# A CURSORY EVALUATION OF THE DEEPLAKE TAILINGS DISPOSAL SYSTEM AT COMINCO'S BENSON LAKE OPERATION

Manuscript Report

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TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

# I. INTRODUCTION

The Benson Lake Coast Copper Mine commenced operations in August 1962. The mine is currently processing approximately 850 tons of ore per calendar day and a feasability study shows the potential for expansion to 1500 tons per day. At the expanded production rate the mine has a life expectancy of ten years.

Impoundment of tailings in the vicinity of the mine was impossible because of lack of suitable terrain. Therefore, the company was permitted to discharge into Benson Lake. It was anticipated that the tailings would settle rapidly and lake turbidity would not result. However, it soon became apparent that the finer fraction of the tailings did not settle readily and the company experimented with several flocculating agents. Although bench tests were favorable, the practical results were less impressive and the lake remained turbid for much of the year. Following spring turnover the epilimnion gradually becomes clear probably because the colloidal tailings remain in the deep waters of the hypolimnion, and a density barrier is formed at the thermocline.

In the past, a combination of adverse climatic conditions and unsatisfactory maintenance of flocculent and tailings lines were largely responsible for the reduced lake clarity during the winter months. Although little can be done to prevent flash floods or freezing temperatures, in 1970 the company did improve the tailings and flocculent lines to prevent the annual winter spillages into Benson Lake. At the request of the Fisheries Service the tailings float was also moved to a deeper portion of the lake to prevent blockage at the downspout from tailings buildup. At present the tailings are being discharged at a depth of 30.5 meters with a settling clearance of approximately 14 meters. The flocculent Alchem

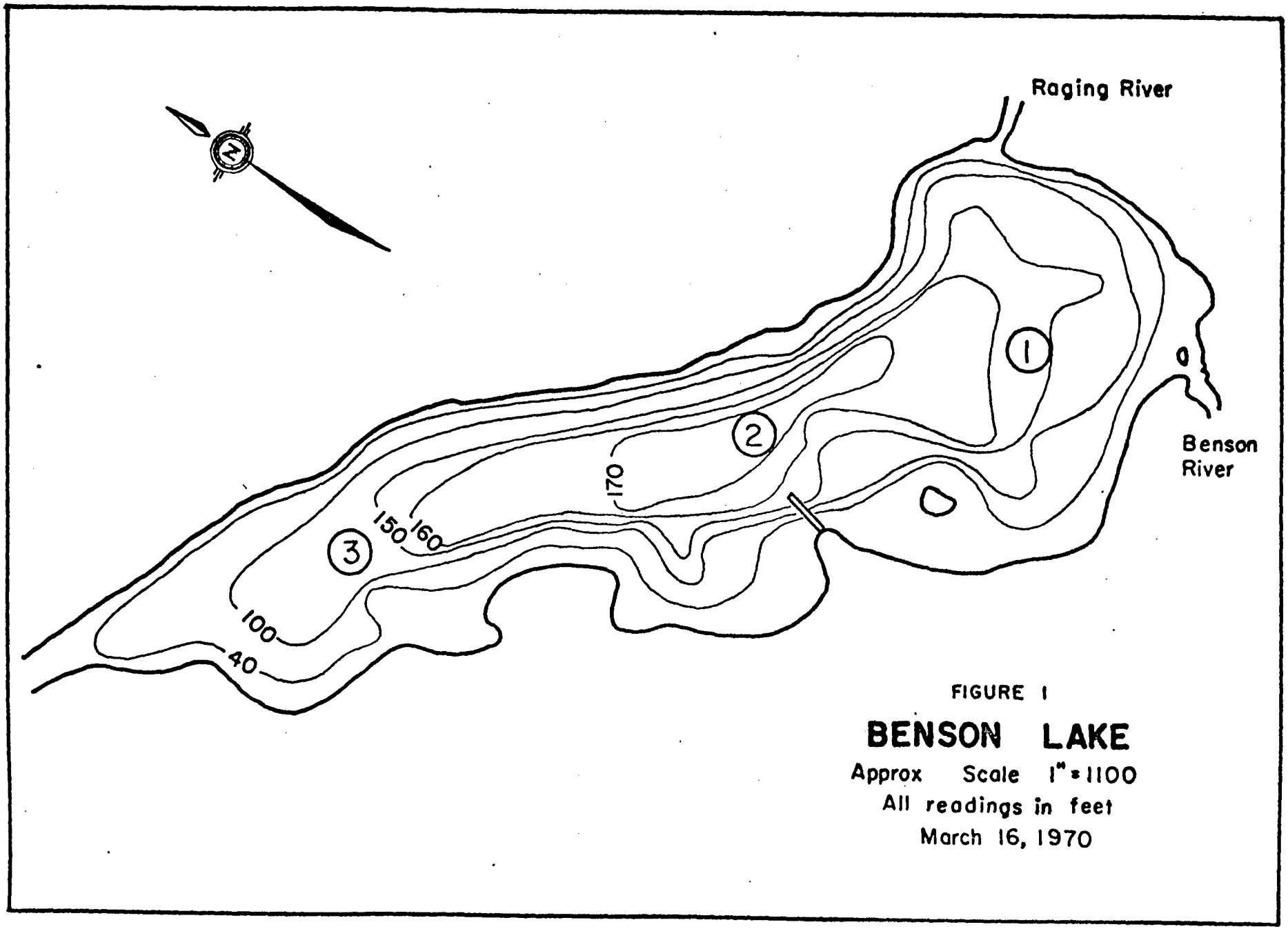



FIGURE 1

**BENSON LAKE**

Approx Scale 1" = 1100

All readings in feet

March 16, 1970

D176 is prepared at the mill, piped to the lake, and added to the tailings at a mixing box on the discharge float. An insulated $1\frac{1}{4}$ inch PVC line carries the flocculent to the float and an electrical alarm system has been installed which alerts the mill people should the flocculent flow into the mixing box cease. Even with the addition of flocculents the lake has consistently shown a high degree of turbidity indicating that colloidal tailings fines remain in suspension. Turbidity has been especially noticeable during winter months when isothermal conditions prevail and on occasions turbid waters have extended past Kathleen Lake and into Alice Lake.

Since startup, Cominco has submitted secchi disc readings taken from three lake stations at approximately ten day intervals. The location of the discharge float and the survey stations are depicted in Figure 1. Data prior to operations is not available. Although Maynard Lake waters are characteristically brownish in color compared to the clear waters of the Benson lake and river system, easy accessibility by mine personnel dictated its choice as a control. Figures 2 and 3 depict several years average monthly secchi disc readings of the two lakes. The drastic reduction in the clarity of Benson Lake water following the October turnover should be noted (Figure 2) and compared to the relatively small range between winter and summer values for Maynard Lake. The readings were reduced to monthly averages to minimize the effects of variable light conditions and procedural differences.

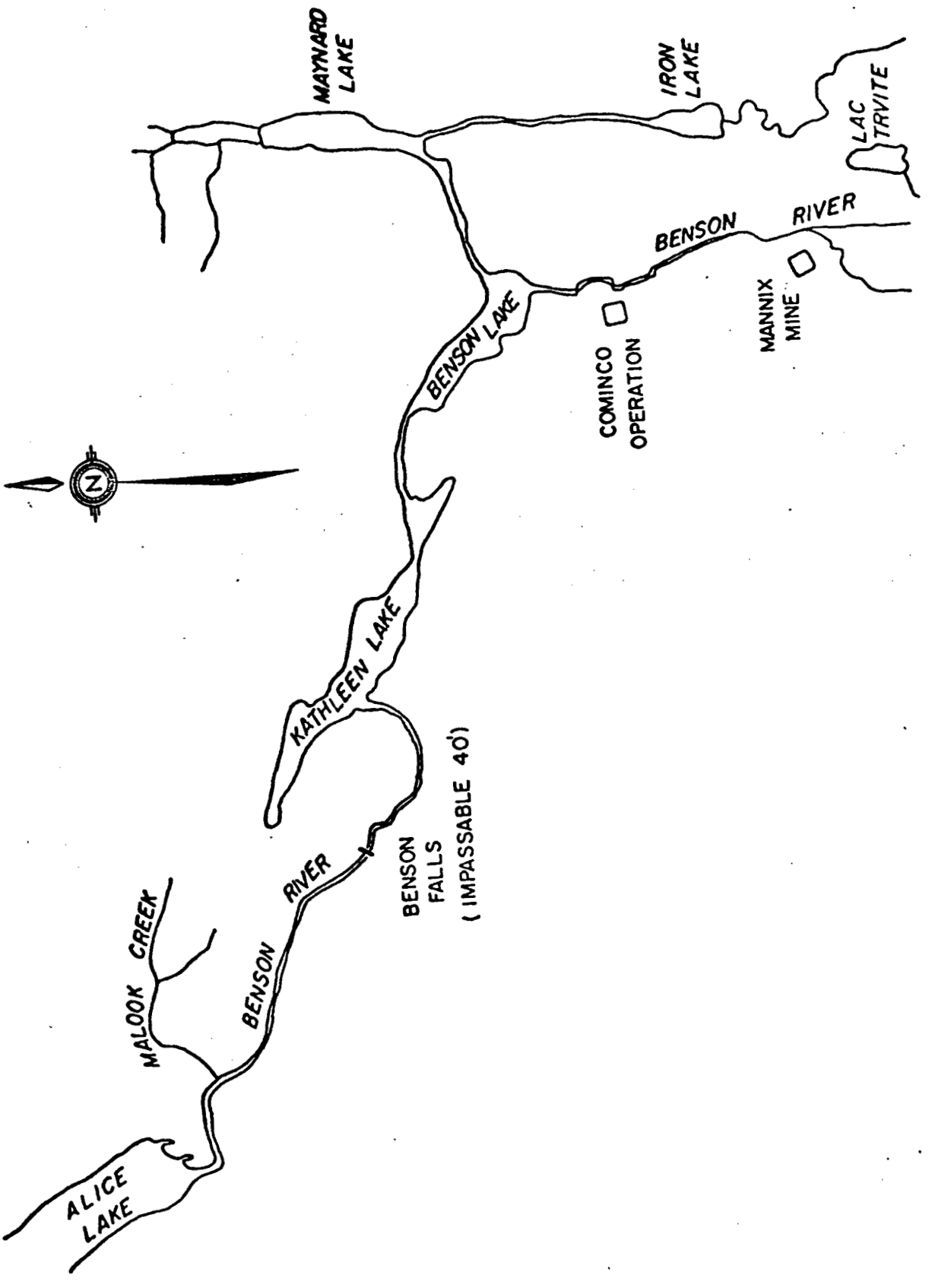



FIGURE 1A. LOCATION MAP - BENSON RIVER AND MINE

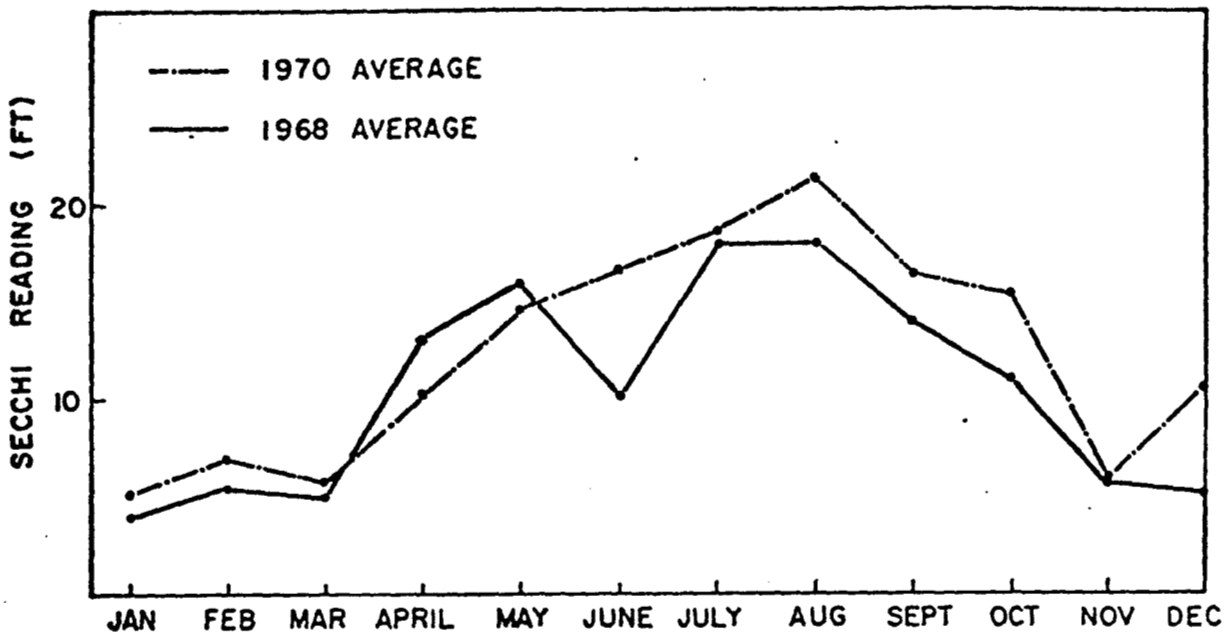



FIGURE 2. 1968 & 1970 AVERAGE SECCHI DISC VALUES
BENSON LAKE STATION 2

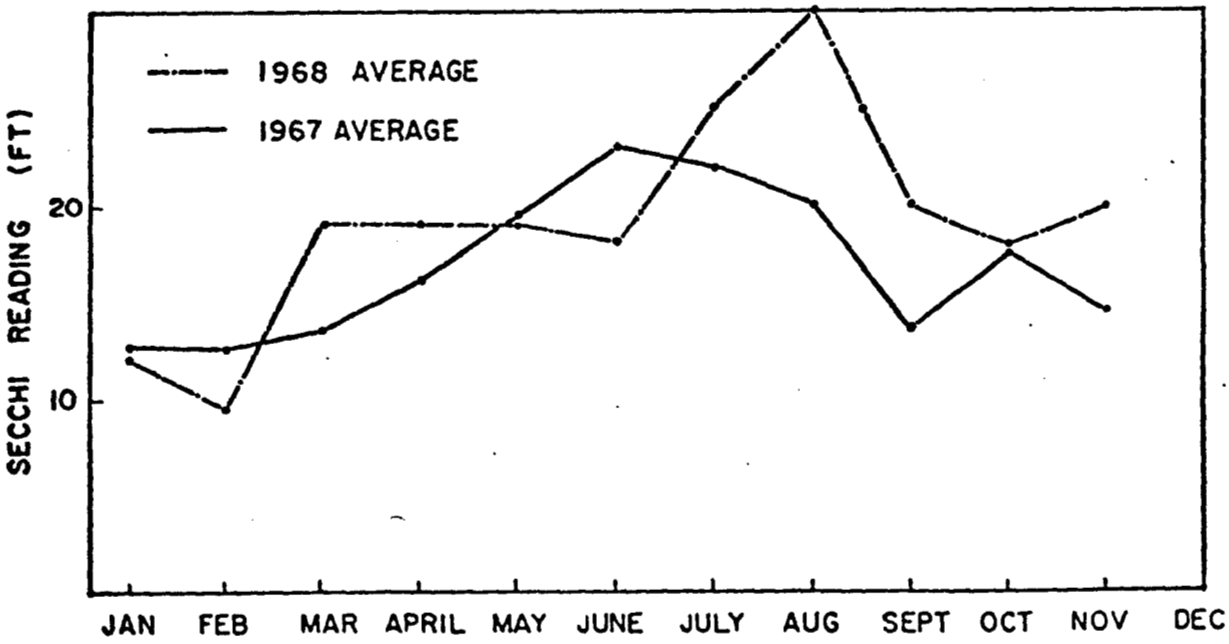



FIGURE 3, 1967 & 1968 AVERAGE SECCHI DISC VALUES
MAYNARD LAKE

## II. METHODS, RESULTS AND DISCUSSION

### (1) Biological Investigation

On February 16, 1967 a program was conducted to determine the composition of Benson Lake substrate and document the benthic fauna. Results indicated that the whole lake bottom was covered with tailings and no benthic organisms were found. A cursory examination of rocks in the Lower Benson River also revealed a shallow layer of tailings fines. Aquatic invertebrates were collected from this section of the river using a Surber sampler. Eighty percent of the organisms collected belonged to the genus Ephemerella which is reported to be associated with turbid water conditions. In contrast the comparable mayfly populations from the Raging River, a tributary to the system, consisted primarily of the genus Baetis a clean water form.

On November 20, 1968 a 1.5 inch mesh, 50 foot long gillnet was set in Benson Lake. Thirty-two fish were caught. The fish were relatively uniform in size, with a range of 15 to 25 cm. The catch consisted of 18 Salmo gairdneri, 7 Salmo clarki, 6 Salvelinus alpinus, and 1 Cottus asper. A cursory examination of the digestive tracts indicated that these fish had consumed a variety of aquatic and terrestrial invertebrates. The following orders were represented: Gastropoda, Oligochaeta, Hemiptera, Ephemeroptera, Pelecypoda, Trichoptera, Arachnida, and Hymenoptera. Since the 1967 dredge survey revealed a complete void of benthic organisms in the relatively sterile substrate of the deeper portions of the lake, it was hypothesized that the indigenous Benson Lake fish receive their sustenance mainly from drift entering the lake through the Raging and Upper Benson Rivers aided by terrestrial insects which drop into the lake from the prolific

coastal forest surrounding these waters.

On March 16, 1971 gillnets of sizes 1 and 1.5 inch mesh were again set in Benson and Maynard Lakes. Few fish were caught this time. Two cuthroat trout (Salmo clarki) from each lake were quick frozen and sent to the Cominco laboratory at Trail for heavy metal analyses. The results are tabulated in Table I and indicate no significant difference of heavy metal concentrations between the four fish from these lakes. However, because of the small sample size it cannot be categorically stated at this time that heavy metal concentrations of fish in Benson Lake are indeed equal to or less than those concentrations found in Maynard Lake fish.

Table I Mean concentrations of some metals in trout and water from Benson and Maynard Lakes.

| Specimen | Metals | Benson Lake (ppm) | | | Maynard Lake (ppm) | |
|---|---|---|---|---|---|---|
| | | Water | Fish | $\bar{x}$ wt (gm) | Fish | $\bar{x}$ wt (gm) |
| Salmo clarki | Hg | <0.00005 | 0.1 | 128.0 | 0.1 | 64.2 |
| | Cu | <0.005 | 0.2 | | 0.3 | |
| | Zn | 0.06 | 6.5 | | 8.5 | |
| | Pb | <0.01 | 0.1 | | 0.1 | |
| | Cd | | 0.1 | | 0.1 | |

Benson Lake water was collected on February 16, 1971 and again analysed in the Cominco laboratory. These results are also included in Table I. The zinc levels are relatively high in both water and animal tissue. High concentrations of zinc have been reported previously from Benson River water which is also classified as very soft. Since the toxicity of heavy metals to aquatic organisms and their synergistic effects are enhanced in soft waters, the heavy metal concentrations both in aquatic organisms and water should be kept under surveillance.

(2) Lake Sounding

On March 16, 1970 the Fisheries Service conducted a sounding survey of Benson Lake (Figure 1) to ascertain the effect of the eight year deposit of tailings on the depth of Benson Lake and also to establish the capacity of the lake to absorb future tailings from the Cominco operation. A comparison with soundings taken by the company in 1962 indicated that the operation to date had not altered the depth of the lake significantly.

(3) Turbidity Evaluation

As previously mentioned in 1970 the company instituted the following key changes to their disposal system at the request of the Fisheries Service:

(a) the tailings float was moved to a lake depth of 45 meters.

(b) a larger insulated flocculent line was installed.

(c) an electrical alarm system was instituted to notify mill personnel should the flocculent flow into the mixing box cease.

(d) surveillance of the tailings and flocculent lines was increased.

In order to assess the effects of these improvements on Benson Lake water quality, the Fisheries Service conducted several surveys in 1970 and 1971. Figures 4, 5 and 6 delineate the temperature regimes at stations 1, 2 and 3. In July 1970 the lake was stratified with an epilimnion of 7.5 meters, a thermocline between the 7.5 and 20 meter layer and a deeper hypolimnion. The lake was isothermal on March 16, 1971 and again on September 9, 1971 suggesting an early fall turnover.

The turbidity of the lake was measured by three methods. Water samples were procured with a Nansen bottle and the temperature recorded with a centigrade thermometer. An

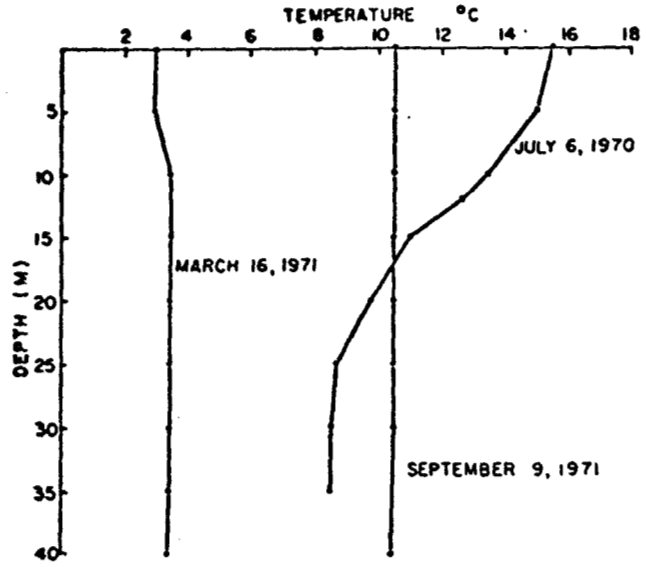



FIGURE 4. BENSON LAKE THERMAL STRATIFICATION STATION 1

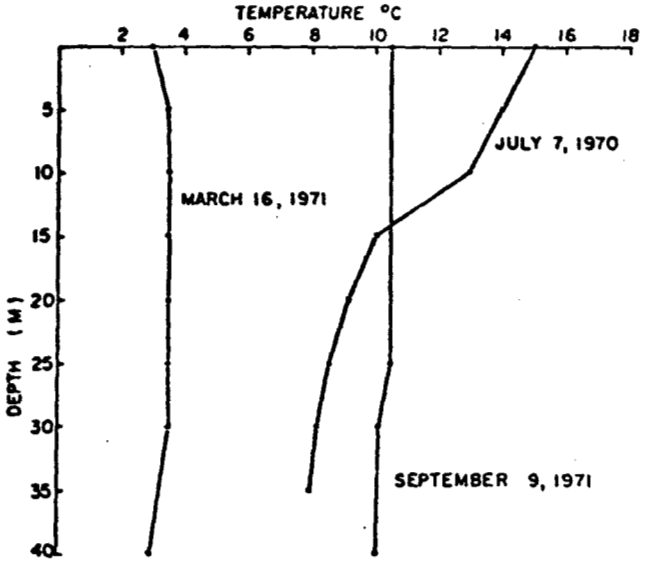



FIGURE 5 BENSON LAKE THERMAL STRATIFICATION STATION 2

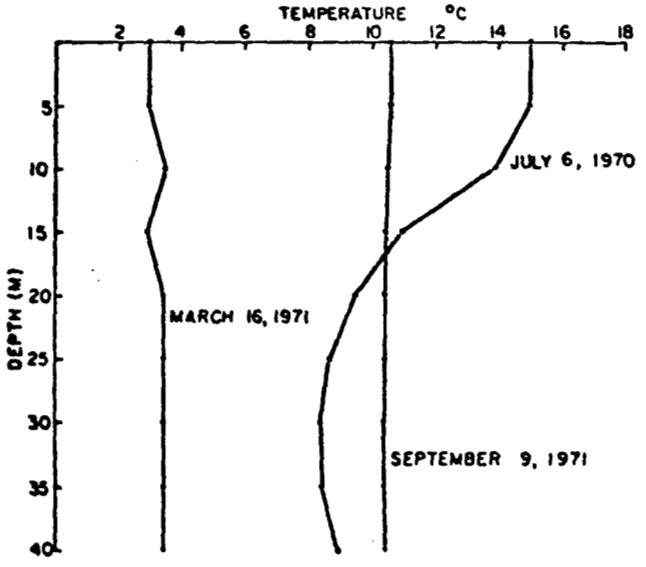



FIGURE 6 BENSON LAKE THERMAL STRATIFICATION STATION 3

arbitrary turbidity scale was devised to record the visual clarity of each sample. Clear water was rated zero; partially discolored water and turbid water were given a rating of 1 and 2 respectively. A glass B.O.D. bottle with clear surface of river water was used as a standard and given a rating of zero. The standard and samples from each depth were then rated by looking through the sample into the sun. Water samples from the three stations as well as additional sites were also collected and subjected to total solids, suspended solids, and turbidity analyses at the Fisheries Service laboratories. Results of the 1970-71 turbidity analyses of Benson Lake water are listed in Table II and although correlation was not always perfect, a close relationship can be noted between the visual turbidity ratings and the suspended solids results.

The results from the July 6, 1970 survey indicated the presence of turbid water below the 30 meter depth, approximately 10 meters below the thermocline. This phenomenon was uniform throughout the lake as can be noted from the visual turbidity ratings at stations 1, 2 and 3 in Table II. In 1970 the turbid water layer also started at the depth of the tailings discharge pipe. The significance of the cloudy waters below the 30 meter depths is not readily apparent. However, it may be postulated that the tailings had settled to this depth following summer stratification or that the tailings fines were dispersed laterally throughout the lake at the depth of the downspout.

No tailings contaminated waters were found at the three stations on March 16 or September 9, 1971 down to a depth of 45 meters. However, in September, at Station 2 the fifty meter sample contained suspended mine tailings as indicated by the arbitiary visual turbidity rating of three, a reading of 14 Jackson turbidity units, and a total and suspended solids result of 80 and 11.3 ppm respectively (Table II). Following

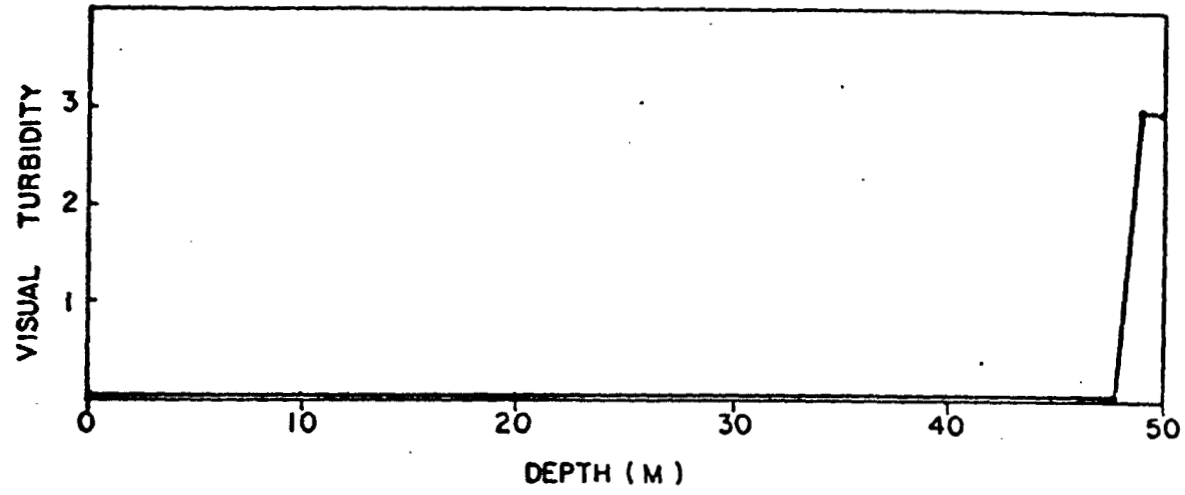
Table II Summary of the 1970-71 Benson Lake Water Analyses Data

| Station | Depth(m) | Visual Turbidity 6/7/70 | 16/3/71 | 9/9/71 | Total Solids (ppm) 6/7/70 | 16/3/71 | 9/9/71 | Suspended Solids (ppm) 6/7/70 | 16/3/71 | 9/9/71 | Jackson Turbidity Units 6/7/70 | 16/3/71 | 9/9/71 | Temp. °C 6/7/71 | 16/3/71 | 9/9/71 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 0 | 0 | 0 | 0 | - | 34 | 53 | - | - | 2.4 | - | - | 3 | 15.5 | 3.0 | 10.5 |
| | 5 | 0 | 0 | 0 | - | 64 | 55 | - | - | 2.2 | - | - | 4 | 15.0 | 3.0 | 10.5 |
| | 10 | 0 | 0 | 0 | - | 41 | 52 | - | - | 3.2 | - | - | 3 | 13.5 | 3.5 | 10.5 |
| | 15 | 0 | 0 | 0 | - | - | 53 | - | - | 3.3 | - | - | 3 | 11.0 | 3.5 | 10.5 |
| | 20 | 0 | 0 | 0 | - | - | 49 | - | - | 3.2 | - | - | 4 | 9.8 | 3.5 | 10.5 |
| | 25 | 0 | 0 | 0 | - | 28 | 48 | - | - | 3.0 | - | - | 4 | 8.7 | 3.5 | 10.5 |
| | 30 | 1 | 0 | 0 | - | - | 53 | - | - | 5.6 | - | - | 5 | 8.6 | 3.5 | 10.3 |
| | 35 | 2 | 0 | 0 | - | 24 | 47 | - | - | 5.2 | - | - | 5 | 8.5 | 3.5 | 10.3 |
| | 40 | | 1 | | | | | | | | | | | | 3.5 | 10.3 |
| | 45 | | | | | | | | | | | | | | | |
| | 50 | | | | | | | | | | | | | | | |
| II | 0 | 0 | 0 | 0 | 53 | - | 41 | - | - | 2.2 | - | - | 3 | 15.0 | 3.0 | 10.5 |
| | 5 | 0 | 0 | 0 | - | - | 51 | - | - | 3.4 | - | - | 4 | 15.0 | 3.5 | 10.5 |
| | 10 | 0 | 0 | 0 | - | 37 | 45 | - | - | 0.9 | - | - | 3 | 13.5 | 3.5 | 10.5 |
| | 15 | 0 | 0 | 0 | - | 35 | 48 | - | - | 11.2 | - | - | 4 | 11.8 | 3.5 | 10.5 |
| | 20 | 0 | 0 | 0 | 55 | 36 | 57 | - | - | 4.1 | - | - | 5 | 9.7 | 3.5 | 10.5 |
| | 25 | 0 | 0 | 0 | - | 31 | 54 | - | - | 3.8 | - | - | 4 | 9.2 | 3.5 | 10.5 |
| | 30 | 1 | 0 | 0 | - | - | 57 | - | - | 3.9 | - | - | 3 | 9.0 | 3.5 | 10.3 |
| | 35 | 2 | 0 | 0 | - | 30 | 49 | - | - | 3.1 | - | - | 4 | 9.2 | 3.5 | 10.3 |
| | 40 | 2 | 0 | 0 | - | - | - | - | - | 3.3 | - | - | 5 | 9.2 | - | 10.3 |
| | 45 | 2 | 0 | 0 | 103 | 52 | 66 | - | - | 7.6 | - | - | 7 | 9.0 | 3.0 | 10.3 |
| | 50 | | | 3 | - | - | 80 | - | - | 11.3 | - | - | 14 | | | 9.5 |
| III | 0 | 0 | 0 | 0 | - | - | 44 | - | - | 2.1 | - | - | 3 | 15.0 | 3.0 | 10.7 |
| | 5 | 0 | 0 | 0 | - | 25 | 58 | - | - | 4.4 | - | - | 6 | 15.0 | 3.5 | 10.7 |
| | 10 | 0 | 0 | 0 | - | 39 | 70 | - | - | 3.7 | - | - | 4 | 13.8 | 3.5 | 10.5 |
| | 15 | 0 | 0 | 0 | - | 40 | 40 | - | - | 4.0 | - | - | 4 | 11.0 | 3.0 | 10.4 |
| | 20 | 0 | 1 | 0 | - | - | 49 | - | - | 3.7 | - | - | 3 | 9.5 | 3.5 | 10.4 |
| | 25 | 0 | 1 | 0 | - | 50 | 46 | - | - | 5.6 | - | - | 3 | 8.7 | 3.5 | 10.4 |
| | 30 | 1 | 1 | 0 | - | - | 50 | - | - | 4.5 | - | - | 4 | 8.5 | 3.5 | 10.4 |
| | 35 | 2 | 1 | 0 | - | 47 | 61 | - | - | 7.0 | - | - | 4 | 8.5 | 3.5 | 10.4 |
| | 40 | 2 | 1 | 0 | - | - | 57 | - | - | 8.2 | - | - | 4 | 9.0 | 3.5 | 10.4 |
| | 45 | | | | | | | | | | | | | | | |
| | 50 | | | | | | | | | | | | | | | |

the discovery of the tailings contaminated deep waters, two additional stations were established to confirm these findings. Station 1A and 2A were located between stations 1 and 2 and 2 and 3 respectively and the turbidity results from these samples were recorded in Table III along with results from the Benson River inflow (B.R.) and Raging River (R.R.) inflow into Benson Lake adjacent to the tailings discharge float (F). Due to a mill breakdown no tailings were discharged into the lake during the time of the September survey.

Table III Turbidity results from Station 1A, 2A, B.R. and R.R. collected September 9, 1971 at Benson Lake.

| Station | Depth (m) | Visual Turbidity | Total Solids (ppm) | Suspended Solids (ppm) | Jackson Turb. Units | Temp. °C |
|---|---|---|---|---|---|---|
| 1A | 44 | 0 | 66 | 6.0 | 5 | 9.8 |
| | 45 | 0 | 53 | 6.0 | 5 | 9.8 |
| | 46 | 1 | 84 | 7.7 | 8 | 9.5 |
| | 47 | 1 | 58 | 9.0 | 9 | 9.4 |
| | 48 | 2 | 80 | 6.6 | 13 | 9.2 |
| | 49 | 2 | 68 | 12.9 | 12 | 8.8 |
| | 50 | 2 | - | - | - | 9.0 |
| 2A | 48 | 0 | 67 | 4.1 | 4 | 10.5 |
| | 49 | 2 | 74 | 10.5 | 15 | 9.5 |
| | 49 | 2 | 65 | 22.1 | 11 | 9.0 |
| B.R. | 0 | 0 | 48 | 1.6 | 0.3 | 8.8 |
| R.R. | 0 | 0 | 47 | 5.6 | 3 | 10.5 |
| F. | 0 | 0 | 75 | 1.2 | 4 | 10.8 |
| | 10 | 0 | 54 | 6.2 | 5 | 10.8 |
| | 20 | 0 | 50 | 10.2 | 4 | 10.6 |
| | 30 | 0 | 49 | 4.6 | 4 | 10.6 |
| | 35 | 0 | 67 | 3.6 | 4 | 10.6 |
| | 37 | 0 | 46 | 7.5 | 4 | 10.6 |



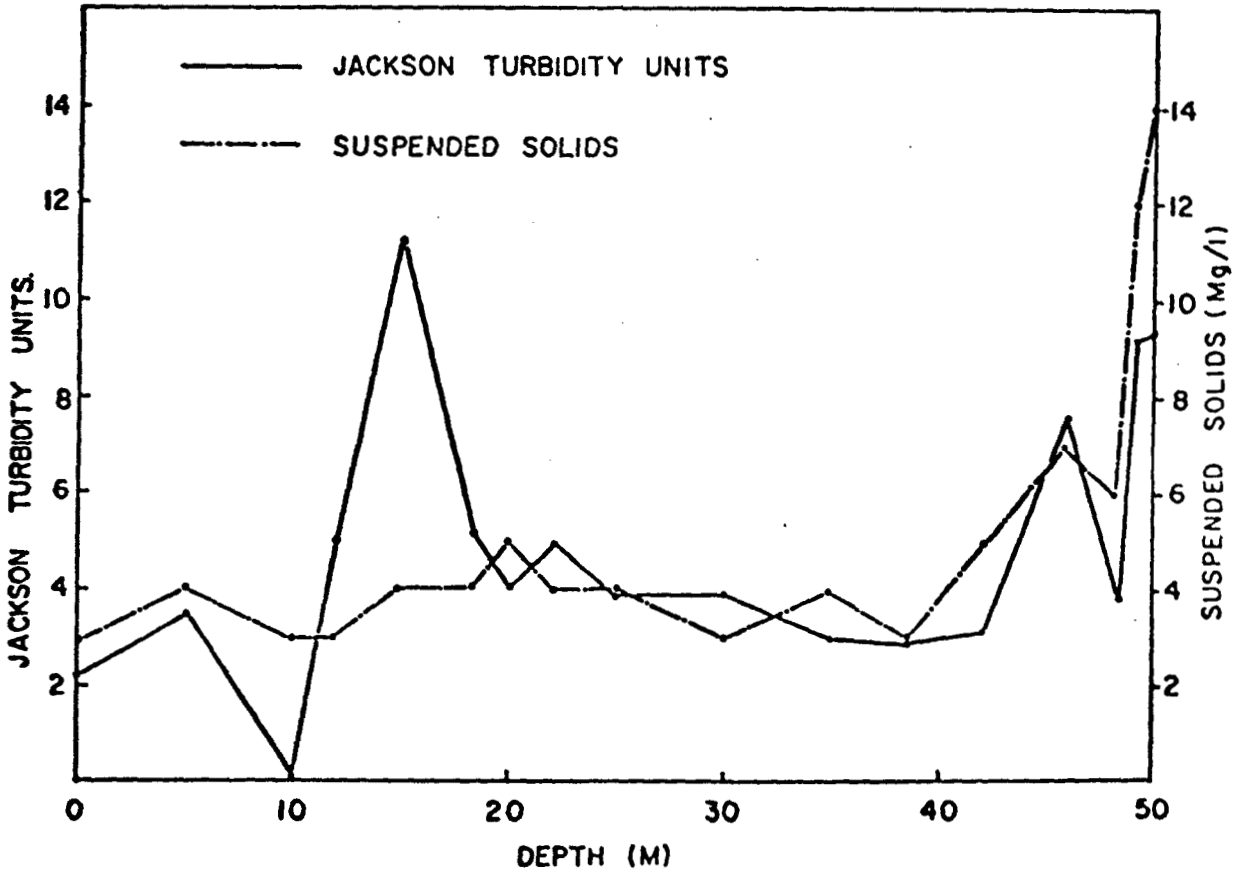




FIGURE 7 TURBIDITY MEASUREMENTS AT STATION 2
BENSON LAKE, SEPTEMBER 9, 1971

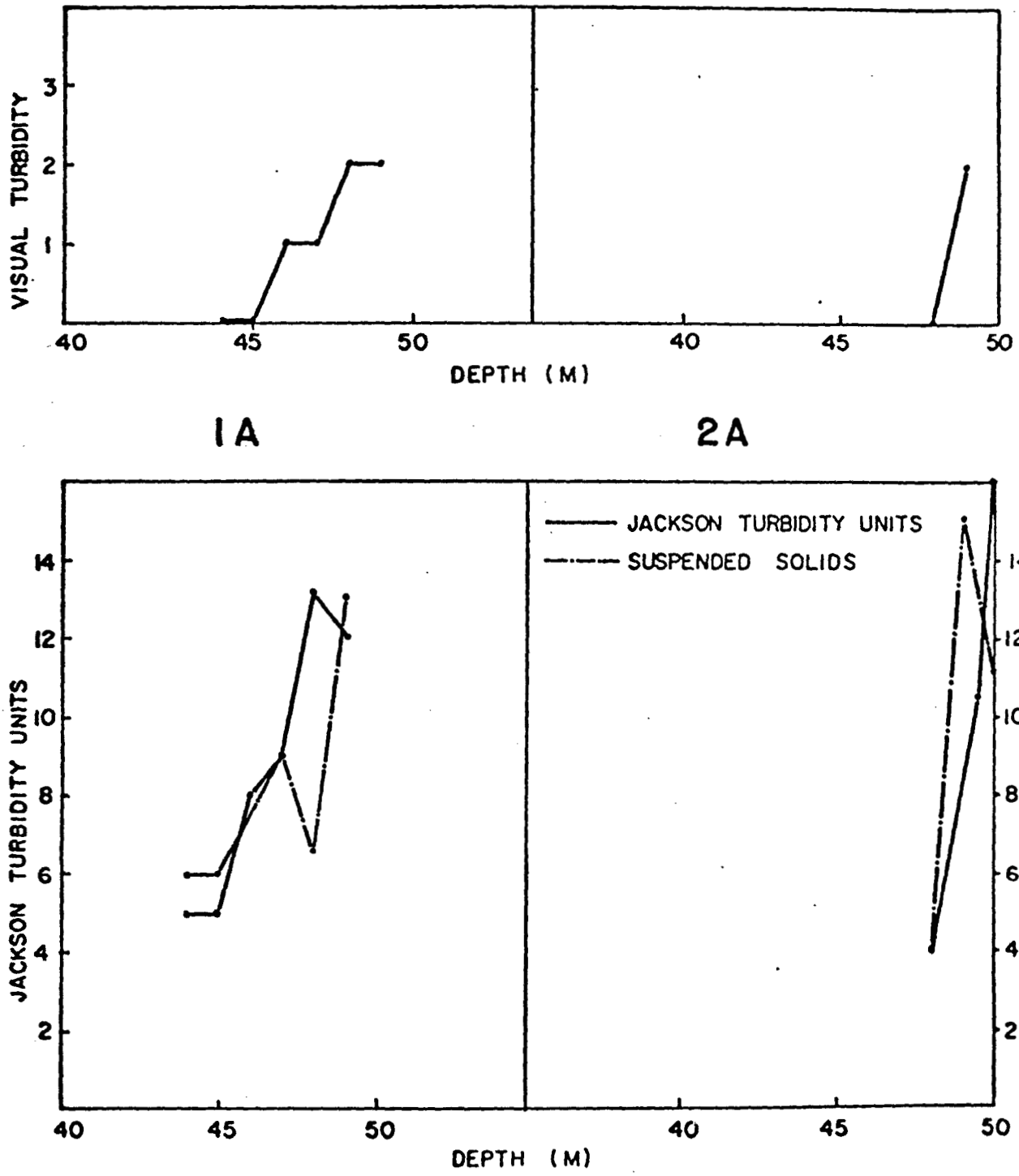



FIGURE 8, TURBIDITY MEASUREMENTS AT STATIONS 1A AND 2A, BENSON LAKE, SEPTEMBER 9, 1971.

A graphical presentation of the turbidity measurements from Station 1A and 2A are presented in Figures 7 and 8. Again the close relationship between the visual turbidity ratings and the suspended solids and Jackson turbidity units can be noted. Although the lake appeared quite murky in September it was surmised that the brownish surface turbidity was due to surface runoff while the grey waters located below the 48 meter depths represented the non-settled tailings fractions. On September 9, the Benson River water was quite clear as evidenced by the low turbidity values recorded in Table III. However, following heavy rains that night, the Benson River became murky and undoubtedly was responsible for much of the turbidity of the surface waters. It is quite feasable that much of the winter turbidity in Benson Lake is a naturally occuring phenomenon and directly related to the turbidity of inflowing streams. Additional surveys are recommended to assess the effects of the improved tailings disposal procedure in relation to the 1971 position of the tailings contaminated waters as depicted in Figures 7 and 8.

## III. ACKNOWLEDGEMENTS

Thanks are due to Cominco who provided lodging and field and laboratory assistance throughout the survey. The assistance of Messrs. W. Schouwenburg and J. Watkins of the Fisheries Service who critically reviewed the program and the report is also acknowledged.