Maps: ML0 to ML37; S1-1 and S1-2; S2-1 and S2-2; S3-1 and S3-2; S4-1 and S4-2; S5-1 and S5-2 have no PDF formats and are not in PDF report database. They are paper copy only and are in Laurentian Library in Sudbury.

APPENDIX 2

EM SURVEYS MAPS - MUD LAKE AREA
and
INTERPRETATION OF ELECTROMAGNETIC SURVEYS AND FOLLOW-UP ANOMALY TESTING (PIEZOMETER INSTALLATION) - SEPTEMBER 30, 1995

FINAL REPORT 1995

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APPENDIX 2: DETAILED INTERPRETATION OF THE ELECTROMAGNETIC SURVEYS AND FOLLOW UP ANOMALY TESTING THROUGH PIEZOMETER INSTALLATIONS MUD LAKE SEEPAGE PATH

1.0 Introduction

The geophysical surveys carried out in the South Bay Mine area since 1992 have established that ground based electromagnetic surveys are effective for both detecting and mapping the migration of plumes of Acid Mine Drainage (AMD) in the groundwater, and for evaluating the effectiveness of the remediation measures that were implemented.

During 1995, the electromagnetic surveying was focused in four areas:

(1) Mud Lake
(2) West of the Tailings
(3) South of the Tailings/ Townsite
(4) Mine Site

Numerous geophysical anomalies were identified, and anomalies with unexplained sources of conductivity were tested during an extensive programme of piezometer installation.

This section presents the results of the geophysical surveys in the Mud Lake area and west of the tailings area, along with water quality data obtained from the piezometers that were installed to test geophysical anomalies. These areas are all “exploratory” in nature where the surveys are being conducted for the first time.
The survey was carried out step by step, adding lines as was indicated due to anomalies. Those were then used to place piezometers, and confirm or refute the presence of seepage pathways and delineate their extent.

2.0 Methods and materials

Linecutting and Grids: Prior to geophysical surveying, grids were established in all 4 areas. Linecutting and picketing were conducted in the forested areas around Mud Lake, while much of the open areas around the Mine Site and lake portions required only chaining and picketing. All pickets were removed from the lake portions of the grids upon completion of the surveys.

Generally, lines were established at either 50 m or 100 m spacing as required with the exception of the Mine Site grid where all the lines are 50 m apart. Stations were established at 10 m intervals along all the lines. A small amount of cross griding was required in the area West of the Tailings to test for anomalies with varying orientations.

Instrument/ Methodology: The surveying was conducted with a Geonics EM 34-3 XL unit at 10 m, 20 m and 40 m transmitter - receiver coil separations. Readings were taken at 10 m intervals at 10 m and 20 m coil separation, and at 20 m intervals at 40 coil separation. Maximum depth penetration is in the range of 50% to 75% of the coil separation, or about 7 m, 15 m, 25 m. In addition, the coil separations are linked with frequencies of 6.4 kHz, 1.6 kHz and 0.4 kHz respectively. This configuration is targeted to locate plumes of contaminated groundwater Additional instrument specifications are available from the manufacturer, Geonics Limited, Mississauga, Ontario.

Data Presentation: Readings were recorded, tied into any previous surveys, levelled and plotted. Geomar Geophysics Limited presented the results in a series of colour contoured maps at scales of 15000 for the first three areas. The Mine Site grid results were plotted at a scale of 1:2500 to conform to scales used in previous surveys over this grid, and to facilitate a direct comparison of results.

Separate maps were created for readings taken at each of the three coil separations. Two additional maps were produced with reduced overburden responses, one for readings taken at 20 m and 40 m separation, and a second for combined 10 m and 20 m coil separations. All maps are presented in Appendix 2 and are numbered with the prefix ML in sequence.

3.0 Survey results for the Mud Lake and West of tailings

Mud Lake Grid: This grid covers an area roughly 1 kilometre square immediately north of the Tailings, including all of Mud Lake, the area north of Decant Pond Outflow, and a portion of the Mud Lake Ouftlow. There are two main anomalous features, namely the MUD LAKE ANOMALY and the EAST OF MUD LAKE GROUP OF ANOMALIES (Maps ML28, 30, 32, 34, 36).

The MUD LAKE ANOMALY is a very broad and strong anomaly which trends NNE through the long axis of Mud Lake. Peak conductivities at 10 m coil separation are slightly over 40 mS/m (ML28). The anomaly is strong and well defined at all three coil separations (ML28, 30, 32).

There are three possible sources of conductivity which may contribute in varying degrees to the overall Mud Lake Anomaly. The conductivity of Mud Lake water falls in the range of 600 to 800 uS/cm while the sediment conductivities vary from 1000 uS/cm to almost 4000 uS/cm. (Note: All water and sediment conductivity measurements have been standardized to 25” C) The peak sediment conductivities occur at the north end of the lake in the area of discharge of AMD from the groundwater. In addition, the lake is underlain by clay of unknown thickness and conductivity, which may in part contribute to the overall conductivity of this area.

Two well defined anomalies which originate in the NW corner of the Tailings merge into the Mud lake Anomaly (ML28, 30, 32). The CHARA PONDS ANOMALY trends north from the Tailings and links up with the Mud Lake Anomaly at the south end of Mud Lake. The GRAVEL PIT ANOMALY originates along the western margin of the NW corner of the Tailings and connects with the Mud Lake Anomaly at approximately 50mE on L400mN along the western margin of Mud Lake. Piezometers installed along both these anomalies indicate the conductivity source as plumes of contaminated groundwater (AMD). The Chara Ponds and Gravel Pit Anomalies are discussed in section 4.2

Although AMD has been observed to be discharging into Mud Lake at the north shore, readings taken at 10 m and 20 m coil separations indicate that the Mud Lake Anomaly currently extends for about 100 m beyond the north shore at depths of probably less than 12-15 m. One interpretation of the geophysical results suggest an upward migration of contaminated groundwater from a deeper to a shallower aquifer somewhere between L600mN and L700mN, and continued lateral flow at shallower depths for another 100 m to the north. If contaminated groundwater is indeed at least in part the source of the anomalous readings, this would indicate that not all of the plume of AMD is discharging into Mud Lake. Currently there are no piezometers located north of Mud Lake to test for this possibility.

The only two piezometers which are underlain by the Mud Lake Anomaly are M-62 and M-63. Both were installed directly into the “Black Holes”, ie, into the discharge points of AMD into Mud Lake.

The EAST OF MUD LAKE GROUP OF ANOMALIES are much weaker than the Mud Lake Anomaly. They extend northward from the Decant Pond Ouflow area to the shores of NE lake, a distance of nearly 900 m. This group of anomalies occurs as a series of interconnected lobes of slightly varying intensities. Peak readings are in the range of 6 mS/m to 8 mS/m, or well below the 25 to 40 mS/m range of the Mud Lake Anomaly (Maps ML28, 30, 32, 34, 36).

This group of anomalies was tested with 6 piezometers. M-68, M-70A,-70B, -70C and M-71 were installed in 1995. M-61 was drilled in 1994 at a time when the geophysical coverage was limited to the immediate area of Decant Pond Ouflow. In all cases the source of the anomalous responses was conductive clay. Conductivities of the groundwater from these holes were in the range of 152 to 329 uS/cm. The highest zinc concentration was 0.29 mg/L in M-68.

West of the Tailings: The investigation in this area focused on the 2 anomalies originating from the NW corner of the Tailings (Map ML29, 31, 33, 35, 37).

The CHARA POND ANOMALY extends from about 50mE on L50mN and merges into the Mud Lake Anomaly at approximately 150mE on L230mN. It has been tested by piezometers M-66A and M-74. A third piezometer on the anomaly, M-58, did not reach bedrock. Conductivities in M-66A and M-74 were recorded as high as 1465 uS/cm and 1604 uS/cm respectively in the groundwater. Zinc concentrations were 60 mg/L in M-66A which is located nearest the Tailings, and 1.27 mg/L in M-74.

The GRAVEL PIT ANOMALY originates out of the Tailings at approximately 30 m west of the base line in the vicinity of L100mS - L150mS. It extends northward for about 600 m and merges into the Mud Lake Anomaly at approximately 50mE on L400mN. This anomaly was previously identified in 1994 in piezometers M-39A and M-60A as a major plume of contaminated groundwater originating from the Tailings. Prior to implementing any remediation technology, it was deemed important to investigate the area of the plume in greater detail with a specificemphasis on bedrock topography, soil stratigraphy, the chemical characteristics and flow rates/volumes of the plume. Since 16 additional piezometers along 5 sections were installed along the general trend in 1995 (Maps ML29, 31, 33, 35, 37).

A limited amount of detailed geophysical surveying was conducted in the area where the plume emerges from the Tailings. Survey lines were established along two orientations to test for secondary plumes which may be migrating in directions different to the main plume. Of particular concern was any migration initially to the south of L150mS, and then to the west, directly into Confederation Lake (Maps ML29, 31, 33, 35 37).

Unfortunately the area immediately west of the Tailings contains numerous buried mining debris including ore cars, pipes, light standards which generated very strong responses and would have interfered with any responses originating from contaminated groundwater. As a result, two north-south trending lines were established at 130mW and 200mW to test for plumes migrating westward. The higher responses on L130mW probably reflect buried mine debris. The responses 70m further west on L200mW are generally low except for a slight rise in reading confined to an area underlain by a black spruce swamp. The nature of these responses suggests that they are originating from a clay layer under the swamp.

A ridge of outcropping bedrock trends parallel to the shore of Confederation Lake and would likely be a barrier for groundwater flow in this direction. Similarly, a large hill of bedrock is situated immediately southwest of the Tailings which would also impede or restrict the flow in this direction.

List of EM maps for Mud Lake

Map #	Area	Date	Scale 1: [m]	Instrument	Mode	Coil Separation [m]	Conductivity Scale [mS/m]
ML0	Diversion Ditch	March, 1992	2400	EM34	H	20	0 - 20
ML1	Diversion Ditch	March, 1992	2400	EM31	V	-	0 - 20
ML2	Diversion Ditch	March, 1992	2400	EM34	H	10	0 - 20
ML3	Tailings Dams 1&2	March, 1992	2400	EM31	V	-	5 - 75
ML4	Diversion Ditch	September, 1993	2400	EM31	H	-	0 - 20
ML5	Diversion Ditch	September, 1993	2400	EM31	V	-	0 - 20
ML6	Tailings Dams 1&2	September, 1993	2400	EM31	H	-	5 - 75
ML7	Tailings Dams 1&2	September, 1993	2400	EM31	V	-	5 - 75
ML8	Mud Lake	June, 1994	2000	EM34	H	10	-1 - 10.5
ML9	Mud Lake	June, 1994	2000	EM34	H	20	-1 - 10.5
ML10	Mud Lake	June, 1994	2000	EM34	H	40	-1 - 10.5
ML11	Mud Lake	June, 1994	2000	EM34	H	20&10	-1 - 10.5
ML12	Mud Lake	June, 1994	2000	EM34	H	20&10	-1 - 10.5
ML13	Mud Lake	June, 1994	5000	EM34	H	10	-1 - 10.5
ML14	Mud Lake	June, 1994	5000	EM34	H	20	-1 - 10.5
ML15	Mud Lake	June, 1994	5000	EM34	H	40	-1 - 10.5
ML16	Mud Lake	June, 1994	5000	EM34	H	20&10	-1 - 10.5
ML17	Mud Lake	June, 1994	5000	EM34	H	40&20	-1 - 10.5
ML18	Mud Lake	February, 1995	5000	EM34	H	10	0 - 24
ML19	Mud Lake	February, 1995	5000	EM34	H	20	0 - 24
ML20	Mud Lake	February, 1995	5000	EM34	H	40	0 - 24
ML21	Mud Lake	February, 1995	5000	EM34	H	20&10	0 - 24
ML22	Mud Lake	February, 1995	5000	EM34	H	40&20	0 - 24
ML23	Mud Lake, Northern	March,1995	5000	EM34	H	10	-1 - 11
ML24	Mud Lake, Southern	March, 1995	5000	EM34	H	10	-1 - 11
ML25	Mud Lake, Northern	March, 1995	5000	EM34	H	20	-1 - 11
ML26	Mud Lake, Southern	March, 1995	5000	EM34	H	20	-1 - 11
ML27	Mud Lake, Northern	March, 1995	5000	EM34	H	40	-1 - 11
ML28	Mud Lake, Northern	March, 1995	5000	EM34	H	10	-1 - 11

ML29	Mud Lake, Southern	March, 1995	5000	EM34	H	10	-1 - 11
ML30	Mud Lake, Northern	March, 1995	5000	EM34	H	20	-1 - 11
ML31	Mud Lake, Southern	March, 1995	5000	EM34	H	20	-1 - 11
ML32	Mud Lake, Northern	March, 1995	5000	EM34	H	40	-1 - 11
ML33	Mud Lake, Southern	March, 1995	5000	EM34	H	40	-1 - 11
ML34	Mud Lake, Northern	March, 1995	5000	EM34	H	20&10	-1 - 11
ML35	Mud Lake, Southern	March, 1995	5000	EM34	H	20&10	-1 - 11
ML36	Mud Lake, Northern	March, 1995	5000	EM34	H	40&20	-1 - 11
ML37	Mud Lake, Southern	March, 1995	5000	EM34	H	40&20	-1 - 11
S-1	Mud Lake + Mine Slte	March, 1995	5000	EM34	H	10	-1 - 11
S-2	Mud Lake + Mine Site	March, 1995	5000	EM34	H	20	-1 - 11
S-3	Mud Lake + Mine Site	March, 1995	5000	EM34	H	40	-1 - 11
S-4	Mud Lake + Mine Site	March, 1995	5000	EM34	H	20&10	-1 - 11
S-5	MudLake + Mine Site	March, 1995	5000	EM34	H	40&20	-1 - 11