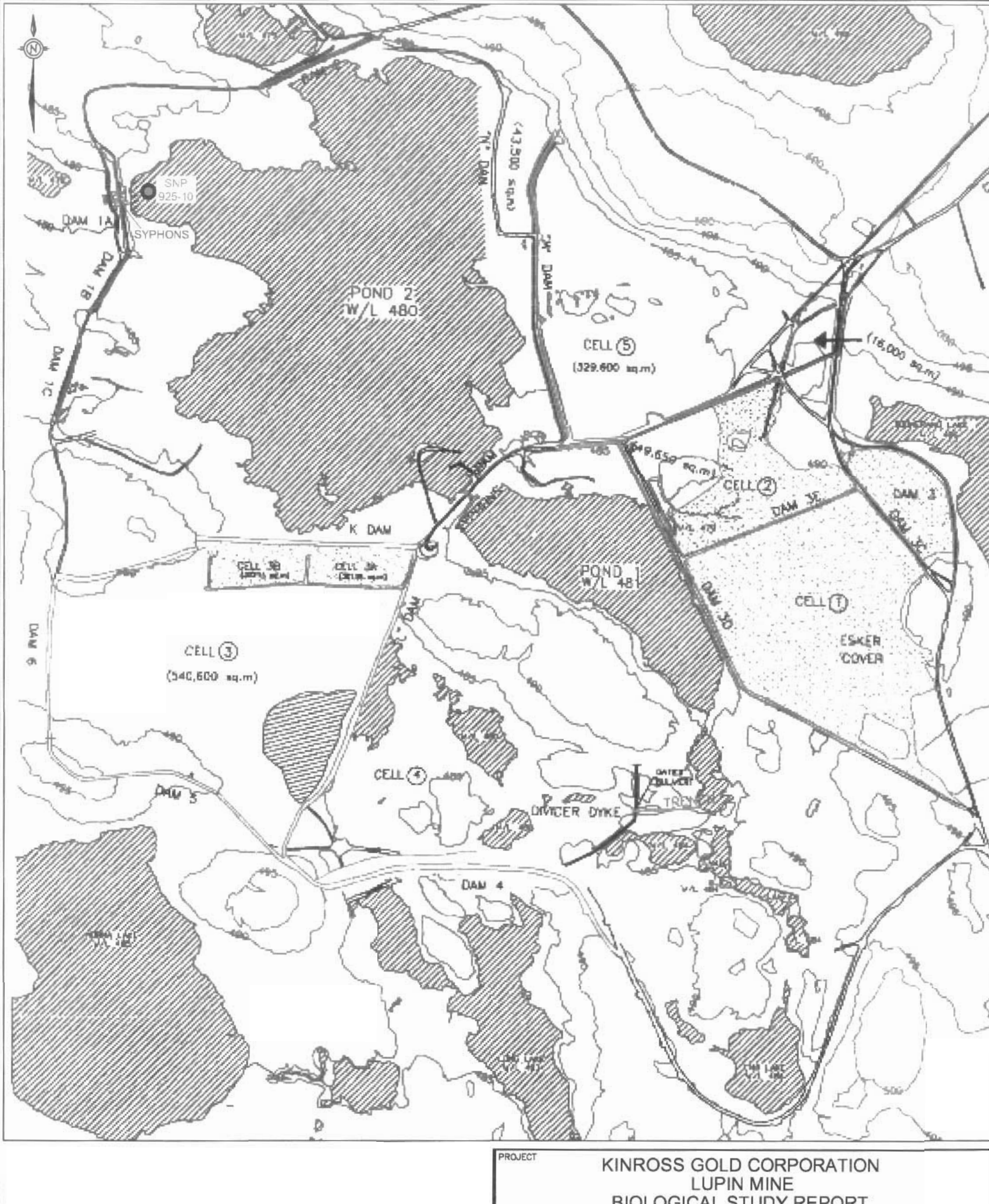


PROJECT

KINROSS GOLD CORPORATION
LUPIN MINE
BIOLOGICAL STUDY REPORT

TITLE

LUPIN MINE
TAILINGS CONTAINMENT AREA

300 0 300
SCALE METRES

Golder Associates
Edmonton, Alberta

PROJECT 04-1373-046.1000			FILE No. Tailings Containment	
DESIGN	MD	01/12/04	SCALE 1:15000	REV. 0
CADD	PSR	01/12/04		
CHECK	MD	02/12/04	**FIGURE: 3-1**	
REVIEW				

R:\CAD\2004\1370-Edmonton\1373-ES\04-1373-046\1000\ Drawing file: FIGURE 3-1LUPIN MINE TAILINGS CONTAINMENT AREA.dwg Dec 02, 2004 - 6:05pm

- The following year, water is released from Cell 4, through a gated culvert, into Pond #1, where it is held for a further one-year period, before being siphoned into Pond #2. If necessary, the water can be treated with ferric-sulphate during the siphoning process to precipitate arsenic in Pond #2.

    - Historically, water was retained only for a 2-year period and arsenic levels were still high in Pond #1. An arsenic treatment plant was built between Ponds #1 and #2, so that the water could be injected with ferric sulphate solution as it was being siphoned between the two ponds. Since 2000, water has been retained for a 3 year period (1 year in Cell 4, 1 year in Pond #1, and 1 year in Pond #2). The extra year of water retention before going into Pond #2 has resulted in naturally lowering the arsenic levels, thus negating the use the plant. Periodically, treatments of ferric sulphate (two tonne batches) are placed into Pond #1 to control arsenic concentrations.

- Depending on the water level and water quality in Pond #2, water can be released to the environment after 15 July of any year (as per Nunavut Water Board water licence). Water quality is monitored on a daily basis during discharge to ensure that discharge criteria are not exceeded.

3.5.4 Sewage Disposal

Sewage and domestic grey water is pumped to the Sewage Lake Disposal System for natural degradation. The system features two small unnamed lakes located to the south of the mine and empty via an unnamed creek into Contwoyto Lake (EBM 1994).

3.6 Final Discharge Water Quality

Kinross identified one final discharge point to Environment Canada in 2003. Plans, specifications, operation, and maintenance information were provided in accordance with Section 9 of the MMER (2002). The final discharge point is regularly monitored under licensing agreement with the Nunavut Water Board (Surveillance Network Point [SNP] 925-10), along with downstream receiving environment sampling locations. Effluent is siphoned from TCA Pond 2 over Dam 1a into Dam 1a Lake, a headwater tributary of Seep Creek. A brief description of the final discharge water quantity, quality, and plume delineation is provided below.

3.6.1 Water Discharge

Discharge at SNP 925-10 is monitored regularly with annual quality reports submitted to the Nunavut Water Board. Total annual and mean monthly discharge volumes from 1994 to 2004 are provided in Table 3-1.

Table 3-1 Total Annual Discharge Volumes from Lupin Mine TCA (SNP 925-10), 1994 to 2004

Year	Annual Total (m^3)	Discharge Period[a]
1994	863 868	15 - 29 Jul
1995	938 715	15 Jul – 2 Aug
1996	1 139 233	15 Jul – 7 Aug
1997	2 892 289	15 Jul – 1 Sep
1998	0	n.a.
1999	0	n.a.
2000	2 701 360	15 Jul – 2 Sep
2001	0	n.a.
2002	3 102 895	15 Jul – 7 Sep
2003	0	n.a.
2004	0	n.a.

[a] n.a. = not applicable

Total annual discharge ranged from 0 m^3 to 3 102 895 m^3 in 2003. The variable discharge amounts and schedules are a result of intermittent mining operations, large TCA relative to tails production, and the use of tailings in paste backfilling.

3.6.2 Water Quality

Water quality at SNP 925-10 is monitored for a variety of constituents at varying frequencies (Table 3-2). Constituents listed in Schedule 4 of the MMER guidance document (MMER 2002), with the exception of radium 226, are routinely measured at SNP 925-10. The maximum concentrations discharged from SNP 925-10 during 2000 and 2002 (Table 3-3) are below authorized limits (MMER 2002).

Table 3-2 Monitoring and Sampling Frequencies of TCA Effluent at SNP 925-10

Constituents	Frequency
pH, Conductivity, Temperature, Total Suspended Solids, Arsenic, Cyanide, Copper, Zinc, Volume	Daily (grab)
Cadmium, Lead, Nickel, Alkalinity, Ammonia, Hardness	Weekly (grab)
24 Metals (Total), ICPMS (inductive coupled plasma mass spectrometer)	First discharge day and monthly thereafter (grab)
Static Pass/Fail Bioassay for Both Rainbow Trout and *Daphnia* Species (per Environment Canada's Environmental Protection Series Biological Test Methods)	Twice per year (grab)

Table 3-3 Maximum Concentrations of MMER Deleterious Substances at the Lupin Mine (SNP 925-10)

Constituent	Units	2000	2002	Maximum Authorized Concentration in a Grab Sample[a]
Arsenic	µg/L	13.3	80.0	1000
Copper	mg/L	0.011	0.034	0.60
Cyanide	mg/L	0.032	0.144	2.00
Lead	mg/L	<0.002	0.0006	0.40
Nickel	mg/L	0.121	0.0893	1.00
Zinc	mg/L	0.303	0.247	1.00
TSS[b]	mg/L	1.5	5.0	30.00

[a] MMER (2002) ; [b] TSS = Total Suspended Solids

Several metals and other constituents were measured as part of the routine water quality monitoring program at SNP 925-10 (Table 3-4); these constituents have been sampled a total of six times during the last two years that effluent has been released from the TCA. Conventional constituents such as pH, conductivity and total suspended solids (TSS) have been maintained at consistent concentrations. Conductivity, for example, ranged from 855 to 906 μS/cm. Dissolved calcium generally was around 80 mg/L and ammonium was less than 5.0 mg/L.

3.6.2.1 Toxicity

During effluent discharge there have been no non-compliance events. Daily discharges are generally one or two orders of magnitude lower than the maximum average concentration permit standards. There are no historic sublethal toxicity data available. Acute toxicity data available from the mine indicate no toxicity to rainbow trout, *Daphnia* or Microtox (AQUAMIN 1996b; EVS 1996; EBM 2001b and 2003).

3.6.3 Delineation of Effluent Plume

The MMER requires a determination of the extent of effluent contact with the surrounding water environment to a concentration level of 1% of discharged effluent. Two processes are involved as the effluent reaches this concentration level: dilution and dispersion. Thus, a two stage approach was used to determine the dispersal of treated tailings effluent from the Lupin Mine. First the potential dilution, by contributory stream flows, was calculated for the effluent stream at the narrows leading to Outer Sun Bay. Second the dispersion of the effluent plume from the narrows into Outer Sun Bay of Contwoyto Lake was determined using the U.S. EPA mixing model Cornell Mixing Model (CORMIX™). Both methods are detailed in the sections that follow.

3.6.3.1 Dilution Modelling

Treated tailings effluent from TCA Pond No. 2 is discharged into Seep Creek via the siphons at Dam 1-A. The effluent travels along Seep Creek through two small ponds then into Unnamed Lake. At Unnamed Lake the effluent mixes with drainage coming from Concession Lake via Concession Creek. From Unnamed Lake, the effluent flows through a set of rapids into Inner Sun Bay and then through the Narrows into Outer Sun Bay.

Discharge data for streams contributing to the effluent stream are sparse. From data collected in 1983 and 1984, the average monthly flow in Seep Creek varies between 0.21 m^3/s in July to 0.08 m^3/s in September, the months in which the effluent is discharged. Estimates made in September 1985 give discharges of 2-3 m^3/s for Seep Creek and 3-4 m^3/s for Concession Creek (Mudroch and Sutherland 1988).

Table 3-4 Water Quality of Lupin Mine TCA Effluent at SNP 925-10

Constituent	Units	2000				2002	
		15 Jul	16 Jul	21 Aug	2 Sep	15 Jul	12 Aug
Conventional							
Field Temperature	°C	--	14.4	12.3	6.2	14.7	15.9
pH	units	6.95	7.00	7.05	6.53	7.01	6.95
Conductivity	µS/cm	869	887	n.a.	906	858	855
Total Suspended Solids	mg/L	1	1	0.5	1.2	<1	<1
Total Alkalinity (as $CaCO_3$)	mg/L	10	11	7	<5	20	10
Total Hardness (as $CaCO_3$)	mg/L	227	227	244	239	245	218
Inorganic Non-metallic							
Ammonium-N	mg/L	4.57	4.00	3.91	3.07	1.08	1.36
Cyanide	mg/L	0.016	0.016	0.014	0.016	0.004	0.078
Major Ions							
Calcium (dissolved)	mg/L	78.7	78.9	n.a.	n.a.	84.7	75.1
Magnesium (dissolved)	mg/L	7.49	7.37	n.a.	n.a.	8.03	7.41
Hydroxide	mg/L	<5	<5	n.a.	n.a.	<5	<5
Carbonate	mg/L	<6	<6	n.a.	n.a.	<6	12
Bicarbonate	mg/L	13	14	n.a.	n.a.	24	<5
Metals (Total)							
Aluminum	mg/L	0.063	0.056	0.090	0.096	0.055	0.080
Antimony	mg/L	<0.006	<0.006	<0.006	<0.006	<0.002	0.0052
Arsenic	mg/L	<0.01	<0.01	<0.01	0.01	0.0149	0.0108
Barium	mg/L	0.0142	0.0150	0.0158	0.0162	0.016	0.017
Beryllium	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0001	<0.0001
Bismuth	mg/L	<0.008	<0.008	<0.008	<0.006	<0.0005	<0.0005
Boron	mg/L	0.126	0.134	0.116	0.099	0.098	0.106
Cadmium	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	0.00019	0.00018
Calcium	mg/L	78.1	82.1	77.6	81.0	71.6	76.8
Chromium	mg/L	<0.0009	<0.0009	<0.0009	<0.0009	0.0007	<0.0005
Cobalt	mg/L	0.0626	0.0658	0.0654	0.0684	0.0559	0.0566
Copper	mg/L	0.003	0.005	0.007	0.011	0.012	0.006
Iron	mg/L	0.068	0.075	0.227	0.250	0.980	0.267
Lead	mg/L	<0.002	<0.002	<0.002	<0.002	0.0005	0.0004
Lithium	mg/L	0.018	0.019	0.018	0.019	0.018	0.019
Magnesium	mg/L	7.31	7.67	7.55	8.23	7.10	7.66
Manganese	mg/L	1.26	1.32	1.30	1.36	1.10	1.14
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	0.002	0.003
Nickel	mg/L	0.103	0.110	0.107	0.111	0.0807	0.0838
Phosphorus	mg/L	0.04	<0.03	<0.03	<0.03	n.a.	n.a.

Table 3-4 Water Quality of Lupin Mine TCA Effluent at SNP 925-10 (continued)

Constituent	Units	2000				2002	
		15 Jul	16 Jul	21 Aug	2 Sep	15 Jul	12 Aug
Potassium	mg/L	7.0	7.4	7.2	7.7	6.3	6.5
Selenium	mg/L	<0.004	<0.004	0.009	0.027	<0.0002	<0.0002
Silicon	mg/L	2.76	2.87	2.93	2.83	2.32	2.28
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001
Sodium	mg/L	94.4	99.0	94.4	102	77.0	81.0
Strontium	mg/L	0.247	0.265	0.253	0.258	0.271	0.293
Sulphur	mg/L	121	126	120	125	107	112
Thallium	mg/L	<0.004	<0.004	0.006	0.006	<0.00005	<0.00005
Tin	mg/L	0.005	<0.003	<0.003	<0.003	n.a.	n.a.
Titanium	mg/L	0.0009	<0.0004	0.0008	<0.0004	0.0045	0.0050
Uranium	mg/L	n.a.	n.a.	n.a.	n.a.	<0.0005	<0.0005
Vanadium	mg/L	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001
Zinc	mg/L	0.239	0.252	0.245	0.258	0.191	0.193
Zirconium	mg/L	n.a.	n.a.	n.a.	n.a.	<0.001	<0.001

To obtain better estimates of the flows in Seep and Concession creeks, a regional analysis using surrounding Water Survey of Canada (WSC) stream-gauging stations was carried out. Discharge records for 11 WSC gauges were examined and those stations that had reliable data and a matching period of record were selected for the analysis (Table 3-5).

Table 3-5 Water Survey of Canada Stream-Gauging Stations

Station Number	Station Name	Latitude	Longitude	Catchment Area (km^2)
06JB001	Hanbury River above Hoare Lake	63° 35' 28"	105° 09' 16"	5770
10QA001	Tree River near the mouth	67° 38' 06"	111° 54' 08"	5810
10RA002	Baille River near the mouth	65° 00' 38"	104° 29' 26"	14 500
10QB001	Hood River near the mouth	67° 21' 00"	108° 56' 06"	15 600
10QC001	Burnside River near the mouth	66° 44' 00"	108° 48' 08"	16 800
10PB001	Coppermine River at outlet of Point Lake	65° 24'	114° 00'	19 300
10RA001	Back River below Beechy Lake	65° 11' 14"	106° 05' 09"	19 600

The index-flood method was used on discharge data collected at these stations in 1994 to 2002, inclusive, and extrapolated to the Concession and Seep creek catchment areas. The results of the analysis are summarized in Table 3-6.

Table 3-6 Estimated Mean Daily Discharges Based on Regional Analysis

Stream	Catchment Area (km^2)	Mean Daily Discharge (m^3/s)		
		July	August	September
Seep Creek (50% probability of exceedance)	21.8	1.2	0.45	0.07
Seep Creek (90% probability of exceedance)		0.77	0.30	0.05
Concession Creek (50% probability of exceedance)	324	9.2	4.5	1.6
Concession Creek (90% probability of exceedance)		6.0	3.0	1.0

Based on the contributing stream flows, a mass balance approach was used to determine the dilution of the effluent by the time it reached the narrows. Only flow inputs from Seep and Concession creeks into the effluent stream were considered. Other smaller, contributing streams were ignored as their dilution effects on the effluent were considered to be insignificant. Effluent flow rates of 0.65 and 0.82 m^3/s, which were the average and maximum values from the measured discharges in 2000 and 2002, were used in the dilution calculations. The dilution calculations were based on the following equation:

$$C_N = (Q_E C_E + Q_S C_S + Q_C C_C)/(Q_E + Q_S + Q_C)$$

Where:

C_N is the identified constituent concentration at the narrows between Inner and Outer Sun bays;

Q_E is the flow rate (m^3/s) of the tailings effluent;

C_E is the constituent concentration in the effluent;

Q_S is the flow rate (m^3/s) in Seep Creek;

C_S is the constituent concentration in Seep Creek;

Q_C is the flow rate (m^3/s) in Concession Creek, and;

C_C is the constituent concentration in Concession Creek.

3.6.3.2 Dispersion Modelling

CORMIX was used to calculate mixing and dilution behaviour of the effluent in Outer Sun Bay and the West Arm of Contwoyto Lake. Effluent plume behaviour was examined during two time periods with this model a) July, when stream discharges are high, and b) September, when stream discharges are low and concentrations are high due to the lack of dilution.

The CORMIX model considers a suite of physically-based and semi-empirical turbulence formulas and selects the appropriate formula for the discharge and ambient conditions (Jirka et al. 1996). The model is one of the most extensively used models for predicting near-field mixing and dispersion of both conservative and non-conservative substances in surface waterbodies. The model has specific sub-systems for analyzing surface channel discharges (CORMIX3). The CORMIX model system assumes steady-state and generally uniform ambient conditions and effluent discharges. The model predicts the plume geometry and the dilution characteristics required for assessment of near-field mixing and the lateral spreading of flow in the far-field.

3.6.3.3 Model Inputs

Input to the CORMIX model includes primarily ambient conditions and discharge characteristics. The ambient conditions include water depth, wind speed, water current, water density and bottom roughness coefficient. The required discharge data include the geometry of the effluent at the point of discharge, location and orientation of the discharge channel, effluent flow rate, temperature and concentration.

Ambient Information

There are sparse data for bathymetry and no available water current data for Outer Sun Bay. Estimates for a range of values to be modelled were obtained for both of these parameters. Bathymetry was estimated based on spot measurements in Outer Sun Bay taken in 1985 (Mudroch and Sutherland 1988). Depths ranged from 8 to 9 m approximately 400 m from the mouth of the narrows. A bathymetric map of Inner Sun Bay (RCPL and RLL 1985b), which includes a portion of the narrows, shows maximum depths in the narrows to be from 4 to 6 m. Average ambient water depths used for modelling were 4.0, 6.0 and 8.5 m.

The water currents for this area of Contwoyto Lake were roughly estimated by assuming that the velocity of the water is approximately 3% of the wind speed. This would be consistent with previous experience and professional judgment (Dejiang Long, personal communication 2003, as cited in Golder 2003b). Wind rose data for Lupin Airport were examined to determine the wind regime present (Appendix B). July winds are predominately from the north and east. The 10^{th} percentile wind speed is 2.6 km/h, the average wind speed is 17 km/h and the 90^{th} percentile wind speed is 31 km/h. The wind is calm for 7% of the time. In September, the predominant wind directions are from the south and northwest, and the wind speeds are higher. The wind is calm only 4% of the time and the 10^{th} percentile wind speed is 4.3 km/h, the average wind speed is 19 km/h and the 90th percentile wind speed is 35 km/hr. The ambient current velocities obtained from these wind speeds are listed in Table 3-7.

The density of the ambient water was calculated by CORMIX based on fresh water at 10°C. The actual value of the temperature does not affect the modelling, since the modelled area is shallow and would be fully-mixed vertically. Therefore, the discharge and ambient water are represented with the same temperature to create a neutrally-buoyant system. The Manning's 'n' coefficient, a measure of the bottom roughness, does not greatly affect mixing simulations in the near-field. The value used for modelling, 0.025, is a typical value for shallow lakes. A summary of the ambient lake parameters can be found in Table 3-7.

Table 3-7 Summary of Ambient Lake Parameters Used for Analysis

Parameter	Values
Water depth (m)	4.0, 6.0, 8.5
Mean lake currents July (m/s)	0.022, 0.15, 0.26
Mean lake currents September (m/s)	0.04, 0.16, 0.29
Temperature (°C)	10
Manning's 'n' coefficient	0.025

Discharge Information

The discharges used in the CORMIX modelling follow those used in the dilution modelling. They ranged from 7.6 to 11.2 m^3/s for July and 1.9 to 2.5 m^3/s for September. These discharges correspond to the 90% and 50% probability of exceedance discharges during those months combined with the effluent flows.

The narrows or discharge channel into Outer Sun Bay is described as being 25 m wide (Mudroch and Sutherland 1988) and the bathymetric map of Inner Sun Bay indicates the channel depth is about 4 m. Orientation of the Narrows into Outer Sun Bay is towards the northwest based on topographic maps.

3.6.3.4 Results

Dilution modelling of the effluent stream at the narrows showed that dilution levels were the highest in July when contributing stream flows were the highest. Estimated concentrations at the narrows ranged from 5.9% with average effluent and average stream flows (50% probability of exceedance) to 7.3% with maximum effluent flow and average stream flow. Dilution levels in September were significantly lower, ranging from 28% with average effluent and stream flows to 33% with maximum effluent flow and average stream flow. Under low flow conditions (90% probability of exceedance), the concentrations ranged from 8.8 to 11% in July and 38 to 44% in September.

The concentration estimates, based on stream flows from a regional hydrologic analysis, were confirmed by specific conductivity and metals concentrations measurements taken in 2000 and 2002. Specific conductivity measurements revealed concentration levels of 7.4 and 30% at the narrows based on mean values in 2000 and 2002, respectively. Further discussion of dilution effects on constituent levels can be found in Section 3.7.2.

The effluent outflow from the narrows disperses into Outer Sun Bay on the West Arm of Contwoyto Lake. The bay is formed by two peninsulas and an island, which enclose an area approximately 1 km^2 in size. The currents in this bay would be dominated by the flow from the narrows during calm conditions; however, the wind data for Lupin Airport indicate that calm conditions exist less than 7% of the time during the period when tailings effluent is discharged. Consequently, wind induced currents are expected to play a significant role in mixing in the bay.

To cover a wide variety of conditions in Outer Sun Bay, several discharge and current scenarios were modelled to delineate the 1% dilution of the effluent plume. The modelling of the induced currents was performed along the predominant wind directions to determine the potential maximum extent of the effluent plume. Easterly to southerly winds will push the effluent plume out of Outer Sun Bay resulting in wind-induced mixing. Northerly to westerly winds will keep the plume within the bay resulting in an unsteady build-up of effluent constituents in the bay.

At average effluent discharge and ambient current velocity (average conditions), the effluent disperses to a concentration of 1% between 850 and 1200 m from the mouth of the narrows. At maximum effluent discharge and high ambient current velocity (worst case conditions), the discharge is dominated by advection and moves farther into Contwoyto Lake. Under this scenario, the effluent reaches 1% dilution between 1220 and 1630 m from the mouth of the narrows. The extent of the effluent plume under average and worst case conditions is delineated in Figure 3-2 and summarized in Table 3-8.

Water quality is monitored in Outer Sun Bay (SNP 925-25) approximately 500 m from the mouth of the narrows. Based on the mean water quality data from 2000 and 2002 (see Table 3-9 in Section 3.7), effluent concentrations of 1.3 to 3.4% are present in the bay. These values are consistent with the results of the dilution and dispersion analysis and seem to indicate that there is sufficient mixing in Outer Sun Bay.

Table 3-8 Effluent Dilutions in Contwoyto Lake

Scenario	Wind direction	Ambient velocity (m/s)	Effluent flow rate (m^3/s)	Distance to 1% effluent concentration (m)
Avg. effluent flow, avg. ambient velocity (July)	East	0.15	0.65	850
High effluent flow, high ambient velocity (July)	East	0.26	0.82	1220
Avg. effluent flow, avg. ambient velocity (September)	South	0.16	0.65	1200
High effluent flow, high ambient velocity (September)	South	0.29	0.82	1630

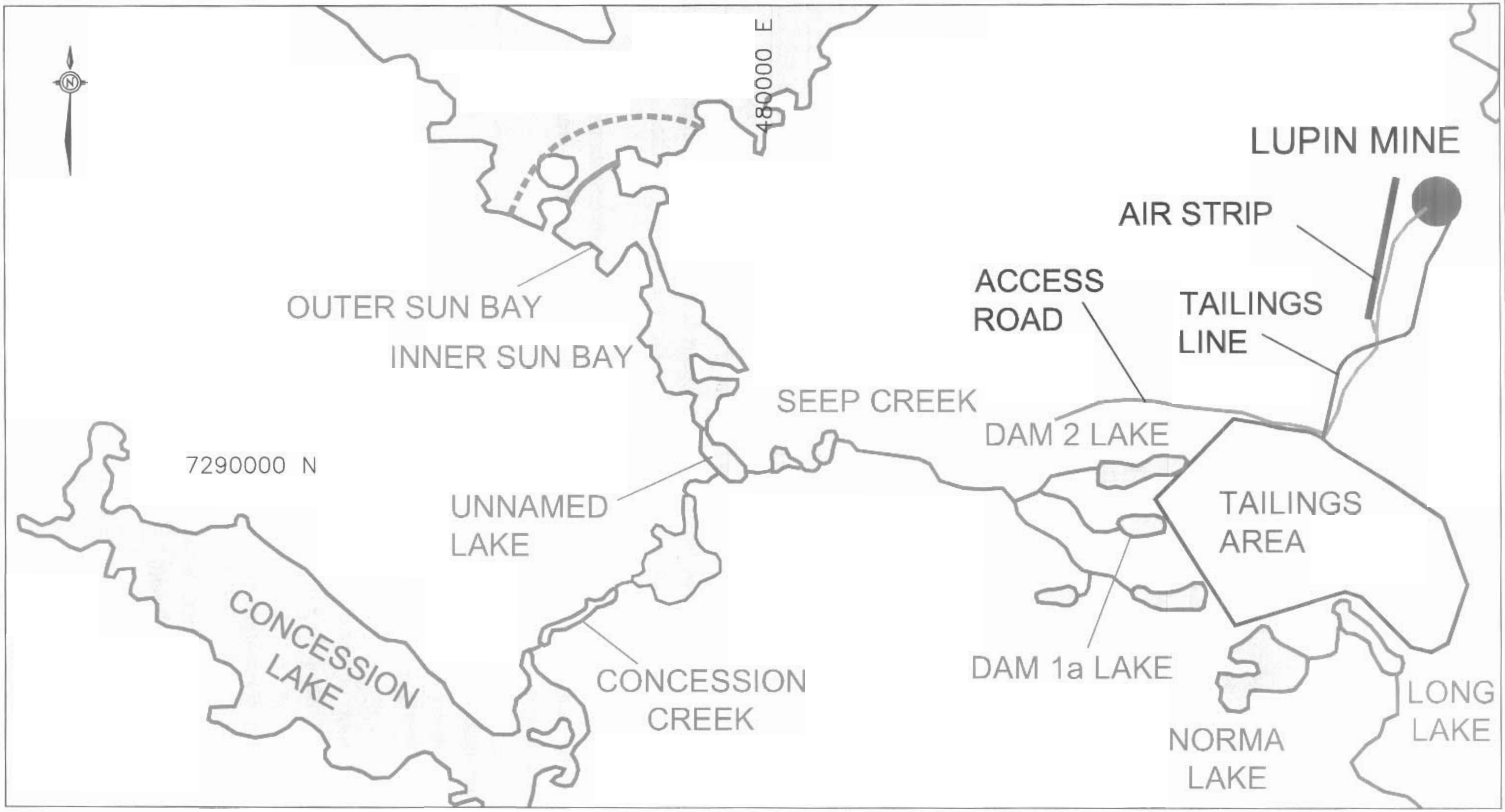
3.7 Exposure Area Characterization and Previous Assessments

It is recommended by EEM that the "exposure area is selected to ensure that the fish collected have been exposed to the effluent" (Environment Canada 2002). Based on modelling of the Lupin Mine effluent plume in Section 3.6.3, the downstream portion of Seep Creek, all of Inner Sun Bay, and a portion of Outer Sun Bay ending approximately 1600 m into the bay (i.e., from the lakeward side from the narrows separating Inner Sun Bay from Outer Sun Bay) can be considered as an appropriate exposure area. Seep Creek is the first waterbody to receive the effluent discharge. This area encompasses stream habitat that is frequented by fish exposed to the Lupin Mine treated effluent during periods of discharge.

3.7.1 General Characteristics

In the subArctic regions of northern Canada, waterbodies generally tend to be nutrient-poor. Low nutrient levels in the surrounding geological material and soils, low solar energy inputs due to approximately eight months per year of ice cover, and the resulting low water temperatures reduce the cycling of nutrients in the system; therefore, productivity within these systems is low relative to more temperate biomes.

R:\CAD\2004\1370-Edmonton\1373-ES\04-1373-046\1000\ Drawing file: Fig 3-2 Dispersion of Effluent Plume.dwg Dec 03, 2004 - 11:41am



LEGEND

- AVERAGE CONDITIONS (1% CONCENTRATION)
- WORST CASE CONDITIONS (1% CONCENTRATION)

SCALE 1.5 0 1.5 KILOMETRES

PROJECT
KINROSS GOLD CORPORATION
LUPIN MINE
BIOLOGICAL STUDY REPORT

TITLE
DISPERSION OF EFFLUENT PLUME

Golder Associates
Edmonton, Alberta

PROJECT 04-1373-046.1000			FILE No. Dispersion_Eff-Plume	
DESIGN	MD	29/11/04	SCALE 1:75000	REV. 1
CADD	PSR	02/12/04		
CHECK	MD	03/12/04	FIGURE: 3-2	
REVIEW				

3.7.2 Water Quality

Baseline Conditions

Numerous water quality studies have been conducted in the vicinity of the Lupin Mine. Historical information on the water quality for the tailings area, effluent discharge and areas downstream of the discharge can be found throughout the reports appended to Golder (2003a). Initial characterization of surface waters, prior to commencement of tailings disposal, was carried out by RCPL and RL&L (1985b); pertinent water quality data are provided in Appendix C. A synopsis of RCPL and RL&L's findings is as follows:

- In general, the surface waters in the vicinity of the Lupin Mine are typical of oligotrophic northern waterbodies in the Canadian Shield, with low pH, low alkalinity, and low total and dissolved chemical constituents.
- The waters of a small lake (colloquially referred to as Dam 2 Lake situated to the northwest of the tailings pond; Figures 2.1, 3.1 and 3.2), are unique in the study area, having significantly higher concentrations of total dissolved solids, calcium, magnesium, sulphate, copper, nickel, and zinc than any other sites sampled. These characteristics were observed prior to the commencement of tailings deposition; however, seepage from the tailings Pond #2 to Dam 2 Lake occurred in July and August 1984. The seepage area was dyked and repaired, and the water pumped back into Pond #2. This seepage event likely affected the water quality results.
- Concession Creek and Inner Sun Bay waters had the lowest concentrations of chemical constituents, and Dam 1a Lake and Seep Creek waters are intermediate to the former sites and Dam 2 Lake.
- The water quality data showed seasonal trends, although there were few statistically significant differences, in water quality conditions among seasons. The seasonal trends observed were:
    - maximum concentrations of chemical constituents occurred in lakes during winter and spring ice cover;
    - minimum concentrations in lakes occurred during fall;
    - minimum concentrations of chemical constituents in streams occurred during spring runoff; and,

maximum concentrations in streams occurred during summer/fall low flow periods.

Discharge Conditions

Water quality sampling occurred at several locations in the exposure area downstream of the final discharge point (Figure 3-3). Several monitoring constituents are listed for the downstream (west) end of Seep Creek before emptying into unnamed lake (SNP 925-20), mouth of Concession Creek (SNP 925-21), centre of Inner Sun Bay (SNP 925-22), Inner Sun Bay narrows (SNP 925-24), and Outer Sun Bay (SNP 925-25) (Table 3-9).

Monitoring data from these locations shows decreasing concentrations of several constituents with increasing distance from the mouth of Seep Creek. In 2000, mean conductivity at the mouth of Seep Creek was 887 μS/cm, 296 μS/cm at the centre of Inner Sun Bay, 78.4 μS/cm at the Sun Bay narrows, and 25.3 μS/cm in Outer Sun Bay. Nickel, zinc, hardness, and ammonium also exhibited similar data trends of decreasing concentrations with increasing distance (Table 3-9).

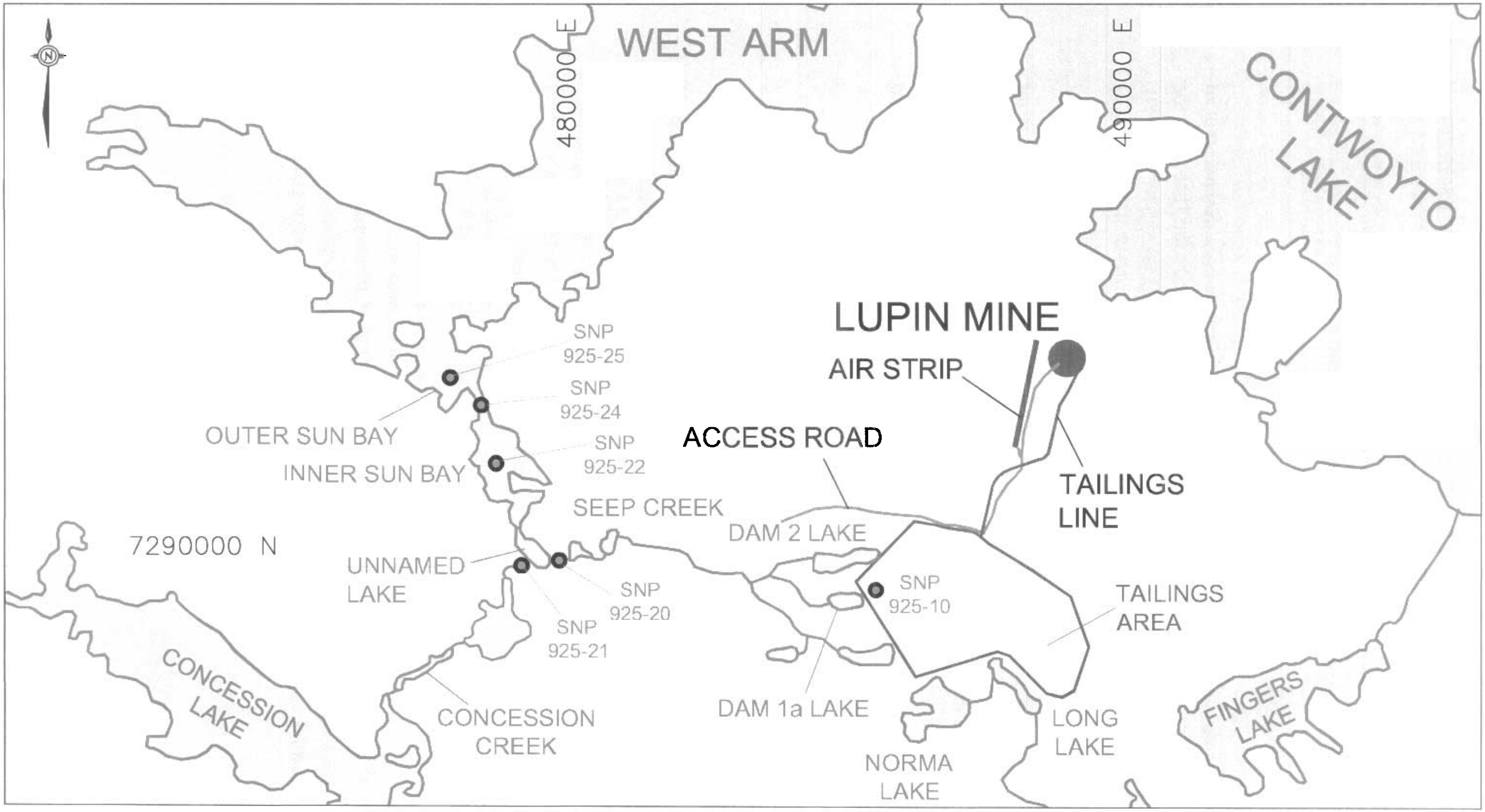
Assessments

Mudroch and Sutherland (1988)

Environment Canada carried out an initial study in 1985 to determine the effects of tailings effluent from the Lupin Gold Mine on the benthic macroinvertebrates, water and sediment quality of Inner and Outer Sun bays, Contwoyto Lake (Mudroch and Sutherland 1988). Sampling took place before (August) and during (September) effluent discharge from the Lupin Mine to determine whether increases in arsenic, metal, and cyanide concentrations had occurred in water and sediment samples collected from Inner and Outer Sun Bay.

Conductivity values measured during August were similar to values cited by previous studies (prior to 1988) of Contwoyto Lake. Conductivity values measured in September were one order of magnitude greater in Seep Creek than those measured in August. Conductivity values measured in September at all stations with the exception of Station 2 (the control site located along the western side of Outer Sun Bay) also were greater than the August values.

R:\CAD\2004\1370-Edmonton\1373-ES\04-1373-046\1000\ Drawing file: Fig 3-3 EXPOSURE AREA_WQM STATIONS.dwg Dec 03, 2004 - 11:38am



PROJECT
KINROSS GOLD CORPORATION
LUPIN MINE
BIOLOGICAL STUDY REPORT

TITLE
EXPOSURE AREA
WATER QUALITY MONITORING STATIONS

Golder Associates
Edmonton, Alberta

PROJECT 04-1373-046.1000			FILE No. Exposure_WQM Stns	
DESIGN	MD	01/12/04	SCALE 1:100000	REV. 1
CADD	PSR	02/12/04	FIGURE: 3-3	
CHECK	JD	03/12/03		
REVIEW				

Table 3-9 Summary of Water Quality Monitoring Data in the Exposure Area Downstream of the Lupin Mine Effluent Discharge

Constituent[a]	Mouth of Seep Cr. (SNP 925-20)						Mouth of Concession Cr. (SNP 925-21)						Centre of Inner Sun Bay (SNP 925-22)						Sun Bay Narrows (SNP 925-24)						Outer Sun Bay (SNP 925-25)					
	2000			2002			2000			2002			2000			2002			2000			2002			2000			2002		
	n	Mean[c]	SD[d]	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
pH (units)	7	6.03	0.25	7	6.48	0.15	7	6.43	0.32	7	6.28	0.41	7	6.33	0.33	7	6.37	0.09	7	6.47	0.29	7	6.36	0.29	7	6.51	0.28	7	6.39	0.35
Conductivity (µS/cm)	3	887	37	7	748	114	3	13.7	5.5	7	12.4	0.7	3	296	130	7	336	88.5	3	78.4	48.5	7	267	114	3	25.3	19.8	7	40.7	25.7
TSS[b]	7	0.53	0.17	7	0.93	0.73	7	0.96	1.35	7	<1	0	7	0.47	0.20	7	<1	0	7	0.37	0.30	7	<1	0	7	0.46	0.27	7	0.8	0.6
Total Arsenic	7	0.0024	0.0006	7	0.0036	0.0006	7	0.0004	0.0003	7	0.0011	0.0017	7	0.0010	0.0004	7	0.014	0.0003	7	0.0007	0.0005	7	0.0011	0.0002	7	0.0012	0.0021	7	0.0006	0.0001
Total Cyanide	7	0.007	0.004	7	0.015	0.014	7	<0.002	0	7	0.003	0.004	7	0.007	0.010	7	0.007	0.004	7	0.006	0.012	7	0.004	0.002	7	0.001	0.001	7	0.002	0.001
Total Cadmium	7	<0.0006	0	7	0.00017	0.00003	7	<0.0006	0	7	<0.00001	0	7	<0.0006	0	7	0.00006	0.00002	7	<0.0006	0	7	0.00003	0.00002	7	<0.0006	0	7	<0.00001	0
Total Copper	7	0.005	0.002	7	0.004	0.002	7	0.001	0.001	7	0.001	0.001	7	0.002	0.001	7	0.003	0.004	7	0.002	0.002	7	0.002	0.001	7	0.001	0.001	7	0.002	0.002
Total Lead	7	<0.002	0	7	0.0002	0.0002	7	0.001	0.001	7	0.0001	0.0001	7	<0.002	0	7	0.0002	0.0002	7	<0.002	0	7	0.0002	0.0003	7	<0.002	0	7	0.0002	0.0004
Total Nickel	7	0.115	0.009	7	0.0755	0.0084	7	0.008	0.018	7	0.0006	0.0003	7	0.041	0.016	7	0.0270	0.0070	7	0.012	0.011	7	0.0163	0.0073	7	0.002	0.001	7	0.0026	0.0016
Total Zinc	7	0.228	0.026	7	0.146	0.017	7	0.008	0.010	7	0.003	0.003	7	0.080	0.034	7	0.054	0.017	7	0.025	0.022	7	0.038	0.014	7	0.009	0.004	7	0.007	0.004
Total Alkalinity (as $CaCO_3$)	7	<5	0	7	7.4	9.2	7	<5	0	7	<5	0	7	<5	0	7	<5	0	7	<5	0	7	<5	0	7	<5	0	7	<5	0
Hardness (as $CaCO_3$)	7	231	9.1	7	199	34.3	7	4.4	0.6	7	4.8	0.3	7	88.0	25.0	7	82.7	21.9	7	31.2	22.6	7	64.3	26.4	7	6.63	3.86	7	9.97	5.52
Ammonium	7	2.72	0.48	7	0.72	0.31	7	0.32	0.16	7	0.03	0.02	7	1.06	0.28	7	0.24	0.12	7	0.57	0.28	7	0.15	0.10	7	0.28	0.16	7	0.04	0.02

[a] Concentration units are mg/L, unless otherwise listed; [b] Total Suspended Solids; [c] where a portion of the results were below methodological detection limits, half of this limit was used to calculate means and SD; [d] parameters with "0" SD indicate that all measurements were below the methodological detection limit.

The August concentrations of arsenic and metals in the water column were similar to values cited in previous studies. In September, concentrations of all elements, with the exception of arsenic, were significantly higher than the concentrations measured in August. Elemental concentrations decreased with increasing distance downstream from the mouth of Seep Creek. A statistical comparison of August and September water quality data demonstrated that, although natural increases in elemental concentrations of arsenic took place in Outer Sun Bay, these changes were small relative to the changes resulting from the discharge of the tailings effluent.

The September concentrations of copper, zinc and arsenic exceeded Canadian water quality guidelines for the protection of aquatic life (CCME 1999) at the mouth of Inner Sun Bay. Water quality guidelines were exceeded for copper and arsenic in Inner Sun Bay and for copper in Outer Sun Bay. The results of time-series water sampling carried out in September indicated that water quality in Outer Sun Bay fluctuated significantly from day to day during the tailings effluent discharge period.

EVS (1996)

EVS (1996) attempted to assess water quality between an exposure area (Inner and Outer Sun bays) and a reference area (South Bay of Contwoyto Lake); however, due to the intermittent effluent discharge schedule at the mine (i.e., Lupin Mine discharged effluent for a short period [15 July through 7 August 1996]), EVS was not able to collect water quality samples concurrent with effluent discharge. This report is appended to Golder (2003a) and represents the latest known attempt to assess Lupin Mine operations on water quality in receiving environments.

EVS (1996) assessed water quality between their exposure and reference areas by compiling historic data. Such data have shown that changes in water quality (elevated concentrations of copper, zinc and arsenic in exposure area) have occurred as a result of effluent discharges (Table 3-10). Water quality conditions appear to rapidly (i.e., within weeks) return to background concentrations following completion of each discharge event. Furthermore, available data from the first effluent decant in 1985 may not be representative of effluent discharges in later years, as a result of process changes that have improved effluent quality.

Table 3-10 Summary of Historic Total Metals (mg/L; ranges provided) in Water of Contwoyto Lake[a]

Location	Year	Month	Conductivity (μS/cm)	As	Cu	Ni	Zn
Shallow Bay[b]	1983[c]	Jun-Sep	8-11	<0.001	0.0015-0.0026	<0.005-0.008	<0.01-0.016
Inner Sun Bay	1983[c]	Jun-Sep	10 -13	<0.001	0.001-0.0021	<0.005	<0.01-0.017
	1985[d]	Aug[e]	12-15	<0.001	0.0007-0.0008	0.0008-0.0009	0.0005-0.0007
	1985[d]	Sep[f]	335-347	0.184-0.196	0.022-0.027	0.0082-0.0089	0.0386-0.0395

[a] Table adapted from EVS (1996b); [b] Data not available for South Bay; Shallow Bay, which is upstream of South Bay is used for comparison; [c] Data from RCPL and RL&L (1985); [d] Data from Mudroch and Sutherland (1988); [e] Pre-discharge data (August); [f] Post-discharge data (September).

With regard to the 1996 water samples (i.e., samples collected one month following discontinuation of effluent discharge) collected by EVS (1996), the authors found that there were many significant differences between their reference and exposure areas; they noted conductivity, several metals and major ions were higher at the reference location. Differences between the two study locations may be due to geological differences between the south (reference) and west (exposure) basins, which would affect water flowing into Contwoyto Lake.

3.7.3 Benthic Macroinvertebrates

Benthic macroinvertebrates have been sampled from waterbodies in the vicinity of the Lupin Mine since the late 1970s (e.g., Moore 1978; Gordon and Grenkow 1981; RL&L 1996a). Total number of benthic invertebrate taxa collected varied considerably among the studies, and ranged from 30 to 75 taxa per study. Midges (Chironomidae) and bristle worms (Oligochaeta) tended to be the dominant groups encountered; fingernail clams (Sphaeridae; Bivalvia) were common at deep water sites (usually greater than 3 to 5 m). Periodically, roundworms (Nematoda) were reported to be a dominant taxon. Total densities varied greatly, and typically ranged from about 200 to 5000 animals/m^2.

Benthic macroinvertebrate surveys conducted in the vicinity of the Lupin Mine site during the late 1970s and early 1980s reflect conditions prior to the operation of the Lupin mine and the discharge of effluent from the tailings ponds. Numerous subsequent studies have monitored and assessed benthic macroinvertebrate composition, abundance and distribution as related to tailings disposal in the receiving waters. Primary studies conducted on the benthos of exposure area waterbodies include RCPL and RL&L

(1985b), Mudroch and Sutherland (1988), Porter et al. (1992), EVS (1996), and RL&L (1996a). Often these studies included water quality and/or sediment quality assessments in association with benthic invertebrate communities. With the exception of RCPL and RL&L (1985b), these documents are appended to Golder (2003a).

Baseline Aquatic Studies (RCPL and RL&L 1985)

Benthic macroinvertebrate samples were sampled (five replicates per site) at eight locations. Four of these sites were located in the proposed effluent exposure area (Seep Creek watershed and Inner Sun Bay) and four were located in the watershed to the south of the TCA, including Shallow Bay of Contwoyto Lake. Samples were collected during September of 1982, 1983, and 1984; all samples were collected prior to Lupin Mine's initial effluent discharge in 1985.

Study Conclusions

In total, 30 benthic macroinvertebrate taxa were identified among all samples collected. Midges and bristle worms were the dominant taxa. Bivalves were present at deep water sites, including Inner Sun Bay. Shallow water study sites featured considerable variability in numbers and diversity of organisms because of extreme environmental conditions (freezing, thawing, and temperature fluctuations).

Phase 1 - Initial Assessment (Mudroch and Sutherland 1988)

Environment Canada carried out an initial study in 1985 to determine the effects of tailings effluent from the Lupin Gold Mine on the benthic macroinvertebrates, water and sediment quality of Inner and Outer Sun bays, Contwoyto Lake (Mudroch and Sutherland 1988). Sampling took place before (August) and during (September) effluent discharge from the Lupin Mine to determine whether increases in arsenic, selected metals, and cyanide concentrations had occurred in water and sediment samples collected from Inner Sun Bay and Outer Sun Bay. Water quality results from Mudroch and Sutherland (1988) results are summarized previously Section 3.7.2; sediment and benthic invertebrate observations are provided below.

Study Conclusions - Sediment and Benthic Invertebrates

Although no trends were identified in the distribution of elements in the sediment of the study area in August, an increase in zinc, copper and nickel at two study stations located in Outer Sun Bay (seven stations were established, three in Inner Sun Bay and four in Outer Sun Bay) occurred during the effluent decant. Concentrations of these elements increased between 13% and 81% during this period.