 - 4162	70	4.8	-	-	Stream 22' from portal
209	28-6-67	2200 - 4200	68	6.8	24	-	Little South Tomogonops above dam. H:17, Fe:0.1, NaCl:25
210	28-6-67	765 - 334	53	6.8	-	-	Stream
211	28-6-67	762 - 350	51	6.8	-	-	Stream
212	28-6-67	762 - 352	54	6.5	-	-	Stream
213	28-6-67	762 - 352	50	6.6	-	-	Spring
214	28-6-67	765 - 351	52	6.6	-	-	Stream
215	28-6-67	766 - 355	48	6.5	-	-	Spring
216	28-6-67	759 - 357	60	6.0	-	-	Stream
217	28-6-67	758 - 353	55	6.2	-	-	Stream
218	28-6-67	754 - 343	58	6.8	-	-	Stream
219	29-6-67	745 - 357	57	6.0	-	-	Stream
220*	29-6-67	745 - 360	61	7.8	-	-	Stream
221*	29-6-67	755 - 372	62	7.8	-	-	Stream. Same stream as 220 but nearer mouth
222*	29-6-67	754 - 375	63	7.6	-	-	South Tomogonops at old mill site
223	29-6-67	748 - 380	58	6.9	-	-	Stream
224	30-6-67	836 - 260	-	6.7	-	-	Stream. Fraser Road. Off map sheet
225	30-6-67	834 - 260	-	6.7	-	-	Stream. Fraser Road. Off map sheet
226	30-6-67	827 - 259	-	6.0	-	-	Stream. Fraser Road. Off map sheet
227	30-6-67	833 - 258	-	6.8	-	-	Stream. Fraser Road. Off map sheet
228	30-6-67	820 - 252	-	6.7	-	-	Stream. Fraser Road. Off map sheet
229	30-6-67	813 - 257	-	6.0	-	-	Stream. Fraser Road. Off map sheet
230	30-6-67	800 - 254	-	4.8	-	-	Stream. Fraser Road. Off map sheet
231	30-6-67	797 - 254	-	6.5	-	-	Stream. Fraser Road. Off map sheet
232	30-6-67	783 - 253	-	6.8	-	-	Stream. Fraser Road. Off map sheet
233	30-6-67	779 - 253	-	6.0	-	-	Stream. Fraser Road. Off map sheet
234	30-6-67	779 - 253	-	6.6	-	-	Stream. Fraser Road. Off map sheet
235	30-6-67	773 - 252	-	6.0	-	-	Stream. Fraser Road. Off map sheet
236	30-6-67	771 - 252	-	6.0	-	-	Stream. Fraser Road. Off map sheet
237	30-6-67	750 - 250	-	6.0	-	-	Stream. Fraser Road. Off map sheet
238	30-6-67	750 - 250	-	7.0	-	-	Stream. Fraser Road. Off map sheet
239	30-6-67	748 - 249	-	6.2	-	-	Stream. Fraser Road. Off map sheet

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
240	29-6-67	751 - 378	53	6.8	-	-	Stream
241	29-6-67	751 - 381	45	8.4	-	-	Spring
242*	29-6-67	745 - 396	62	7.5	-	-	Lake Brook
243	29-6-67	743 - 405	48	7.5	-	-	Spring
244	29-6-67	766 - 404	65	7.5	-	-	Tomogonops River below railway bridge
245	29-6-67	765 - 403	44	7.4	-	-	Spring
246	29-6-67	764 - 403	42	7.4	-	-	Spring
247	5-7-67	753 - 377	53	7.5	-	-	Stream
248	5-7-67	755 - 377	50	7.5	-	-	Stream
249	5-7-67	761 - 376	51	7.8	-	-	Stream
250	5-7-67	781 - 391	44	6.8	-	-	Spring
251*	5-7-67	789 - 378	61	6.9	70	-	Tomogonops River above junction with South Tomogonops River
252*	5-7-67	788 - 378	60	7.9	220	-	South Tomogonops at mouth. Smells
253	5-7-67	790 - 377	55	6.7	-	-	Stream
254*	5-7-67	785 - 372	55	4.0	-	-	Stream
255	5-7-67	777 - 366	42	6.2	28	-	Spring
256	17-8-67	210 - 413	-	4.0	1055	-	Camp Brook, in swamp west of mill
257	6-7-67	765 - 353	49	6.5	-	-	Spring
258	6-7-67	778 - 364	51	6.5	-	-	Stream
259	6-6-67	783 - 362	64	6.5	-	-	Stream
260	6-7-67	786 - 361	65	6.5	-	-	Stream
261*	7-7-67	268 - 372	52	8.0	-	-	Stream
262	7-7-67	241 - 362	50	6.9	-	-	Stream
263	7-7-67	221 - 357	60	7.0	45	-	Little River
264	10-7-67	232 - 411	60	6.8	-	-	Stream
265	10-7-67	251 - 406	62	6.8	-	-	Stream
266	10-7-67	735 - 405	72	6.5	-	-	Stream
267	10-7-67	261 - 406	70	6.8	-	-	Stream
268	10-7-67	741 - 377	54	7.8	-	-	Stream
269	10-7-67	735 - 381	41	7.0	-	-	Spring
270*	11-7-67	231 - 393	70	6.1	-	0.0	Stream. White mud
271*	11-7-67	231 - 392	46	5.8	-	0.0	Spring
272*	11-7-67	229 - 394	48	6.5	590	0.0	Spring ferruginous
273*	11-7-67	229 - 395	57	7.0	390	0.0	Stream

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
274*	12-7-67	233 - 388	-	5.5	-	0.0	Stream
275*	12-7-67	232 - 388	-	6.8	-	-	Stream
276	12-7-67	225 - 387	48	7.0	-	-	Spring
277*	12-7-67	222 - 390	55	5.0	-	0.0	Spring
278	12-7-67	225 - 393	58	4.8	750	0.0	Stream. Green moss
279	13-7-67	226 - 394	57	5.5	600	0.0	Stream
280*	12-6-67	2250 - 3960	-	6.5	-	-	Present Tailing Pond at No. 1 outlet
281	14-7-67	2250 - 3962	-	5.0	-	-	Leakage at Tailing Pond Dam at No. 1 outlet
282	14-7-67	2249 - 3967	-	4.8	-	0.0	Stream
283*	14-7-67	225 - 394	55	5.0	-	-	Leakage through dam. Source of sample No. 279. Green moss
284*	14-7-67	2195 - 3912	42	7.5	-	-	Spring at base of dam. Iron rust (bacteria)
285	14-7-67	2180 - 3912	70	7.2	-	-	Leakage through dam
286*	14-7-67	2181 - 3912	42	6.8	-	-	Similar to No. 284
287*	14-7-67	2172 - 3908	54	6.5	-	-	Leakage through dam. Yellowish-green moss
288	14-7-67	2167 - 3908	56	6.5	-	0.5	Out of pipe. Slimy iron bacteria
289	14-7-67	2170 - 3909	72	7.0	-	-	Leakage through dam
290*	27-6-67	2092 - 4128	62	5.0	22	-	"A" pit outflow. Specific conductance could be an error
291*	6-6-67	208 - 413	-	5.0	-	-	"A" pit at surface
292	17-7-67	163 - 393	71	6.8	20	-	North Little River Lake. Outside area studied
293	17-7-67	146 - 388	62	7.5	35	-	Stream. Outside area studied
294	18-7-67	2235 - 4170	62	7.0	405	1.5	Stream
295*	12-6-67	2236 - 4160	-	5.0	-	-	Clear water channel flume
296*	27-6-67	2236 - 4150	58	4.8	2450	-	Stream (Cu Box)
297	18-7-67	2216 - 4150	70	4.0	-	-	Camp Brook
298	18-7-67	2175 - 4110	80	8.1	-	-	Stream
299	17-8-67	209 - 412	-	4.0	239	0.4	Stream in swamp along Camp Brook
300	18-7-67	207 - 413	-	5.0	850	>15.0	"A" pit at 110 feet
301*	18-7-67	224 - 417	-	6.5	180	0.5	Little South Tomogonops River below pump house of No. 296
302	21-7-67	2391 - 4219	-	5.0	-	0.5	Stream under fill at shaft No. 3
303*	21-7-67	256 - 432	63	7.0	38	-	Tomogonops River above mine. Fishes
304*	21-7-67	259 - 414	70	6.5	158	0.5	Little South Tomogonops River at old camp
305	21-7-67	259 - 414	72	7.5	-	-	Stream
306	21-7-67	263 - 417	74	6.8	60	-	Stream
307	22-7-67	248 - 422	65	5.0	40	-	Stream

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
308	22-7-67	248 - 422	59	5.0	25	-	Stream
309	22-7-67	737 - 424	62	6.8	65	-	Stream
310	22-7-67	739 - 425	68	6.8	160	-	Little South Tomogonops River at mouth. Brown rocks (iron)
311*	22-7-67	740 - 426	66	8.0	43	-	Tomogonops River above Little South Tomogonops. Black rocks
312*	22-7-67	741 - 425	-	7.5	102	-	Tomogonops River below Little South Tomogonops. Slippery bottom
313	22-7-67	225 - 455	75	7.5	35	-	Tomogonops River at Mines Road
314*	22-7-67	216 - 421	42	6.0	22	-	Spring. Flow 50 gpm (approx.)
315	22-7-67	207 - 427	48	6.0	28	-	Spring
316	22-7-67	207 - 428	48	7.0	25	-	Spring
317	22-7-67	207 - 430	70	7.5	35	-	Little South Tomogonops River above Mine
318	24-7-67	858 - 339	-	7.5	142	-	Northwest Miramichi below mouth of Tomogonops River. Outside area studied.
319	24-7-67	215 - 402	-	9.5	3650	0.0	Mill water at old Tailing Pond
320	24-7-67	215 - 402	-	9.5	1850	0.0	Mine and Mill water mixed
321	24-7-67	2222 - 4160	-	5.0	1300	15.0	Settling pond for No. 2 shaft. Mine water
322	28-7-67	2222 - 4155	-	5.5	-	-	Mine water from No. 2 shaft at settling pond
323*	29-7-67	2230 - 3895	-	6.9	-	-	South Tomogonops before first marsh
324*	29-7-67	234 - 385	-	5.3	-	-	South Tomogonops at junction of No. 108 (sample)
325*	29-7-67	231 - 387	-	6.4	-	-	South Tomogonops above dead swamp
326*	31-7-67	2375 - 4160	62	5.0	2060	15.0	Stream at old pump house below No. 3 shaft
327*	31-7-67	238 - 414	67	6.5	290	-	Little South Tomogonops River above staff gauge at No. 3 shaft
328*	31-7-67	233 - 416	71	6.8	115	-	Little South Tomogonops River
329*	31-7-67	2337 - 4160	46	5.0	1150	10.0	Spring from under waste pile at portal (Green Cu?)
330	31-7-67	2318 - 4154	71	6.0	135	-	Little South Tomogonops River
331	31-7-67	2297 - 4160	70	5.0	675	0.5	Stream. Fe:1.5
332	31-7-67	2290 - 4152	43	6.0	40	-	Spring
333	31-7-67	2285 - 4160	65	6.0	330	-	Stream
334	31-7-67	2284 - 4160	46	8.3	58	-	Spring
335	31-7-67	2263 - 4156	68	4.5	690	2.0	Stream
336	31-7-67	2238 - 4164	60	5.0	1125	10.0	Stream. White rocks
337	31-7-67	2237 - 4165	-	7.0	63	-	Little South Tomogonops River before sample No. 336 enters
338*	31-7-67	2240 - 4164	-	7.0	50	-	Little South Tomogonops River below sample No. 336
339*	29-7-67	2213 - 3927	-	7.8	-	-	South Tomogonops below No. 2 outlet of Tailing Pond
340*	29-7-67	2213 - 3915	-	7.8	-	-	South Tomogonops in falls below No. 2 outlet
341	2-8-67	2203 - 3907	64	6.9	993	-	Stream

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
342*	29-7-67	2208 - 3900	-	5.0	-	-	Stream
343*	29-7-67	2213 - 3900	-	6.5	-	-	Stream. Combined No. 277, 341 and 342
344*	29-7-67	2213 - 3907	-	7.3	-	-	South Tomogonops above No. 343
345*	2-8-67	226 - 389	65	6.9	940	-	South Tomogonops below first marsh
346	2-8-67	228 - 391	48	6.9	290	-	Spring. (Maybe same as No. 279)
347	2-8-67	228 - 392	55	6.5	450	-	Stream
348*	2-8-67	236 - 387	-	7.8	64	-	Stream
349*	2-8-67	236 - 383	65	5.0	850	-	South Tomogonops above third marsh
350*	2-8-67	237 - 380	67	5.0	875	-	South Tomogonops at log road
351	2-8-67	246 - 380	64	5.0	810	-	South Tomogonops at power line
352	2-8-67	260 - 378	65	7.0	685	-	South Tomogonops above stream junction
353	2-8-67	360 - 378	49	8.5	73	-	Spring
354	2-8-67	260 - 379	45	8.2	120	-	Spring
355	2-8-67	269 - 375	65	7.0	650	-	South Tomogonops at old camp
356*	2-8-67	740 - 373	67	7.0	998	-	South Tomogonops (spec. cond. value appears erroneous)
357	3-8-67	763 - 405	-	7.5	80	-	Tomogonops River at railway above bridge
358	4-8-67	256 - 414	61	6.8	137	-	Little South Tomogonops River
359	4-8-67	253 - 414	60	6.8	133	-	Little South Tomogonops River
360	4-8-67	252 - 414	59	7.5	82	-	Stream
361	4-8-67	252 - 413	60	6.6	149	-	Little South Tomogonops River
362	4-8-67	250 - 414	50	7.0	30	-	Spring. Source of No. 360
363	4-8-67	248 - 413	61	6.6	140	-	Little South Tomogonops River
364	4-8-67	247 - 413	46	7.0	88	-	Spring
365	4-8-67	246 - 414	61	6.1	122	-	Little South Tomogonops River
366	4-8-67	245 - 414	52	6.8	65	-	Stream
367	4-8-67	244 - 416	48	6.8	35	-	Spring
368	4-8-67	244 - 415	62	6.8	121	-	Little South Tomogonops River
369	4-8-67	241 - 414	47	7.5	30	-	Spring
370	4-8-67	240 - 414	62	6.6	128	-	Little South Tomogonops River
371	4-8-67	239 - 414	46	6.8	40	-	Spring
372*	4-8-67	235 - 416	62	6.6	130	-	Little South Tomogonops River
373	4-8-67	228 - 417	-	6.9	120	-	Little South Tomogonops River
374	4-8-67	2273 - 4153	-	7.0	122	-	Little South Tomogonops River
375	5-8-67	184 - 239	-	7.2	145	-	D.D. Hole at top of Hill. H:85, Fe:0.3, NaCl:25. Off map sheet

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
376	5-8-67	185 - 237	-	7.0	520	0.0	D.D. Hole beside Clearwater Stream. H:307, Fe:5.0, NaCl:37. Off map sheet
377*	8-8-67	2130 - 4120	-	4.0	-	>5.0	Camp Brook at track near mill
378	8-8-67	213 - 412	-	4.0	-	5.0	Spring at track
379*	8-8-67	2131 - 4110	-	-	1125	22.8	Camp Brook across track (Moncton Sample Aug. 11)
380*	8-8-67	2022 - 4082	46	7.0	518	-	Mine water at No. 1 shaft
381	8-8-67	2047 - 4096	98	7.0	33	-	Compressor water at No. 1 shaft
382	8-8-67	2055 - 4011	65	7.0	183	-	North Branch of South Tomogonops River at source
383	8-8-67	2055 - 3970	48	7.0	86	-	Spring
384	9-8-67	2094 - 3936	-	7.0	46	-	Stream. 1/10 gal/min
385	9-8-67	2290 - 3940	68	6.5	560	-	Spring
386	9-8-67	248 - 376	75	6.8	100	-	Stream. Iron bacteria. Small flow
387	10-8-67	840 - 332	70	7.8	85	-	Sprig Brook at mouth
388	10-8-67	840 - 332	46	6.5	35	-	Spring
389	10-8-67	840 - 332	42	6.5	40	-	Spring
390	12-8-67	2313 - 3947	58	5.8	510	0.0	Spring
391	12-8-67	2302 - 3922	56	7.2	280	-	Stream. (Same as sample No. 110)
392	12-8-67	2295 - 3947	55	6.0	510	0.0	Spring
393	12-8-67	233 - 393	62	7.0	595	-	Stream
394	12-8-67	231 - 391	58	6.2	400	0.0	Spring
395	15-8-67	847 - 193	75	7.8	105	0.0	Northwest Miramichi at Trout Brook. Off map sheet
396*	16-8-67	789 - 378	-	7.5	350	-	Tomogonops River below the mouth of South Tomogonops River
397	30-8-67	238 - 422	-	8.0	545	-	U.S. No. 3 shaft. Seam - 9th level - elev. 7550'
398	30-8-67	238 - 422	-	8.0	552	-	U.S. No. 3 shaft. D.D.H. No. 363 - 5th level - elev. 8050'
399	30-8-67	238 - 422	-	7.0	325	-	U.S. No. 3 shaft. D.D.H. No. 359 - 5th level - elev. 8050'
400	30-8-67	238 - 422	-	6.5	295	0.6	U.S. No. 3 shaft. D.D.H. No. 369 - 2nd level - elev. 8450'
401	30-8-67	238 - 422	-	6.5	305	0.5	U.S. No. 3 shaft. D.D.H. No. 365 - 2nd level - elev. 8450'
402	30-8-67	238 - 422	-	6.0	720	5.0	U.S. No. 3 shaft. D.D.H. No. 380 - 2nd level - elev. 8450'
403	30-8-67	238 - 422	-	8.0	235	-	U.S. No. 3 shaft. Seam - 3rd level - elev. 8300'
404	30-8-67	238 - 422	-	7.0	1015	-	U.S. No. 3 shaft. Seam - 6th level - elev. 7950'
405	30-8-67	238 - 422	-	7.5	265	-	U.S. No. 3 shaft. D.D.H. No. B227 - 7th level - elev. 7800'
406	30-8-67	238 - 422	-	+10.0	+10,000	-	U.S. No. 3 shaft. D.D.H. No. B226 - 8th level - elev. 7700' H:1060, Fe:0.0
407	30-8-67	238 - 422	-	9.0	990	-	U.S. No. 3 shaft. D.D.H. No. B209 - 10th level
408	11-9-67	234 - 418	-	6.8	245	-	U.S. "B" incline - Seam

TABLE I (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
409	11-9-67	234 - 418	-	5.0	1025	-	U.S. "B" incline - Seam
410	11-9-67	234 - 418	-	4.0	2550	-	U.S. B ₂ sump overflow
411	11-9-67	234 - 418	-	7.0	355	-	U.S. B ₁ station - 1st level - elev. 8600'
412	11-9-67	234 - 418	-	4.0	1825	-	U.S. 8600 E Drift
413	11-9-67	234 - 418	-	5.8	750	-	U.S. 85 - 1 Drift. D.D.H. No. B 178
414	11-9-67	234 - 418	-	4.0	999	-	U.S. 96 - 1 - 2 Scram Back
415	11-9-67	234 - 418	-	5.7	6500	-	U.A. 94 - 1 Scram Back
416	11-9-67	234 - 418	-	5.7	5500	-	U.S. 93 - 1 Chute
417	11-9-67	234 - 418	-	5.6	8000	-	U.S. 94 - 1 Scram Front
418	11-9-67	234 - 418	-	4.0	1240	-	U.S. 96 - 1 Scram Front
419	11-9-67	234 - 418	-	4.7	3450	-	U.S. 96 - 2 Scram Front
420	11-9-67	234 - 418	-	6.0	340	-	U.S. D.D.H. No. B 146
421	11-9-67	234 - 418	-	5.5	525	-	U.S. D.D.H. No. B 143

U.S. Underground Sample

All values for hardness (H), iron (Fe) and sodium chloride (NaCl) are in parts per million (ppm)

* See Table II for additional samples obtained at this site

TABLE II

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
1	8-6-67	215 - 402	-	5.0	-	-	
1	24-7-67	215 - 402	-	5.0	1250	15.0	
16	9-6-67	781 - 312	64	6.5	-	-	
16	8-8-67	781 - 312	85	8.0	108	-	
17	5-6-67	806 - 298	-	6.9	-	-	West side of river
17	15-6-67	806 - 298	-	7.5	-	-	West side of river
17	21-6-67	806 - 298	60	7.5	-	-	West side of river
17	24-7-67	806 - 298	-	8.0	45	-	West side of river
17	29-7-67	806 - 298	-	7.5	45	-	West side of river
17	4-9-67	806 - 298	-	8.0	50	-	West side of river
17	4-9-67	806 - 298	-	7.7	42	-	West side of river
19	5-6-67	805 - 299	-	8.5	-	-	
19	22-6-67	805 - 299	58	8.5	305	-	
21	5-6-67	797 - 302	-	7.0	-	-	
21	24-7-67	797 - 302	-	8.0	89	-	
21	16-8-67	797 - 302	-	8.0	100	-	
42	5-6-67	739 - 354	-	5.5	-	-	
42	22-6-67	739 - 354	50	5.4	22	-	
43	5-6-67	738 - 355	-	6.9	-	-	
43	28-7-67	738 - 355	-	8.0	135	-	
48	12-6-67	2338 - 4207	-	5.0	-	-	Clean water
48	7-7-67	2338 - 4207	-	4.0	1300	5.0	Clean water
48	4-9-67	2338 - 4207	47	4.0	1225	17.5	Dirty water
49	5-6-67	221 - 392	-	9.0	-	-	
49	12-6-67	221 - 392	-	9.0	-	-	
49	15-6-67	221 - 392	-	9.5	-	-	
49	16-6-67	221 - 392	-	9.5	-	-	
49	27-6-67	221 - 392	59	9.5	760	-	
49	24-7-67	221 - 392	-	8.0	950	-	
49	28-7-67	221 - 392	-	8.5	1000	-	
49	29-7-67	221 - 392	-	7.8	-	-	
49	2-8-67	221 - 392	-	8.5	990	-	
49	4-8-67	221 - 392	-	8.0	1100	-	
51	12-6-67	243 - 379	-	7.5	-	-	
51	20-6-67	243 - 379	62	7.8	-	-	
51	22-6-67	243 - 379	60	7.8	495	-	
51	8-7-67	243 - 379	-	6.9	675	-	Gauge height 1.23
51	24-7-67	243 - 379	-	5.0	775	0.5	Gauge height 1.10
51	28-7-67	243 - 379	-	5.0	800	-	
51	29-7-67	243 - 379	-	5.0	775	-	
51	2-8-67	243 - 379	64	5.0	825	-	
51	4-8-67	243 - 379	-	5.3	735	-	8:35 a.m.
51	4-8-67	243 - 379	-	6.0	590	-	2:50 p.m.
51	5-8-67	243 - 379	-	6.5	645	-	
51	8-8-67	243 - 379	-	6.0	-	-	Gauge height 1.02
51	9-8-67	243 - 379	-	6.0	790	0.2	
51	15-8-67	243 - 379	-	5.0	875	0.2	
51	17-8-67	243 - 379	-	5.0	890	0.4	
51	18-8-67	243 - 379	-	4.8	850	-	Gauge height 1.10
51	21-8-67	243 - 379	-	5.0	730	-	Gauge height 1.36
51	4-9-67	243 - 379	-	4.0	800	0.5	Gauge height 1.68
63	14-6-67	864 - 289	-	7.5	-	-	
63	4-9-67	864 - 289	-	6.7	48	-	
64	14-6-67	872 - 334	-	7.5	-	-	
64	4-9-67	872 - 334	-	7.3	58	-	

TABLE II (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
65	14-6-67	853 - 347	50	7.5	-	-	
65	15-6-67	853 - 347	-	7.8	-	-	
65	6-7-67	853 - 347	-	7.0	162	-	
65	8-7-67	853 - 347	-	7.0	180	0.0	
65	24-7-67	853 - 347	-	7.5	215	-	
65	28-7-67	853 - 347	-	7.2	245	-	Fish
65	29-7-67	853 - 347	-	7.2	225	-	Fish
65	3-8-67	853 - 347	-	8.0	260	-	
65	10-8-67	853 - 347	-	7.5	268	0.1	
65	15-8-67	853 - 347	59	7.2	295	0.2	
65	21-8-67	853 - 347	-	7.5	300	0.2	
65	4-9-67	853 - 347	-	6.9	225	0.5	
94	19-6-67	807 - 361	54	4.5	-	-	
94	8-7-67	807 - 361	58	4.5	22	-	
103	20-6-67	252 - 373	46	7.8	-	-	
103	9-8-67	252 - 373	43	8.0	105	-	
105	20-6-67	249 - 374	62	6.2	-	-	
105	9-8-67	249 - 374	63	8.0	102	-	
108	20-6-67	236 - 388	60	6.8	-	-	
108	29-7-67	236 - 388	-	7.0	-	-	
109	20-6-67	232 - 391	58	8.0	-	-	
109	12-8-67	232 - 391	62	7.0	600	-	
110	20-6-67	231 - 393	59	7.8	-	-	
110	11-7-67	231 - 393	55	7.5	400	0.0	
110	4-8-67	231 - 393	-	7.5	1085	-	
110	12-8-67	231 - 393	56	7.0	390	-	
139	22-6-67	851 - 238	58	7.2	-	-	
139	24-7-67	851 - 238	-	7.5	79	-	
139	29-7-67	851 - 238	-	7.2	80	-	9:10 a.m.
139	29-7-67	851 - 238	-	8.0	75	-	3:30 p.m.
139	3-8-67	851 - 238	-	8.0	80	-	
139	21-8-67	851 - 238	-	7.5	98	-	
139	4-9-67	851 - 238	55	7.0	85	-	
169	24-6-67	185 - 236	-	7.5	-	-	
169	8-7-67	185 - 236	-	7.5	58	-	
169	5-8-67	185 - 236	-	8.0	75	-	
170	24-6-67	123 - 228	-	7.0	-	-	
170	5-8-67	123 - 228	-	8.0	62	-	
171	24-6-67	099 - 198	-	7.0	-	-	
171	5-8-67	099 - 198	-	8.0	65	-	
173	24-6-67	096 - 197	-	6.5	-	-	
173	5-8-67	096 - 197	-	6.5	20	-	
174	27-6-67	2233 - 4166	46	5.0	645	-	
174	18-7-67	2233 - 4166	64	5.0	425	2.0	
174	28-7-67	2233 - 4166	-	5.0	-	0.5	
175	27-6-67	2233 - 4164	58	6.9	44	-	
175	18-7-67	2233 - 4164	66	7.0	40	-	
175	31-7-67	2233 - 4164	-	7.0	38	-	
175	15-8-67	2233 - 4164	-	7.0	60	-	
175	17-8-67	2233 - 4164	-	6.8	62	-	H:30
175	4-9-67	2233 - 4164	49	6.8	38	-	

TABLE II (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
182	27-6-67	2250 - 3965	58	5.8	-	-	
182	9-8-67	2250 - 3965	68	6.5	118	-	
187	12-6-67	224 - 417	-	6.5	-	-	
187	27-6-67	224 - 417	58	6.0	-	-	
194	27-6-67	2162 - 4153	94	7.0	-	-	
194	18-7-67	2162 - 4153	104	7.0	-	-	
200	27-6-67	232 - 417	48	5.0	-	-	
200	31-7-67	232 - 417	55	5.0	1400	15.0	
200	4-8-67	232 - 417	55	-	-	-	
220	29-6-67	745 - 360	61	7.8	-	-	
220	24-7-67	745 - 360	-	8.0	120	-	
220	28-7-67	745 - 360	-	8.0	-	-	
220	4-9-67	745 - 360	-	7.0	100	0.1	
221	29-6-67	755 - 372	62	7.8	-	-	
221	2-8-67	755 - 372	66	8.5	120	-	
222	29-6-67	754 - 375	63	7.6	-	-	
222	24-7-67	754 - 375	-	7.0	520	-	
222	28-7-67	754 - 375	-	7.0	535	-	
222	29-7-67	754 - 375	-	7.2	510	-	
222	2-8-67	754 - 375	65	7.0	568	-	
222	3-8-67	754 - 375	-	7.0	580	-	
222	10-8-67	754 - 375	-	7.0	540	0.2	
222	15-8-67	754 - 375	-	7.5	610	-	
222	21-8-67	754 - 375	-	7.5	690	0.3	
222	4-9-67	754 - 375	-	6.5	545	0.3	
242	29-6-67	745 - 396	62	7.5	-	-	
242	10-7-67	745 - 396	72	7.8	-	-	
242	17-8-67	745 - 396	66	7.8	95	0.2	
251	5-7-67	789 - 378	61	6.9	70	-	
251	16-8-67	789 - 378	-	7.0	87	-	
251	7-9-67	789 - 378	-	6.8	79	0.3	
252	5-7-67	788 - 378	60	7.9	220	-	
252	16-8-67	788 - 378	-	7.5	545	-	
252	7-9-67	788 - 378	-	7.5	449	0.3	
254	5-7-67	785 - 372	55	4.0	-	-	
254	8-7-67	785 - 372	54	4.5	35	-	
261	7-7-67	268 - 372	52	8.0	-	-	
261	2-8-67	268 - 372	65	8.2	139	-	
270	11-7-67	231 - 393	70	6.1	-	0.0	
270	12-8-67	231 - 393	67	7.0	950	0.0	
271	11-7-67	231 - 392	46	5.8	-	0.0	
271	31-7-67	231 - 392	50	6.0	-	-	Decreased flow
272	11-7-67	229 - 394	48	6.5	590	0.0	
272	9-8-67	229 - 394	50	6.5	635	-	
273	11-7-67	229 - 395	57	7.0	390	0.0	
273	9-8-67	229 - 395	55	7.8	240	-	
274	12-7-67	233 - 388	-	5.5	-	0.0	
274	2-8-67	233 - 388	63	6.5	415	-	
274	12-8-67	233 - 388	66	4.0	975	0.0	
274	15-8-67	233 - 388	-	5.0	1000	0.5	Stronger flow

TABLE II (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
275	12-7-67	232 - 388	-	6.8	-	-	
275	29-7-67	232 - 388	-	6.6	-	-	These analyses prove that the source of 274 and 275 is the same (e.g. the dead swamp)
275	2-8-67	232 - 388	64	6.9	400	-	
275	15-8-67	232 - 388	-	5.0	900	0.4	
277	12-7-67	222 - 390	55	5.0	-	0.0	
277	2-8-67	222 - 390	54	5.0	475	-	
277	15-8-67	222 - 390	-	4.5	565	0.8	
280	12-6-67	2250 - 3960	-	6.5	-	-	
280	19-6-67	2250 - 3960	-	9.5	710	-	
280	14-7-67	2250 - 3960	-	7.5	-	-	
280	4-8-67	2250 - 3960	-	8.0	1134	-	
280	9-8-67	2250 - 3960	-	8.0	1075	-	
280	10-8-67	2250 - 3960	-	8.0	1020	0.3	
280	15-8-67	2250 - 3960	-	8.0	1050	-	
280	21-8-67	2250 - 3960	-	8.0	1075	-	Height of water at weir - 4"
280	4-9-67	2250 - 3960	-	7.5	1000	0.3	
283	14-7-67	225 - 394	55	5.0	-	-	
283	18-8-67	225 - 394	61	4.9	815	0.4	
284	14-7-67	2195 - 3912	42	7.5	-	0.5	
284	18-7-67	2195 - 3912	-	6.8	850	-	
284	18-8-67	2195 - 3912	44	7.0	810	0.3	
286	14-7-67	2181 - 3912	42	6.8	-	-	
286	18-8-67	2181 - 3912	44	6.3	675	-	
287	14-7-67	2172 - 3908	54	6.5	-	-	
287	18-8-67	2172 - 3908	67	6.0	960	-	
290	27-6-67	2092 - 4128	62	5.0	22	-	Specific conductance value could be erroneous
290	18-7-67	2092 - 4128	-	5.0	-	-	
290	21-8-67	2092 - 4128	-	4.5	470	-	
290	4-9-67	2092 - 4128	-	4.0	375	25.0	
291	6-6-67	208 - 413	-	5.0	-	-	
291	17-7-67	208 - 413	-	5.0	340	5.0	Fe:1.0
295	12-6-67	2236 - 4160	-	5.0	-	-	
295	27-6-67	2236 - 4160	56	4.8	500	-	H:171, Fe:1.0, NaCl:25
295	18-7-67	2236 - 4160	70	4.0	650	1.5	
296	27-6-67	2236 - 4150	58	4.8	2450	-	
296	18-7-67	2236 - 4150	66	4.0	2800	15.0	
296	29-7-67	2236 - 4150	-	4.5	-	15.0	
296	31-7-67	2236 - 4150	-	4.5	2090	15.0	
296	4-8-67	2236 - 4150	-	5.0	2750	-	
296	9-8-67	2236 - 4150	-	4.0	2700	45.0	
296	17-8-67	2236 - 4150	-	5.0	2700	68.0	Above box
296	17-8-67	2236 - 4150	-	5.0	2700	72.0	Below box
296	21-8-67	2236 - 4150	-	4.5	2300	50.0	
296	4-9-67	2236 - 4150	50	4.0	1500	14.8	Heavy precipitation does change this stream
299	17-8-67	209 - 412	-	4.0	239	0.4	
299	21-8-67	209 - 412	-	4.5	340	-	
301	18-7-67	224 - 417	-	6.5	180	0.5	
301	28-7-67	224 - 417	-	6.5	95	0.5	
301	29-7-67	224 - 417	-	6.9	80	-	
301	31-7-67	224 - 417	71	7.0	88	-	
301	9-8-67	224 - 417	-	7.0	88	0.2	
301	17-8-67	224 - 417	-	6.8	85	0.2	
301	21-8-67	224 - 417	-	5.0	280	-	Ditch is flowing in Little South Tomogonops River after rain
301	4-9-67	224 - 417	49	4.0	365	11.5	Ditch is flowing in Little South Tomogonops River after rain

TABLE II (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
303	21-7-67	256 - 432	63	7.0	38	-	
303	28-7-67	256 - 432	-	7.0	-	-	
303	15-8-67	256 - 432	-	7.5	39	-	
303	4-9-67	256 - 432	49	7.0	40	-	
304	21-7-67	259 - 414	70	6.5	158	0.5	
304	29-7-67	259 - 414	-	6.5	118	-	
304	4-8-67	459 - 414	60	6.8	140	-	
304	10-8-67	259 - 414	-	6.9	130	0.2	
304	15-8-67	259 - 414	-	5.2	160	0.8	
304	21-8-67	259 - 414	-	5.0	325	2.6	
304	4-9-67	259 - 414	-	4.0	380	15.0	
311	22-7-67	740 - 426	66	8.0	43	-	
311	18-8-67	740 - 426	-	7.8	45	0.1	
311	7-9-56	740 - 426	-	7.0	38	0.2	
312	22-7-67	741 - 425	-	7.5	102	-	
312	18-8-67	741 - 425	-	7.8	90	0.2	
312	7-9-67	741 - 425	-	6.5	80	0.4	
314	22-7-67	216 - 421	42	6.0	22	-	
314	17-8-67	216 - 421	44	6.0	25	-	H:20
323	29-7-67	2230 - 3895	-	6.9	-	-	
323	2-8-67	2230 - 3895	68	7.0	975	-	
323	15-8-67	2230 - 3895	-	5.0	950	2.3	
324	29-7-67	234 - 385	-	5.3	-	-	
324	2-8-67	234 - 385	65	5.5	875	-	
324	15-8-67	234 - 385	-	5.0	900	0.3	
325	29-7-67	231 - 387	-	6.4	-	-	
325	2-8-67	231 - 387	66	6.6	920	-	
325	12-8-67	231 - 387	68	4.0	770	0.0	
325	15-8-67	231 - 387	-	5.0	710	0.4	
326	31-7-67	2375 - 4160	62	5.0	2060	15.0	
326	21-8-67	2375 - 4160	-	5.0	3005	65.0	Five times the flow of July sample
326	4-9-67	2375 - 4160	49	4.0	2800	20.0	
327	31-7-67	238 - 414	67	6.5	290	-	
327	18-8-67	238 - 414	-	5.8	160	-	
327	21-8-67	238 - 414	-	5.0	490	4.0	
327	4-9-67	238 - 414	49	4.0	545	11.3	
328	31-7-67	233 - 416	71	6.8	115	-	
328	10-8-67	233 - 416	-	6.5	143	0.5	
328	21-8-67	233 - 416	-	4.7	355	-	
329	31-7-67	2337 - 4160	46	5.0	1150	10.0	
329	4-8-67	2337 - 4160	47	-	-	-	
329	10-8-67	2337 - 4160	-	4.0	1075	6.4	
329	15-8-67	2337 - 4160	-	5.0	1300	50.8	
329	17-8-67	2337 - 4160	-	4.0	1110	10.8	
329	21-8-67	2337 - 4160	-	5.0	1650	12.0	
338	31-7-67	2240 - 4164	-	7.0	50	-	
338	21-8-67	2240 - 4164	-	6.5	118	-	
339	29-7-67	2213 - 3927	-	7.8	-	-	
339	2-8-67	2213 - 3927	-	8.5	990	-	
339	15-8-67	2213 - 3927	-	9.0	1035	-	
340	29-7-67	2213 - 3915	-	7.8	-	-	
340	2-8-67	2213 - 3915	68	8.3	1000	-	
340	15-8-67	2213 - 3915	-	8.0	1025	-	

TABLE II (Cont.)

Hydrogeological Study of Heath Steele Mines Area
Data for Locations at which Samples were Collected - June to September 1967

Sample Number	Date Collected	Coordinates UTM Grid	Temp °F	pH	Specific Conductance Micromhos/cm @ 25°C	Cu ppm	Remarks
342	29-7-67	2208 - 3900	-	5.0	-	-	
342	2-8-67	2208 - 3900	58	4.0	990	2.0	
342	15-8-67	2208 - 3900	-	5.0	1235	3.2	
343	29-7-67	2213 - 3900	-	6.5	-	-	
343	2-8-67	2213 - 3900	64	6.8	965	-	
343	15-8-67	2213 - 3900	-	4.5	1085	2.3	
344	29-7-67	2213 - 3907	-	7.3	-	-	
344	2-8-67	2213 - 3907	69	8.3	990	-	
344	15-8-67	2213 - 3907	-	7.3	1025	-	
345	2-8-67	226 - 389	65	6.9	940	-	
345	15-8-67	226 - 389	-	5.0	790	0.6	
348	2-8-67	236 - 387	-	7.8	64	-	
348	15-8-67	236 - 387	-	8.0	65	-	
349	2-8-67	236 - 383	65	5.0	850	-	
349	15-8-67	236 - 383	-	5.0	850	0.3	
350	2-8-67	237 - 380	67	5.0	875	-	
350	15-8-67	237 - 380	-	5.0	860	0.3	
356	2-8-67	740 - 373	67	7.0	998	-	Specific conductance value could be erroneous This is more like it should be (specific conductance)
356	9-9-67	740 - 373	-	6.5	660	-	
372	4-8-67	235 - 416	62	6.6	130	-	
372	10-8-67	235 - 416	-	6.0	160	0.5	
372	15-8-67	235 - 416	-	5.0	160	0.6	
372	17-8-67	235 - 416	-	6.0	155	0.5	
372	21-8-67	235 - 416	-	5.0	425	-	
377	8-8-67	2130 - 4120	-	4.0	-	>5.0	
377	15-8-67	2130 - 4120	-	5.0	1135	-	
377	21-8-67	2130 - 4120	-	4.2	1175	-	
379	8-8-67	2131 - 4110	-	-	1125	22.8	
379	21-8-67	2131 - 4110	-	4.7	1190	-	
380	8-8-67	2022 - 4082	46	7.0	518	-	
380	4-9-67	2022 - 4082	46	5.0	635	8.0	(Not pumping)
396	16-8-67	789 - 378	-	7.5	350	-	
396	7-9-67	789 - 378	-	6.8	195	0.2	

TABLE III
STREAMFLOW MEASUREMENTS - 1967

Site	Date		Date		Date		Date		Date		Date		Date		Date		Remarks				
	Day	Month	Discharge	cfs	Day	Month	Discharge	cfs	Day	Month	Discharge	cfs	Day	Month	Discharge	cfs	Day	Month	Discharge	cfs	
1	-	-	-	-	-	-	-	-	-	-	15-8	26.4	-	-	-	-	9-9	59.7	Tomogonops at mouth		
2	-	-	-	-	-	-	-	-	-	-	15-8	87.8	-	-	-	-	9-9	107	Northwest Miramichi above Tomogonops		
3	-	-	-	-	-	-	-	-	-	-	15-8	6.0	19-8	4.6	9-9	7.0	South Tomogonops at Mines Road				
4	-	-	-	-	-	-	-	-	-	-	15-8	0.8	-	-	8-9	2.8	Unnamed Brook (at mouth) tributary to South Tomogonops River				
5	-	-	-	-	-	-	-	-	-	-	15-8	8.4	-	-	8-9	13.4	South Tomogonops at old mill				
*6	-	-	-	-	-	-	-	-	-	-	15-8	125	-	-	9-9	235	Northwest Miramichi at Trout Brook				
7	-	-	-	-	-	-	-	-	-	-	16-8	9.8	-	-	7-9	42.2	Tomogonops above South Tomogonops				
8	-	-	-	-	-	-	-	-	-	-	16-8	8.2	-	-	7-9	21.0	South Tomogonops at mouth				
9	-	-	-	-	-	-	-	-	-	-	16-8	16.1	-	-	7-9	58.8	Tomogonops below South Tomogonops				
10	-	-	-	-	-	-	-	-	-	-	16-8	8.7	-	-	9-9	14.8	Little River				
11	-	-	-	-	-	-	-	-	-	-	17-8	0.2	-	-	8-9	1.0	Lake Brook				
12	-	-	-	-	-	-	8-7	Trace	-	-	17-8	3.2	-	-	8-9	5.6	Tailing Pond at No. 1 outlet				
13	-	-	-	-	-	-	-	-	-	-	17-8	0.4	-	-	8-9	0.4	South Tomogonops below Tailing Pond				
14	9-6	60.0	-	-	-	-	8-7	4.0	-	-	17-8	2.2	-	-	6-9	7.2	Little South Tomogonops at Mines Road				
15	-	-	-	-	-	-	-	-	-	-	17-8	0.8	-	-	6-9	1.2	Camp Brook at settling pond				
16	-	-	-	-	-	-	-	-	-	-	18-8	2.7	-	-	7-9	9.7	Little South Tomogonops at mouth				
17	-	-	-	-	-	-	-	-	-	-	18-8	2.9	-	-	7-9	23.8	Tomogonops above Little South Tomogonops				
18	-	-	-	-	-	-	-	-	-	-	18-8	6.3	-	-	7-9	30.2	Tomogonops below Little South Tomogonops				
19	9-6	77.5	-	-	-	-	8-7	5.2	-	-	18-8	1.5	-	-	8-9	5.4	Little South Tomogonops at staff gauge below No. 3 shaft				
20	-	-	-	-	-	-	-	-	-	-	18-8	6.4	-	-	8-9	9.4	Culvert at stinking swamp				
21	-	-	10-6	26.4	16-6	13.5	-	-	9-7	5.7	-	-	-	-	6-9	10.3	Tomogonops at Mines Road				
22	-	-	-	-	-	-	-	-	-	-	23-8	0.1	-	-	8-9	0.1	Ditch				
23	-	-	10-6	15.4	-	-	-	-	9-7	4.8	-	-	-	-	-	-	Tailing Pond at No. 2 outlet				

* Outside map area

Note: It should be noted that two days prior to beginning of measurements in September, there were several days of rain, hence, the stage of the river dropped somewhat over the periods of measurements. Therefore, before direct comparison is made, the dates should be consulted and the change in discharge taken into account.

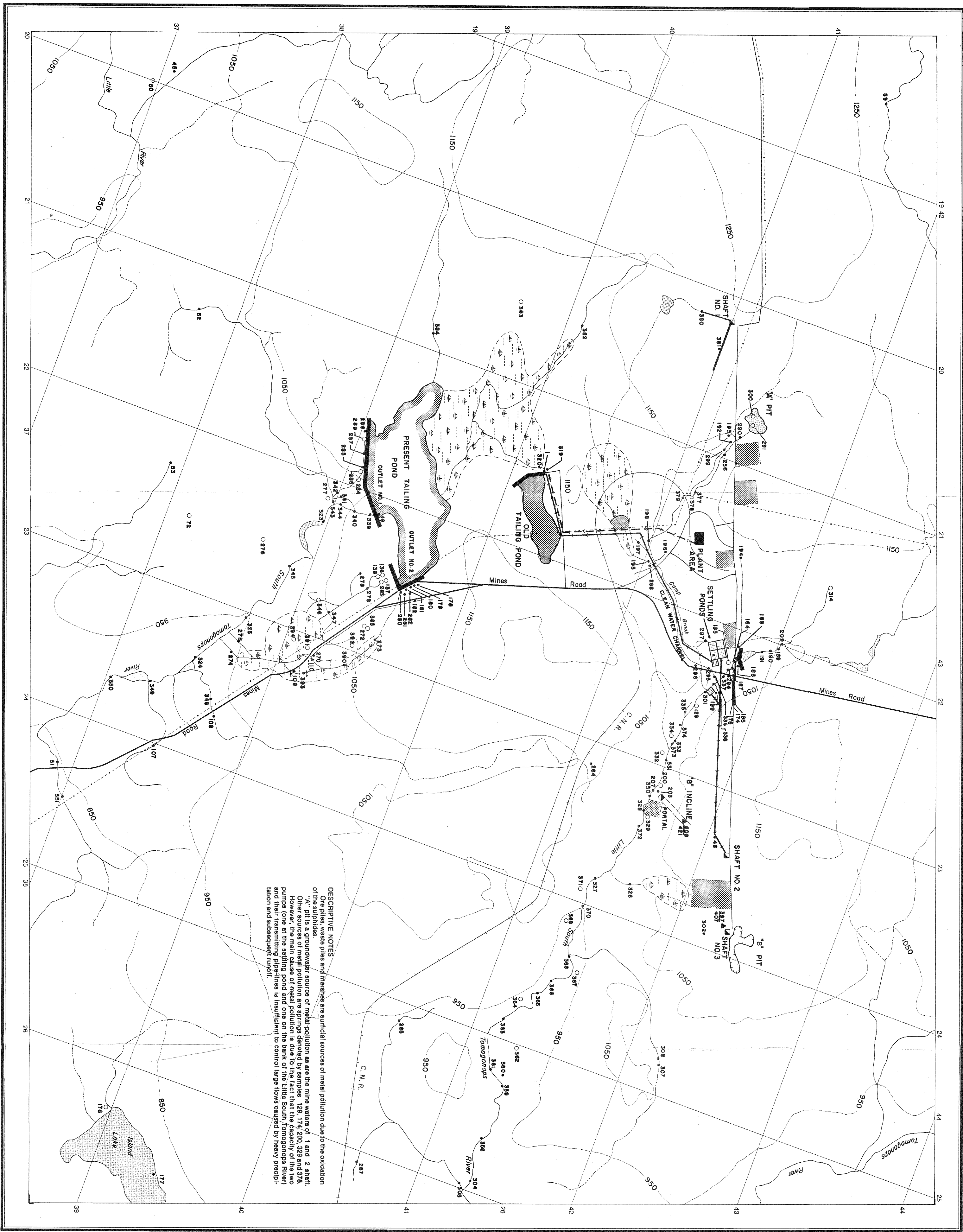
DATA SUPPLIED BY: WATER SURVEY OF CANADA

TABLE IV

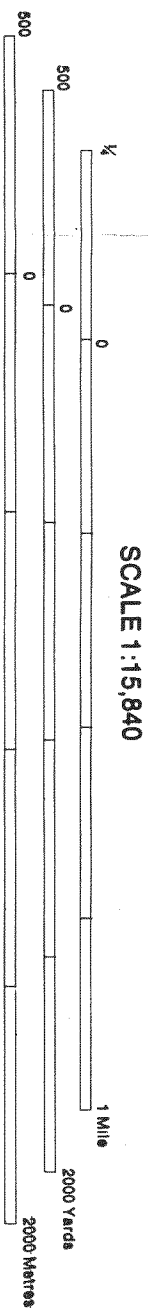
PRECIPITATION DATA - 1967

Date	Rain Gauge at Mines Road Coord. 782-316		Remarks
	Reading in inches	Cumulative	
June 16	0.03		
19	0.12	0.15	
22	0.20	0.35	
23	0.20	0.55	
27	0.60	1.15	June 16-31, Totals 1.15"
July 10	0.13	1.28	
13	0.11	1.39	
14	0.04	1.43	
17	0.45	1.88	
24	0.12	2.00	
29	0.47	2.47	
31	0.60	3.07	July 10-31, Totals 1.92"
Aug. 1	0.03	3.10	
5	0.02	3.12	
11	0.14	3.26	
12	0.01	3.27	
15	0.36	3.63	
21	0.94	4.57	
29	0.88	5.45	Aug. 1-29, Totals 2.38"
Sept 1	0.48	5.93	
3	1.10	7.03	
4	0.72	7.75	
5	0.26	8.01	
11	0.50	8.50	Sept 1-11, Totals 3.06"

FIGURE 2

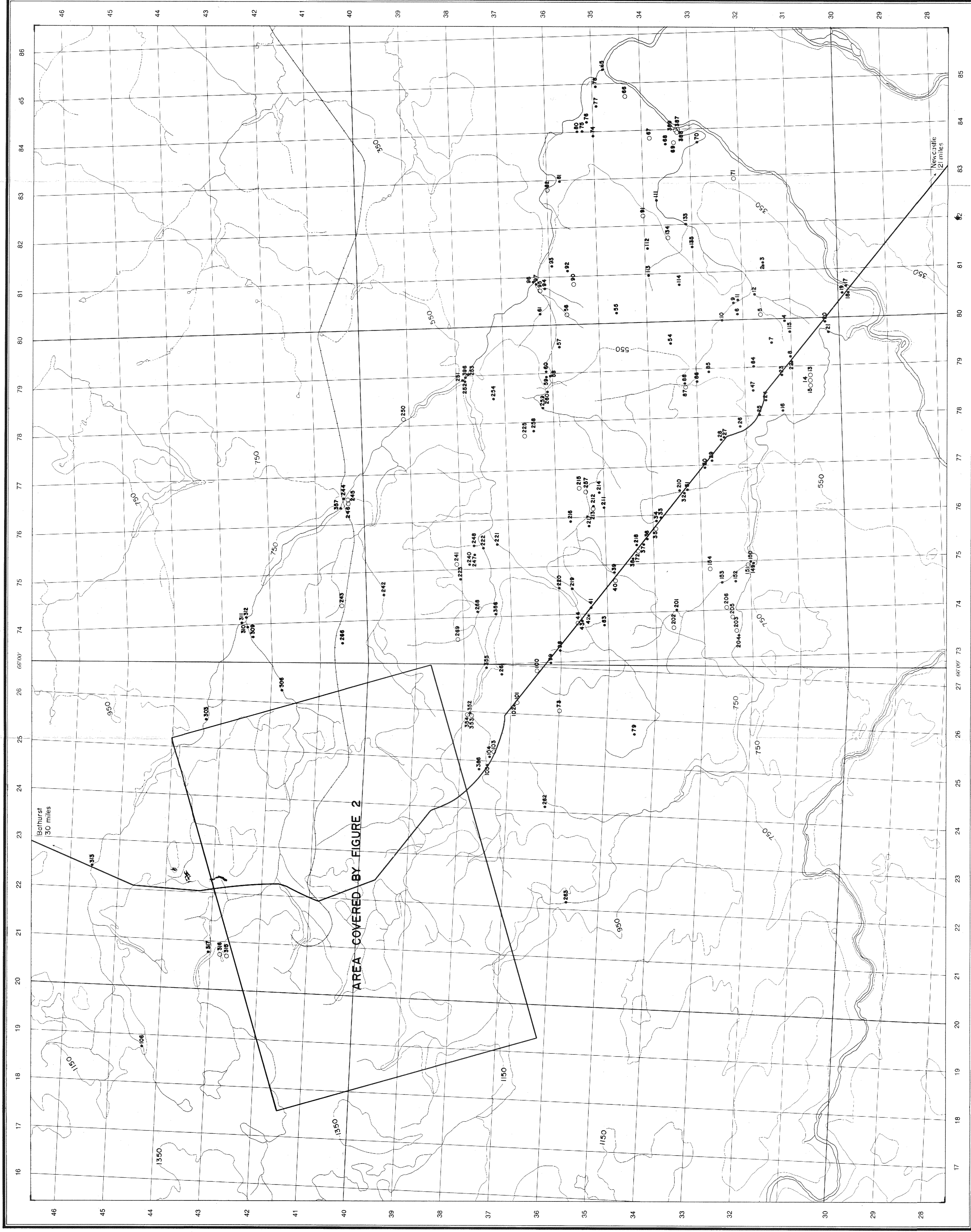


HEATH STEELE MINES
POLLUTION CONTROL LAY-OUT AND SOURCES OF METAL POLLUTION

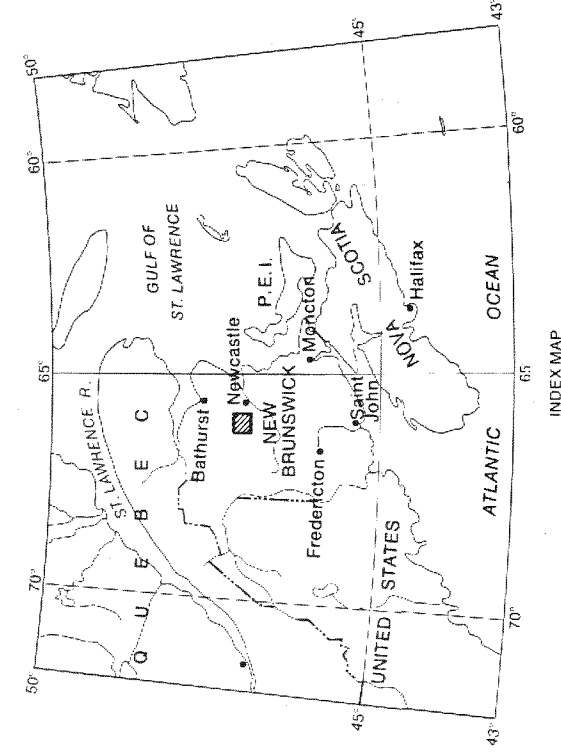


- LEGEND**
- Sample location and number (stream and pipeline)
 - Sample location and number (spring)
 - Sample location and number (mine)
 - Roads (gravel)
 - Roads (gravel)
 - Rivers and streams (perennial)
 - Rivers and streams (intermittent)
 - Contours (Contour Interval 100 ft.)
 - Power transmission line
 - Pipeline (mine water)
 - Pipeline (mill water)
 - Dam
 - Pump
 - One and waste pile
 - Marsh or bog
- POLLUTION CONTROL**
- Pipeline (mine water)
 - Pipeline (mill water)
 - Dam
 - Pump
 - One and waste pile
 - Marsh or bog
- SURFICIAL SOURCE OF POLLUTION**
- One and waste pile
 - Marsh or bog

FIGURE 1



- LEGEND
- Sample location and number - stream and pipeline
 - Sample location and number - spring
 - Roads (paved)
 - Rivers and streams (perennial)
 - Rivers and streams (intermittent)
 - Contours (Contour interval 200 ft)
 - Railways



HEATH STEELE MINES
SAMPLE LOCATION MAP

