Table C1 Continued. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b)

1983

Replicate	Units	8-Aug Norma Cr.		8-Aug Dam 1a Lake		8-Aug Mouth of Seep Cr.		8-Aug Inner Sun Bay		9-Aug Concession Cr.	
		A	B	A	B	A	B	A	B	A	B
Conventional											
pH	units	6.00	6.00	6.75	6.55	6.50	6.25	6.20	6.40	6.25	6.25
Conductivity	µS/cm	12.7	12.6	43.1	43.1	45.8	46.6	9.8	9.8	8.6	8.6
Total Suspended Solids	mg/L	2	1	4	3	1	1	1	1	1	1
Total Disolved Solids	mg/L	11	12	30	29	30	30	< 10	< 10	< 10	< 10
Nutrients/Others											
Bicarbonate	mg/L	3.05	2.80	8.80	8.89	5.17	4.53	4.50	4.50	3.80	3.80
Carbonate	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hydroxide	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride	mg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphate	mg/L	4.5	5.0	12.4	11.4	15.5	15.0	1.0	1.0	2.0	2.0
Nitrate	mg/L	< 0.01	< 0.01	0.046	0.038	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrites	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ammonia	mg/L	< 0.01	< 0.01	0.019	< 0.01	< 0.01	0.036	< 0.01	< 0.01	< 0.01	< 0.01
Cyanide	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	0.23	0.28	0.66	0.91	0.42	0.65	0.32	0.24	0.24	0.19
Metals (Total)											
Aluminum	mg/L	0.071	0.048	0.063	0.056	0.300	0.210	0.050	0.032	0.018	0.027
Antimony	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.001	0.002	0.003	0.004	0.007	0.007	0.002	0.002	0.002	0.002
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	< 0.01	< 0.01	0.051	0.018	< 0.01	0.021	< 0.01	0.011	0.029	0.017
Cadium	mg/L	< 0.0001	< 0.0001	0.0023	0.0005	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	0.85	0.90	3.01	3.00	3.22	3.25	0.76	0.71	0.63	0.65
Chromium	mg/L	0.007	0.057	0.033	0.007	0.019	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.0015	0.0048	0.0072	0.0037	0.0024	0.0039	0.0013	0.0021	0.0015	0.0016
Iron	mg/L	0.068	0.088	0.370	0.360	0.230	0.230	0.110	0.100	0.098	0.140
Lead	mg/L	0.003	0.025	0.010	0.002	0.003	0.001	0.002	0.002	0.003	0.003
Magnesium	mg/L	0.44	0.43	1.68	1.68	1.96	2.01	0.34	0.34	0.27	0.27
Manganese	mg/L	< 0.003	< 0.003	0.010	0.011	0.008	0.008	0.004	0.003	0.005	0.004
Mercury	mg/L	0.00015	0.00020	0.00015	0.00013	0.00015	0.00020	0.00015	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.04	< 0.04	< 0.04
Nickel	mg/L	< 0.005	0.010	< 0.005	< 0.005	0.010	0.026	< 0.005	< 0.005	< 0.005	< 0.005
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.49	0.53	1.68	1.66	0.94	0.94	0.45	0.40	0.43	0.44
Strontium	mg/L	0.005	0.005	0.013	0.013	0.017	0.017	0.005	0.004	0.004	0.004
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	0.026	0.023	0.027	0.028	0.018	0.017	0.014	0.013	0.011	0.011
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.01	0.053	0.050	< 0.01	0.018	< 0.01	0.013	0.017	< 0.01	< 0.01

Note: A and B refer to replicate samples.

Table C1 Continued. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b).

1983

Constituent	Units	19-Sep Norma Cr.		20-Sep Dam 1a Lake		19-Sep Mouth of Seep Cr.		20-Sep Inner Sun Bay		19-Sep Concession Cr.	
		A	B	A	B	A	B	A	B	A	B
Conventional											
pH	Units	6.15	6.10	6.50	6.45	6.05	6.10	6.05	6.05	5.70	5.70
Conductivity	µS/cm	17.8	17.8	53.9	55.0	48.2	48.4	12.1	11.6	9.9	9.9
Total Suspended Solids	mg/L	1	1	3	2	1	1	< 0.5	< 0.5	1	< 0.5
Total Disolved Solids	mg/L	11	11	38	38	33	31	9	7	6	7
Nutrients/Others											
Bicarbonate	mg/L	4.10	4.10	9.56	8.20	7.10	4.10	4.10	2.73	2.73	2.73
Carbonate	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hydroxide	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride	mg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphate	mg/L	4.1	4.0	15.8	17.0	13.4	15.1	1.5	2.0	1.0	1.7
Nitrate	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrites	mg/L	0.003	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ammonia	mg/L	0.020	0.014	0.014	0.018	< 0.01	0.015	< 0.01	< 0.01	0.015	< 0.01
Cyanide	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	0.16	0.14	3.36	3.63	4.99	4.75	0.59	0.59	0.38	0.41
Metals (Total)											
Aluminum	mg/L	0.020	0.013	0.120	0.094	0.190	0.200	0.073	0.073	< 0.005	0.044
Antimony	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.001	0.001	0.005	0.005	0.011	0.010	0.003	0.002	0.002	0.002
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	0.030	0.031	0.030	0.023	0.030	0.030	0.022	0.021	0.030	0.030
Cadium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	1.17	1.11	4.37	4.39	3.62	3.49	0.85	0.85	0.71	0.72
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.0022	0.0029	0.0029	0.0034	0.0023	0.0019	0.0021	0.0010	0.0029	0.0008
Iron	mg/L	0.075	0.068	0.510	0.520	0.470	0.450	0.120	0.120	0.081	0.083
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Magnesium	mg/L	0.58	0.55	2.38	2.51	2.25	2.16	0.42	0.42	0.34	0.33
Manganese	mg/L	< 0.003	< 0.003	0.023	0.016	0.026	0.025	< 0.003	< 0.003	0.003	0.003
Mercury	mg/L	0.00005	0.00005	0.00008	0.00010	0.00005	0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.04	< 0.04	< 0.04
Nickel	mg/L	< 0.005	< 0.005	0.012	0.008	0.022	0.021	0.009	< 0.005	< 0.005	< 0.005
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.68	0.67	1.30	1.37	0.91	0.91	0.34	0.35	0.28	0.29
Strontium	mg/L	0.006	0.006	0.020	0.020	0.019	0.020	0.006	0.006	0.005	0.005
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.016	0.017	< 0.01	< 0.01	< 0.01	< 0.01

Note: A and B refer to replicate samples.

Table C1 Continued. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b).

1984

Constituent	Units	9-Jun Norma Cr.		9-Jun Dam 1a Lake		8-Jun Mouth of Seep Cr.		8-Jun Inner Sun Bay		8-Jun Concession Cr.	
		A	B	A	B	A	B	A	B	A	B
Conventional											
pH	Units	6.5	6.3	6.2	6.1	6.15	6.30	6.30	6.30	6.15	6.10
Conductivity	µS/cm	18.9	19	18.9	18	14.3	14.5	10	9.9	9.7	9.8
Total Suspended Solids	mg/L	2	1	1	< 0.5	1.2	1	< 0.5	< 0.5	1	1.2
Total Disolved Solids	mg/L	12	12	18	17	9.5	10	5.5	5	6.5	6
Nutrients/Others											
Bicarbonate	mg/L	4.93	4.93	3.7	2.46	3.7	3.7	3.7	3.08	3.7	3.08
Carbonate	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hydroxide	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride	mg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphate	mg/L	3	3	6.5	7	2	2.5	< 1.0	< 1.0	< 1.0	< 1.0
Nitrate	mg/L	0.022	0.038	< 0.01	< 0.01	< 0.01	0.014	< 0.01	< 0.01	0.011	0.014
Nitrites	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ammonia	mg/L	0.29	0.22	0.096	0.12	0.05	0.054	0.076	0.099	0.039	0.057
Cyanide	mg/L	0.014	< 0.01	< 0.01	< 0.01	0.061	0.061	0.014	0.018	0.016	0.017
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	1.58	1.55	1.43	1.29	1.18	1.12	0.42	0.42	1.01	0.93
Metals (Total)											
Aluminum	mg/L	0.34	0.33	0.096	0.097	0.12	0.14	0.081	0.11	0.13	0.12
Antimony	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	0.001	0.001	0.003	0.003	< 0.001	0.001	< 0.001	< 0.001	0.001	< 0.001
Barium	mg/L	0.006	0.005	0.009	0.006	0.003	0.004	0.002	0.002	0.002	0.002
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	1.38	1.39	2.91	2.65	0.96	0.96	0.79	0.80	0.64	0.64
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.035	0.032	0.0022	0.0025	0.0018	0.0018	0.0005	0.0008	0.016	0.015
Iron	mg/L	0.52	0.52	0.71	0.68	0.47	0.45	0.1	0.11	0.22	0.21
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Magnesium	mg/L	0.71	0.72	1.33	1.2	0.53	0.52	0.34	0.34	0.28	0.27
Manganese	mg/L	0.21	0.22	0.045	0.044	0.075	0.074	0.032	0.031	0.046	0.048
Mercury	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.04	< 0.04	< 0.04
Nickel	mg/L	0.021	0.031	0.01	0.01	0.007	0.006	< 0.005	< 0.005	< 0.005	< 0.005
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.004	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.56	0.57	1.02	0.91	0.39	0.43	0.41	0.44	0.4	0.4
Strontium	mg/L	0.007	0.007	0.018	0.015	0.005	0.006	0.005	0.004	0.004	0.004
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	0.009	0.01	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Note: A and B refer to replicate samples.

Table C1 Continued. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b)

1984

Replicate	Units	11-Aug Norma Creek			11-Aug Dam 1a Lake			11-Aug Mouth of Seep Cr.		
		A	B	C	A	B	C	A	B	C
Conventional										
pH	units	6.45	6.5	--	6.8	6.7	--	6.50	6.60	--
Conductivity	µS/cm	14	13.8	--	72.5	73.1	--	48.1	48.1	--
Total Suspended Solids	mg/L	2	2	--	2	3	--	14	13.5	--
Total Disolved Solids	mg/L	10	10	--	35	36	--	33		--
Nutrients/Others										
Bicarbonate	mg/L	5.17	6.47	--	9.05	8.41	--	8.41	7.76	--
Carbonate	mg/L	Nil	Nil	--	Nil	Nil	--	Nil	Nil	--
Hydroxide	mg/L	Nil	Nil	--	Nil	Nil	--	Nil	Nil	--
Chloride	mg/L	< 0.5	< 0.5	--	9.93	9.93	--	< 0.50	< 0.50	--
Sulphate	mg/L	1.5	< 1.0	--	5.7	6.0	--	13.5	14.0	--
Nitrate	mg/L	0.24	0.16	--	0.015	< 0.01	--	< 0.01	< 0.01	--
Nitrites	mg/L	< 0.002	< 0.002	--	< 0.002	< 0.002	--	< 0.002	< 0.002	--
Ammonia	mg/L	< 0.01	0.011	--	0.034	0.033	--	0.033	0.026	--
Cyanide	mg/L	< 0.01	0.026	--	< 0.01	< 0.01	--	0.015	< 0.01	--
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	0.55	1.34	0.59	0.84	0.75	0.40	3.10	4.13	5.19
Metals (Total)										
Aluminum	mg/L	0.023	0.017	0.032	0.058	0.070	0.054	0.560	0.380	0.470
Antimony	mg/L	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001
Arsenic	mg/L	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.008	0.002	0.002	0.005	0.008	0.008	0.011	0.013	0.014
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	0.005	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	0.049	0.022	0.034	0.057	0.044	0.030	0.023	0.014	0.015
Cadium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	0.88	0.91	0.88	3.82	4.2	4.13	3.5	3.84	3.77
Chromium	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.0011	0.0012	0.0018	0.002	0.0022	0.004	0.0025	0.0035	0.0025
Iron	mg/L	0.10	0.10	0.10	0.32	0.36	0.36	1.71	1.93	1.97
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Magnesium	mg/L	0.43	0.5	0.47	2.12	2.42	2.48	2.16	2.47	2.51
Manganese	mg/L	0.004	0.003	0.003	0.024	0.031	0.025	0.023	0.026	0.025
Mercury	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	mg/L	< 0.005	< 0.005	< 0.005	0.014	0.012	0.011	0.028	0.032	0.031
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.61	0.41	0.44	3.53	3.96	4.27	1.30	1.20	1.34
Strontium	mg/L	0.005	0.005	0.005	0.017	0.021	0.022	0.018	0.022	0.022
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	0.008	0.011	0.008	0.007	0.011	0.006	0.014	0.016	0.021
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	0.017

Note: A, B, and C refer to replicate samples.

Table C1 Continued. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b).

1984

Replicate	Units	12-Aug Inner Sun Bay			11-Aug Concession Creek		
		A	B	C	A	B	C
Conventional							
pH	units	6.50	6.55	--	6.40	6.50	--
Conductivity	µS/cm	11.4	11.4	--	9.14	9.24	--
Total Suspended Solids	mg/L	2	4	--	4.5	4	--
Total Disolved Solids	mg/L	12	12	--	7	8	--
Nutrients/Others							
Bicarbonate	mg/L	7.11	5.82	--	5.17	6.47	--
Carbonate	mg/L	Nil	Nil	--	Nil	Nil	--
Hydroxide	mg/L	Nil	Nil	--	Nil	Nil	--
Chloride	mg/L	< 0.50	< 0.50	--	< 0.50	< 0.50	--
Sulphate	mg/L	< 1.0	1.5	--	< 1.0	< 1.0	--
Nitrate	mg/L	< 0.01	< 0.01	--	< 0.01	< 0.01	--
Nitrites	mg/L	< 0.002	< 0.002	--	< 0.002	< 0.002	--
Ammonia	mg/L	0.023	0.042	--	0.033	0.038	--
Cyanide	mg/L	< 0.01	< 0.01	--	< 0.01	< 0.01	--
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	2.33	1.24	1.21	0.79	0.80	0.51
Metals (Total)							
Aluminum	mg/L	0.220	0.200	0.230	0.064	0.078	0.068
Antimony	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	0.004	< 0.001	< 0.001
Barium	mg/L	0.004	0.003	0.004	< 0.001	0.002	0.002
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	0.019	0.013	< 0.01	0.021	0.023	0.023
Cadium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	0.89	0.84	0.86	0.66	0.68	0.68
Chromium	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.0021	0.0016	0.0006	0.0003	0.0006	< 0.0001
Iron	mg/L	0.41	0.40	0.40	0.27	0.29	0.29
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Magnesium	mg/L	0.51	0.048	0.48	0.3	0.35	0.35
Manganese	mg/L	0.006	0.006	0.006	0.005	0.007	0.006
Mercury	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.38	0.46	0.44	0.58	0.40	0.36
Strontium	mg/L	0.006	0.006	0.006	0.003	0.005	0.005
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	0.014	0.015	0.027	< 0.006	0.007	0.008
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015

Note: A, B, and C refer to replicate samples.

Table C1 Concluded. Baseline water quality in the vicinity of the Lupin Mine (RCPL and RL&L 1985b).

1984

Constituent	Units	11-Sep Norma Cr.		11-Sep Dam 1a Lake		11-Sep Mouth of Seep Cr.		12-Sep Inner Sun Bay		11-Sep Concession Cr.	
		A	B	A	B	A	B	A	B	A	B
Conventional											
pH	units	6.50	6.50	6.75	6.35	6.20	6.05	6.70	6.35	6.10	6.15
Conductivity	µS/cm	18.1	18.3	115	116	90.5	91.7	14.2	14.1	10.7	10.8
Total Suspended Solids	mg/L	3	2.8	4.4	1.8	2.8	4.4	< 0.5	< 0.5	2	< 0.5
Total Disolved Solids	mg/L	13	13	63	62	60	60	11	11	8	8
Nutrients/Others											
Bicarbonate	mg/L	7.76	7.76	9.70	9.05	5.17	5.17	7.11	5.82	5.17	5.17
Carbonate	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hydroxide	mg/L	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride	mg/L	< 0.50	< 0.50	16.9	16.9	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Sulphate	mg/L	1.0	1.5	15.5	15.0	34.5	34.5	< 1.0	1.5	< 1.0	< 1.0
Nitrate	mg/L	< 0.01	< 0.01	0.084	0.073	0.065	0.11	< 0.01	< 0.01	0.037	< 0.01
Nitrites	mg/L	< 0.02	< 0.02	0.007	< 0.02	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ammonia	mg/L	0.012	< 0.01	0.093	0.08	0.024	0.24	< 0.01	< 0.01	< 0.01	< 0.01
Cyanide	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.014	0.026	< 0.01
Phosphate	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	0.74	0.73	2.27	2.28	5.94	5.52	1.10	1.35	1.06	1.10
Metals (Total)											
Aluminum	mg/L	0.130	0.120	0.110	0.089	0.170	0.190	0.073	0.057	0.070	0.063
Antimony	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.001	0.001	0.011	0.011	0.02	0.019	0.003	0.002	0.002	0.002
Beryllium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bismuth	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Boron	mg/L	0.028	0.041	0.039	0.032	0.022	0.054	0.027	0.035	0.027	0.030
Cadium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	mg/L	1.31	1.33	7.21	7.22	6.51	6.44	1.15	1.16	0.87	0.88
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	0.0008	0.0008	0.001	0.001	0.0011	0.0012	0.0003	0.0029	< 0.0001	< 0.0001
Iron	mg/L	0.098	0.098	0.450	0.450	0.920	0.900	0.240	0.250	0.160	0.160
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Magnesium	mg/L	0.68	0.69	4.03	4.07	4.11	3.99	0.59	0.56	0.41	0.39
Manganese	mg/L	< 0.003	< 0.003	0.037	0.035	0.053	0.052	0.003	0.004	0.005	0.005
Mercury	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	mg/L	0.006	0.008	0.019	0.020	0.042	0.040	< 0.005	< 0.005	0.005	< 0.005
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	0.63	0.70	6.71	6.78	3.63	3.52	0.70	0.74	0.48	0.55
Strontium	mg/L	0.006	0.006	0.034	0.034	0.041	0.031	0.006	0.006	0.004	0.005
Tin	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Titanium	mg/L	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	< 0.005	0.006	0.006	0.02	0.02	0.005	0.005	< 0.005	< 0.005

Note: A and B refer to replicate samples.

APPENDIX D

HISTORICAL DOCUMENTS

Environmental Protection Service
Northwest Region
Manuscript Report NW-78-6
June, 1978

-60

BIOLOGICAL AND WATER QUALITY SURVEYS AT POTENTIAL MINES IN THE NORTHWEST TERRITORIES

II. INCO GOLD PROPERTY, CONTWOYTO LAKE

by

James W. Moore

ABSTRACT

A biological and water quality survey of 10 lakes and one stream in the area of Contwoyto Lake, Northwest Territories (Lat. 65° 45'N; Long. 111°15'W), a potential mine site, was conducted during July 1975. The distribution and abundance of attached and planktonic algae, rotifers, crustaceans, and insects are described. Additional data on the size, age and food of fishes are presented. Discussion of tailings disposal from the potential mine with respect to the Metal Mining Liquid Effluent Regulations is included.

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CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The concentrations of heavy metals in Contwoyto Lake and neighbouring lakes and streams fell below detectable limits and met Canada Drinking Water Standards and Objectives.
2. The species composition, density and population structure of the phytoplankton, phytobenthos, zooplankton and zoobenthos were typical of lakes lying on the barrenlands.
3. Large numbers of lake trout and arctic grayling, capable of supporting a domestic fisheries, were found throughout the study area.
4. Lake trout, arctic grayling and slimy sculpins spawn in Contwoyto Lake in the immediate vicinity of the ore deposit and in several nearby lakes.

RECOMMENDATIONS

1. No deleterious substance resulting from mining and milling activities should be permitted to enter any lake or river containing fish.
2. Detailed aquatic ecological studies should be conducted prior to the commencement of mining and milling at the site. These investigations should include estimates of the seasonal abundance of algae and invertebrates, the level of heavy metals and arsenic in all major fish species, determination of the spawning areas of all major fish species, and the metal content of sediments and water in Contwoyto Lake and neighbouring water courses.
3. Continuous environmental monitoring should be required during any industrial operation in order to protect the present high quality of the lakes and rivers. These studies should include seasonal determinations of the abundance of algae and invertebrates, and the metal content of sediments and water in surrounding lakes and rivers. In addition, the metal content of fish from Contwoyto Lake and surrounding bodies of water should be measured every 2 years after milling start-up.
4. Tailings ponds must not be located near Stream A, Contwoyto Lake or lakes E, F, and H. The practice of tailings disposal must comply with section 5(2) of the Metal Mining Liquid Effluent Regulations if the mine does not receive more than 50% of its revenue from gold.

1 INTRODUCTION

1.1 General

Baseline studies of aquatic ecosystems in watercourses adjacent to major industrial developments are now regarded as essential components in the environmental protection process. A thorough assessment of the naturally prevailing conditions prior to the use of water for industrial purposes and the disposal of wastes from industrial processes is mandatory to the development of effective regulatory controls, and integral to the identification of adequate monitoring programs.

Limnological surveys at potential mine sites in the Northwest Territories were initiated by the Water Management Section of the Department of Indian Affairs and Northern Development in 1974, and were expanded through the addition of biological studies carried out by the Environmental Protection Service of the Department of Fisheries and the Environment in 1975. The first such study was undertaken at the Camlaren gold property (33), and was closely followed by the present investigation. These studies were intended to achieve the following. Firstly, they would provide preliminary baseline information on the quality of waters and the basic population characteristics of the aquatic biota in the rivers, lakes and streams from which water could be taken for industrial purposes, or into which effluents from tailings ponds, surface drainage from piles of waste rock, seepage and industrial waste water from underground workings, and other forms of wastes might be deposited. Secondly, the data from these surveys would describe to the two Departments and the NWT Water Board the nature of the aquatic resources which could be affected by the development of mining and milling operations. Thirdly, these studies would assist the Water Board in formulating and enforcing the terms of reference for major studies of the impact of the proposed development which could be required of the proponent company under Section 11(2) of the Northern Inland Waters Act.

1.2 Area of Study

Contwoyto Lake lies in the tundra zone of the Canadian Shield approximately 400 km northeast of Yellowknife (Figure 1). The lake has a surface area of slightly greater than 950 km^2, and collects the drainage of some 8,000 km^2 of surrounding territory. Water from Contwoyto Lake

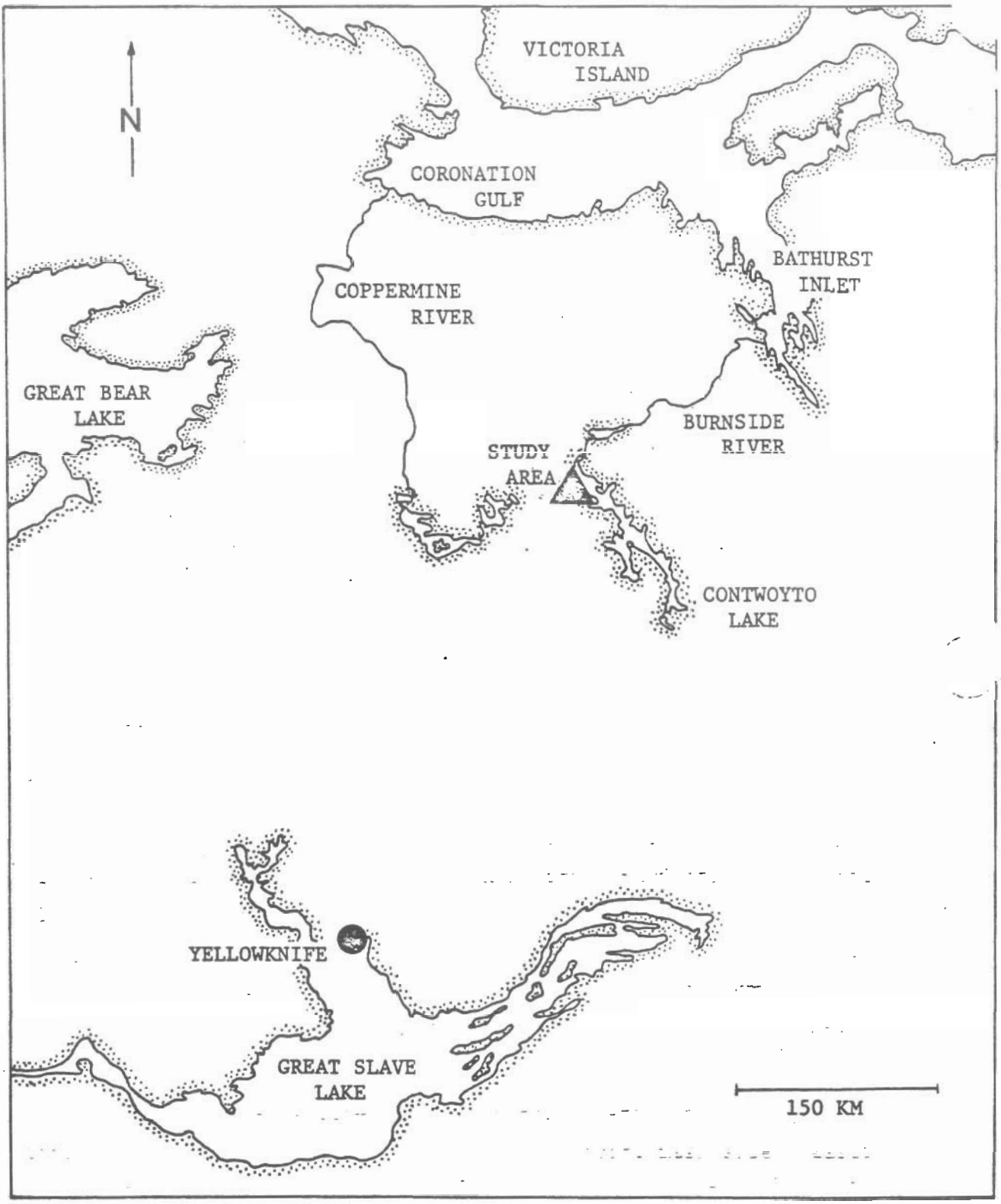

FIGURE 1 LOCATION OF CONTWOYTO LAKE AND ASSOCIATED WATERCOURSES.

eventually enters the Arctic Ocean through two separate routes. The major discharge is through the outlet at the north end of the lake to the Burnside River, which enters the sea at Bathurst Inlet.

Gold was discovered along the western shore of the Contwoyto Lake in 1960, and the main showing (65°44'N, 111°12'W) was incorporated into a block of 300 claims held by the Canadian Nickel Company Limited, part of the International Nickel Company of Canada Limited (INCO). Extensive low grade deposits were delineated by further exploration work, and most were shown to be associated with abundant pyrite and arsenopyrite.

With the dramatic increase in the world price of gold during the present decade, a renewed interest in the deposits at Contwoyto Lake was apparent. While no definitive plans to bring the property into production were ever announced, the possibility of a major environmental impact in the eventual development and production phases was foreseen. Existing gold mines in the Northwest Territories release effluent which is acutely lethal to fish, and contain very high concentrations of toxicants (37), and the present environmental problems are most serious where high concentrations of arsenopyrite exist in the ore (35,36).

In the absence of operational plans for the mine and mill, it was difficult to predict the nature of impacts on the surrounding aquatic environment which might occur. Nonetheless, present practices at existing mines suggested the following could take place. Fresh surface water for mining and milling would be drawn from Contwoyto Lake and pumped to a mine-mill complex in the vicinity of the main ore body. Difficulties in constructing stable embankments and dams under permafrost conditions would likely result in tailings being deposited into one or more small lakes in this area. While conservation of water through total or partial recycling and re-use might be practiced in order to minimize the volume of wastes, and while treatment techniques might be applied to minimize the concentration of toxicants in such wastes, it was nonetheless likely that some quantities of toxicants would eventually reach Contwoyto Lake in the area proximal to the mine. Further, if roasting of the ore was required in order to separate the gold from arsenic, some contamination of surrounding watercourses through airborne emissions would likely be almost inevitable (33).

With this in mind, a program was undertaken to determine the quality of waters and to measure the abundance and distribution of algae and benthic invertebrates in Contwoyto Lake adjacent to the ore body, nine other lakes to the northwest and northeast, and in one stream entering Contwoyto Lake (Figure 2). A total of 52 stations were sampled. Data on the size, age and food of several species of fishes were collected as well. The investigation took place between July 25 and August 1, 1975.

2 MATERIALS AND METHODS

2.1 Water Sampling and Analysis

Water samples were collected on the final day of the survey directly from the surface or from depth intervals using a 4 litre Van Dorn bottle. Samples were preserved for determination of heavy metals by addition of concentrated nitric acid and for measurement of nutrients by freezing upon receipt at the laboratory in Yellowknife, approximately six hours after collection. Analytical methods were identical to those described previously (54). Temperature and conductivity were measured *in situ* using a portable thermister (Model 33, Yellow Springs Instrument Co.).

2.2 Biological Sampling and Analysis

Phytoplankton were sampled at depth intervals of 5 m during daylight hours using a 4 litre Van Dorn bottle. Simultaneous collection of zooplankton and zoobenthos took place using the trap described by Schindler (51) and a 15 x 15 x 23 cm Ekman grab, respectively. Sampling of littoral plants and animals was done at several stations on each lake, and also from stream A (Figure 2) by methods which were described earlier (33). All of the biological samples were immediately preserved in a 10 percent solution of formalin, and analyzed in the laboratory by methods already presented (33).

Fishes were captured using a monofilament gang of 6 nets, set overnight on bottom at a depth of 5 to 6 m. Square mesh sizes measured 38 mm, 51 mm, 64 mm, 76 mm, 89 mm, 102 mm, 136 mm, in 9 m panels. Fish lengths (±1 mm), and wet weights (±50 g) were recorded soon after capture. Scales, taken for aging, were read by personnel of the Fisheries and Marine Service at the Freshwater Institute, Winnipeg, Manitoba. Gonads and the contents of stomachs were removed soon after capture and preserved in 10 percent formalin. Fecundity was later estimated according to the method of Eschmeyer (10).

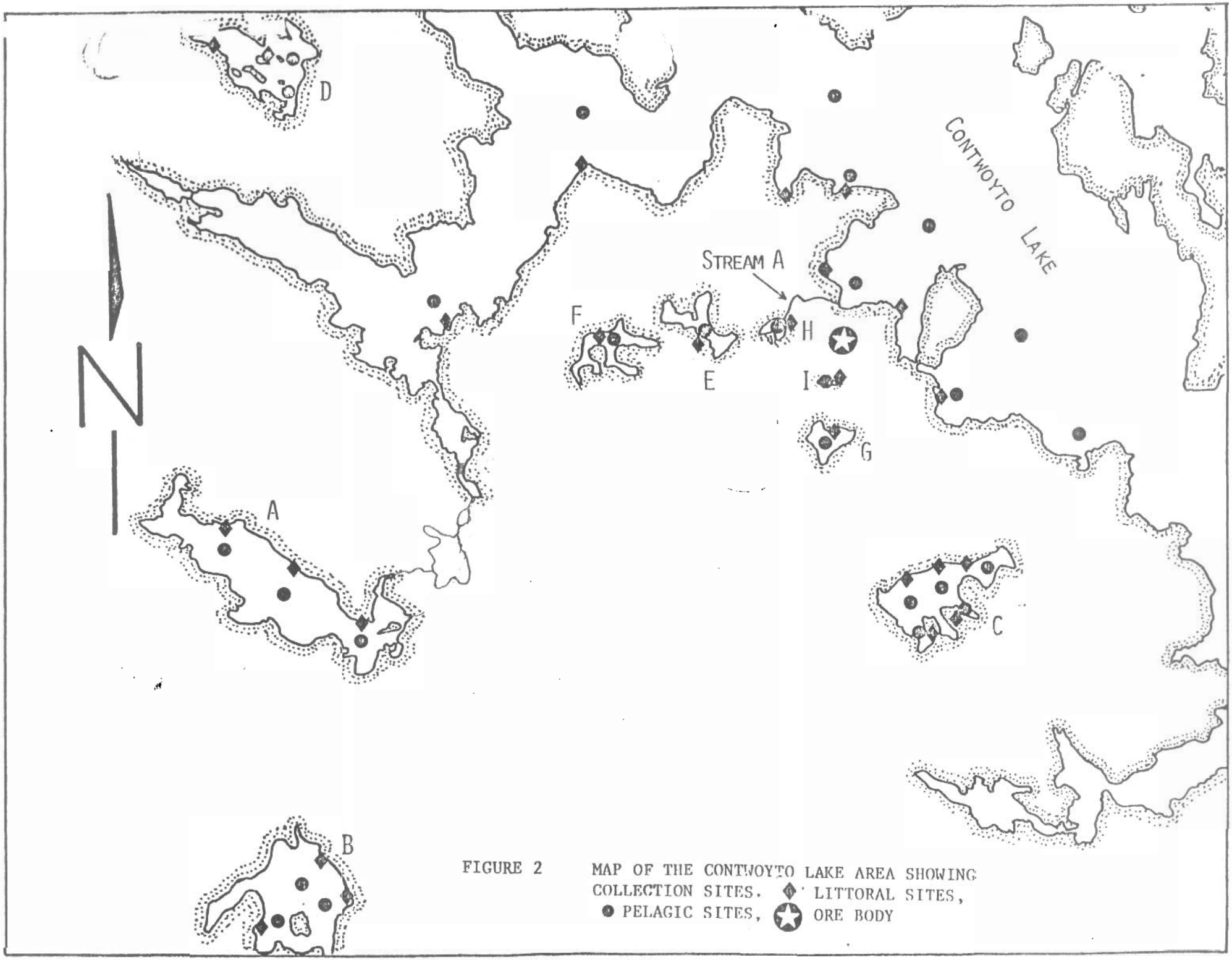

FIGURE 2 MAP OF THE CONTWOYTO LAKE AREA SHOWING COLLECTION SITES. ◆ LITTORAL SITES, ● PELAGIC SITES, ★ ORE BODY

RESULTS AND DISCUSSION

3.1 Physical Features of Lakes and Quality of Waters

The maximum depths measured and the estimated surface areas of the lakes studied together with the temperatures at the surface and bottom are given in Table 1. Surface temperatures of Contwoyto Lake averaged 10° to 11 °C near shore (0.05 km), while at distances of 0.6 to 1.2 km, values were about 7°C. Temperatures decreased with depth, averaging 5°C at 25 m. The other lakes were shallower than Contwoyto with temperatures ranging from 12° to 15°C. Similar temperatures were recorded in Stream A.

Although water temperatures at the surface of Contwoyto Lake exceeded the midsummer values reported for Great Bear Lake (16), Char Lake (51), and Geraldine Lake on Baffin Island (11), they are somewhat lower than those recorded for Great Slave Lake (38) and lakes in central Labrador (7). Since a well-defined stratification was observed, full circulation apparently does not take place during the summer, thus contrasting with the situation in Great Bear Lake (16). Temperatures in the smaller lakes were comparable to those reported for Labrador in mid-summer (7), but were about 5°C cooler than the values recorded for small lakes in the vicinity of Yellowknife. The shallower lakes seemed to be near full circulation, presumably due to wind action.

Metal and nutrient levels in Contwoyto Lake were similar ($P<0.05$) and low at all depths and stations (Tables 2 and 3). Readings for most parameters fell below detection limits, emphasizing the pristine quality of these waters. While the concentrations of metals and nutrients in the other lakes and in Stream A were generally similar to those obtained in Contwoyto Lake, values of phosphorus and dissolved nitrogen were comparatively higher in a few instances (Table 3).

All chemical values fell well below those reported for other northern lakes, including those in the high Arctic and on Baffin Island (7, 11, 16, 51). While the concentration of the substances measured remained constant with depth, this may not be characteristic of northern lakes (16, 51). The values which were measured in this survey are given in Appendix I and are quite similar to those which were recorded in 1974 (Appendix II).

TABLE 1. DEPTHS, SURFACE AREAS AND TEMPERATURES OF LAKES STUDIED
Depth was recorded in meters, surface area in km^2, and temperatures in °C.

LAKE	LOCATION		MAX. DEPTH	SURFACE AREA	SURFACE TEMP.	TEMP. AT MAX. DEPTH
Contwoyto	65°46'	111°10'	30	960	7-11	4-5
Lake A	65°43'00"	111°35'40"	7.5	10.4	12.5	12
Lake B	65°38'00"	111°32'40"	10	6.8	14	12
Lake C	65°43'36"	111°09'00"	6	3.7	14	13
Lake D	65°50'16"	111°33'00"	4	3.2	15	14
Lake E	65°46'16"	111°18'00"	3	0.9	13	13
Lake F	65°46'08"	111°21'20"	7	0.9	13.5	13
Lake G	65°44'36"	111°13'00"	3	0.6	14	14
Lake H	65°46'16"	111°15'20"	2	0.2	14	14
Lake I	65°45'24"	111°13'00"	5	0.05	13.5	12
Stream A	65°45'20"	11°20'40"	0.01	--	14	14