LIBRARIES
UNIVERSITY OF WISCONSIN–MADISON

Appendix 3-4. Volume II

Foley and Lardner
Rhinelander, Wisconsin: Nicolet Minerals Company, [s.d.]

https://digital.library.wisc.edu/1711.dl/VMY7ABIRKC6LQ9D

http://rightsstatements.org/vocab/InC/1.0/

For information on re-use see:
http://digital.library.wisc.edu/1711.dl/Copyright

The libraries provide public access to a wide range of material, including online exhibits, digitized collections, archival finding aids, our catalog, online articles, and a growing range of materials in many media.

When possible, we provide rights information in catalog records, finding aids, and other metadata that accompanies collections or items. However, it is always the user's obligation to evaluate copyright and rights issues in light of their own use.

728 State Street | Madison, Wisconsin 53706 | library.wisc.edu

APPENDIX 3

CULLATON LAKE MINE

TECHNICAL REPORTS CENTER
K.F. WENDT ENGR. LIBRARY
UW - MADISON

0940-1
Nunavut District

HOMESTAKE

INDIAN AND NORTHERN AFFAIRS — CANADA
N.W.T. REGION
MAR 1 2 1997
WATER RESOURCES DIVISION
YELLOWKNIFE, NT

March 10, 1997

Philippe di Pizzo, Executive Director
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NT
X0E 1J0

Dear Mr. di Pizzo;

Re: Cullaton Lake - Water Licence N6L2-0940

Pursuant to the terms of our Water Licence, we are pleased to submit the 1996 Annual Report. The report summarizes A & R activities undertaken at the Cullaton property during the past year, as well as water sampling results and thermistor data.

The Geotechnical Inspection Report completed last year, as a requirement of our licence, has also been appended to the Annual Report.

I trust the above is satisfactory. Should you require additional information or if you have any questions please contact the undersigned.

Sincerely,
HOMESTAKE CANADA INC.

Sharon Meyer

Sharon Meyer
Environmental Analyst

Distribution:

	Nunavut Water Board	4 copies
	DIAND, Water Resources, Yellowknife	1 copy
	DIAND, Water Resources, Iqaluit	1 copy

Homestake Canada Inc.
P.O. Box 11115 • 1100 - 1055 West Georgia Street • Vancouver, BC V6E 3P3 • Phone (604) 684-2345 • Fax: (604) 684-9831

C-7

INDIAN AND NORTHERN
AFFAIRS — CANADA
N.W.T. REGION

MAR 1 2 1997

WATER RESOURCES
DIVISION
YELLOWKNIFE, N.W.T.

CULLATON LAKE GOLD MINES LTD

WATER LICENCE N6L2-0940

ANNUAL WATER LICENCE REPORT 1996

PREPARED BY:
HOMESTAKE CANADA INC
P.O. BOX 11115, 1100 - 1055 WEST GEORGIA STREET
VANCOUVER, B.C.
V6E 3P3

March 1997

TABLE OF CONTENTS

PREAMBLE

1.0 HIGHLIGHTS

2.0 DETAILED SUMMARY

2.1 WATER LICENCE RENEWAL

2.2 WATER QUALITY MONITORING

2.3 TAILINGS

2.4 THERMISTORS

2.5 ROCK QUARRY

2.6 MILL COMPLEX DISMANTLING

2.7 STUDIES AT CULLATON LAKE
- 2.7.1 CANMET Reports
- 2.7.2 Oxidation Study
- 2.7.3 Geotechnical Report

2.8 MISCELLANEOUS

3.0 1997 PROPOSED WORK PROGRAM

APPENDIX 1 Map of Tailings Area Water Sampling Locations
Water Quality Data
Thermistor Data

APPENDIX 2 Oxidation Study
Geotechnical Inspection Report
DIAND Inspection Report

PREAMBLE

The Cullaton Lake Gold Mines property is located in the southern part of the District of Keewatin in the Northwest Territories. The property is 250 km west of Arviat, N.W.T., 400 km northwest of Churchill, Manitoba and 645 km north of Thompson Manitoba. The mine was in operation for four years, from 1981 to 1985. Since September 1985 the mine has remained in a care, maintenance and decommissioning phase.

Cullaton Lake Gold Mines Ltd. is wholly owned by Homestake Canada Inc.

The current water licence (N6L2 - 0940) from the Northwest Territories Water Board was renewed on September 1, 1995 and is effective until August 31, 1999. In July 1996 the water licence was transferred to the jurisdiction of the Nunavut Water Board.

As per this Water Licence, the Company is required to file a yearly report pursuant to Section 13(2) of the Northern Inland Waters Act and Section 15(1) of the Regulations, outlining details on water use or waste disposal at Cullaton Lake Gold Mine.
□

1.0 HIGHLIGHTS

A Draft Abandonment and Restoration Plan was submitted to DIAND and the Northwest Territories Water Board in April 1995. Comments were received following this submission. A revised Abandonment and Restoration (A & R) Plan was submitted in March 1996 to both DIAND and the Northwest Territories (NWT) Water Board. This A & R Plan was subsequently forwarded to the Nunavut Water Board.

The Cullaton Lake water licence was renewed as a B Licence on September 1, 1995 for a period of 4 years. It expires August 31, 1999. In July 1996 the water licence was transferred from the NWT Water Board to the jurisdiction of the Nunavut Water Board.

Homestake Canada personnel presented an overview of the proposed 1996 decommissioning work to the NWT Water Board Technical Advisory Committee on June 3, 1996. A similar presentation was made to the Nunavut Water Board on October 30, 1996.

Phase 2 of the *Cold Storage Kinetic Tests* report was submitted to DIAND and to the Nunavut Water Board on August 12, 1996.

Beak Consultants Ltd. completed an oxygen consumption study on the covered tailings during the summer. The resultant report was forwarded to DIAND, Water Resources Division and the Nunavut Water Board on December 5, 1996.

A geotechnical inspection of the tailings dam was completed by Trow Consulting Engineers during the period of September 15 - 18, 1996. Copies of the report were forwarded to DIAND, Water Resources Division and the Nunavut Water Board on December 6, 1996.

Decommissioning and Reclamation International Inc. (DRI) was on site during the summer and fall to continue the decommissioning work. Personnel from J. P. Consulting & Services, contracted by Homestake, accompanied the decommissioning crew to oversee the decommissioning work.

Water samples were taken on July 4, July 12 and Sept 20, 1996. Thermistor readings were taken on June 21, September 19 and September 26 as part of ongoing monitoring of the temperature regime in the tailings.

Paul Smith, Inspector under the Northwest Territories Water Act, carried out a water licence inspection on August 17, 1996.

□

2.0 DETAILED SUMMARY

2.1 WATER LICENCE RENEWAL

Homestake applied for a water licence renewal on April 28, 1995. A revised 'B' Licence was granted effective September 1, 1995, expiring August 31, 1999. As part of the licence renewal, the Company submitted a revised Abandonment and Restoration Plan in 1996 to DIAND, to the NWT Water Board and to the Nunavut Water Board.

2.2 WATER QUALITY MONITORING

Water sampling continued at Cullaton Lake Mine this year. Sampling is required at 6 stations, once in the late spring and once again after August 1. Water was sampled three times during the summer season, twice in July (once by government personnel), and again in September. In September, Station 940-22 had no visible seepage, therefore no water sample was taken. All sampling results were well within the limits prescribed in the Water Licence N6L2-0940. See Appendix 1 for water quality results.

A DIAND Water Resources inspection was conducted on August 12. A copy of the inspection report and the Company's response is attached in Appendix 2.

2.3 TAILINGS

Trow Consulting Engineers completed a geotechnical inspection of the tailings area dams this summer. The inspection report concluded that the tailings dams are stable under the current site conditions. A recommendation that the exposed liner on tailings Dam 2 be removed, will be followed up in 1997. The inspection report is attached in Appendix 2.

Homestake staff competed an inspection of the tailings area during a site visit in September 1996. After digging into the tailings overburden material in a number of locations across the tailings, it was found that the depth of overburden material was less than the 1.4 metres of material described in the Abandonment and Restoration Plan. As a result of this finding, the Company has arranged for the placement of additional cover material on the tailings in 1997.

2.4 THERMISTORS

In order to prevent possible acid generation, reclamation of the tailings area has involved two oxygen-limiting methods; a water cover overlying the eastern portion of the tailings impoundment area and a till / mine rock cover on the remaining Shear and B-Zone tailings area. The application of the till / mine rock cover was intended to reduce oxygen infiltration, and to raise the level of

permafrost in the tailings. Raising the permafrost level in the tailings will help to retain them in a permanently frozen condition which may prevent development and migration of acid drainage. Thermistors were installed in the covered tailings in August 1991 in order to monitor any rise in permafrost levels.

Thermistor readings have been taken during the spring and late summer months since 1991. Readings from 1992 to 1994 show an upward trend in the permafrost levels. In 1995 the level remained steady. The depth of the summer active zone has been observed to have decreased over the years from 2.8 m to approximately 2.3 m in depth.

In 1996 thermistor readings were taken at Thermistors # 1, 2, 3, and 4 once in June and twice in September (see Appendix 1). At the end of the 1996 summer season, the depth of the active zone remained stationary with respect to 1995 readings. With the placement of additional overburden on the tailings in 1997 (see Section 2.3) we anticipate seeing a resumption in the upward trend in permafrost levels in the future.

2.5 ROCK QUARRY

During the Company's 1995 meeting in Yellowknife with DIAND and the NWT Water Board, agreement was reached to use the quarry pit for disposal of non-salvageable materials. During 1995 some of the non-salvageable materials from the dismantling of the primary mill building were placed in the quarry. Other non-salvageable materials were placed alongside the quarry pit for crushing and burial in 1996. In 1996, the DRI decommissioning crew moved the remainder of the non-salvageable material to the quarry pit for crushing and burial. Some of this material was buried; the remainder will be crushed and buried in the pit in 1997.

2.6 MILL COMPLEX DISMANTLING

The decommissioning crew was on site from June 26 to July 31, and again from August 28 to September 18. During that time the remainder of the mill and auxiliary buildings were dismantled, as were the accommodation buildings.

Inert, non-salvageable material was placed adjacent to the quarry pit for crushing and burial. Salvageable equipment was either flown to Thompson, Manitoba or Arviat, NWT, or was stacked at the airstrip for removal by ice train during the winter of 1996/97 and in 1997 by Hercules transport.

The crew returned for a week in November to prepare the site for next season.

2.7 STUDIES AT CULLATON LAKE

2.7.1 CANMET reports: Phase 1 and Phase 2

The *Phase 2: Cold Temperature Leaching* report was completed by CANMET and received by Homestake Canada in mid-1996. The report was distributed to DIAND, the NWT Water Board and the Nunavut Water Board late in 1996. The CANMET study, *Phases 1 and 2*, is now complete. The study concludes that, under laboratory conditions, oxidation and acid generation occur in both the B Zone and Shear Zone tailings. However, the rate of acid generation is low and decreases with a decrease in temperature. As noted above, HCI has chosen to cover a portion of the tailings with a water cover and a portion with overburden to reduce oxidation.

2.7.2 Oxidation Study

An oxygen consumption survey of the covered tailings was completed this year by Beak Consultants. The study results indicate that covering the tailings material has resulted in an overall decrease, by one order of magnitude, of oxygen consumption within the tailing mass. See Appendix 2 for a copy of the report.

2.7.3 Geotechnical Report of Tailings Containment Area

A geotechnical survey was carried out this year. The report concludes that the tailings dams appear to be in good condition with no signs or distress or erosion. A copy of the report is attached in Appendix 2.

2.8 MISCELLANEOUS

Equipment required for hauling and spreading fill, and for general maintenance remains at the site. This includes a 426 JCI truck, a D8K, 415 JCI truck, 966D loader, 950 loader, cargo truck, fuel truck and two jeeps.

3.0 1997 PROPOSED WORK SCHEDULE

Homestake Canada Inc. intends to complete the remaining decommissioning work in 1997. This includes removing the remaining Atco buildings, removing all salvageable material from the site, and disposing of all non-salvageable material as per our revised A & R Plan.

As well, the crew will cover portions of the tailings area with additional overburden, and seed and fertilize the tailings area and portions of the decommissioned mill site. Selection of seed has been made based on results of a vegetation survey completed during the September site visit, and subsequent discussion with an arctic vegetation consultant (Alaska Biological Research, ABR Inc.). Seed selection may include *Poa glauca* (Tundra Bluegrass), *Poa*

arctica (Alpine Bluegrass), *Arctagrostis latifolia* (Alyeska Polargrass), *Festuca ruba* (Arctared Fescue), and *Deschampsia caespitosa* (Tufted Hairgrass). Final selection will depend upon commercial availability.

APPENDIX 1

Water Quality Data
Thermistor Data

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-2: POND #1 DISCHARGE

Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	<0.001	<0.01	0.007	<0.05	<0.05	<0.01	3.5
07/12/96	0.0087	0.0007	0.043	0.006	0.0035	<0.005	
09/20/96	<0.001	<0.01	0.002	<0.05	<0.05	<0.01	2.0
JUN 1996 - SEP 1996							
Mean	0.0036	0.0069	0.017	0.035	0.0345	0.008	2.8
Minimum Value	0.0010	0.0007	0.002	0.006	0.0035	0.005	2.0
Maximum Value	0.0087	0.0100	0.043	0.050	0.0500	0.010	3.5

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-3: POND #2 DISCHARGE

Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	0.001	0.14	0.002	0.16	<0.05	0.04	1.5
07/12/96	0.0021	0.0043	<0.004	<0.002	0.0038	<0.005	
09/20/96	<0.001	<0.01	0.001	<0.05	<0.05	0.02	1.6
JUN 1996 - SEP 1996							
Mean	0.0014	0.0514	0.002	0.071	0.0346	0.022	1.6
Minimum Value	0.0010	0.0043	0.001	0.002	0.0038	0.005	1.5
Maximum Value	0.0021	0.1400	0.004	0.160	0.0500	0.040	1.6

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-18: TAILINGS POND #1 SPILLWAY

Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	0.001	<0.01	0.007	<0.05	<0.05	<0.01	2.8
09/20/96	<0.001	<0.01	0.002	<0.05	<0.05	<0.01	1.0
JUN 1996 - SEP 1996							
Mean	0.001	0.01	0.005	0.05	0.05	0.01	1.9
Minimum Value	0.001	0.01	0.002	0.05	0.05	0.01	1.0
Maximum Value	0.001	0.01	0.007	0.05	0.05	0.01	2.8

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-19: TAILINGS POND #1 PIESOMETER

Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	0.001	<0.01	0.007	<0.05	<0.05	<0.01	12.4
09/20/96	<0.001	<0.01	0.002	<0.05	<0.05	<0.01	1.2
JUN 1996 - SEP 1996							
Mean	0.001	0.01	0.005	0.05	0.05	0.01	6.8
Minimum Value	0.001	0.01	0.002	0.05	0.05	0.01	1.2
Maximum Value	0.001	0.01	0.007	0.05	0.05	0.01	12.4

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-20: EAST SIDE OF TAILINGS POND #1

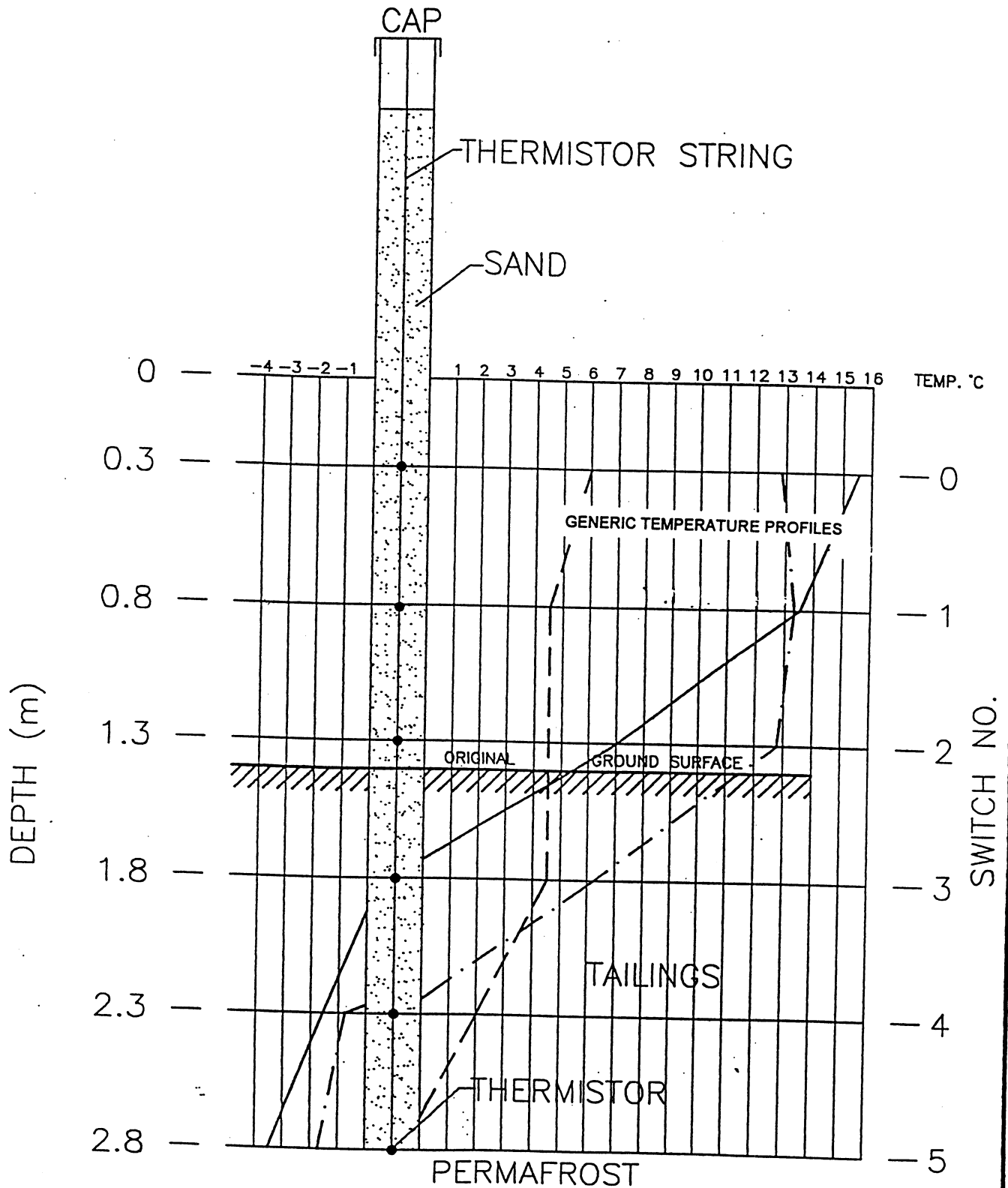
Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	0.001	<0.01	0.007	<0.05	<0.05	0.01	4.3
09/20/96	<0.001	<0.01	0.001	<0.05	<0.05	0.02	2.7
JUN 1996 - SEP 1996							
Mean	0.001	0.01	0.004	0.05	0.05	0.01	3.5
Minimum Value	0.001	0.01	0.001	0.05	0.05	0.01	2.7
Maximum Value	0.001	0.01	0.007	0.05	0.05	0.02	4.3

HOMESTAKE CANADA INC.
Cullaton Lake Water Quality
1996

STATION: 940-22: TAILINGS POND #1 NE CORNER

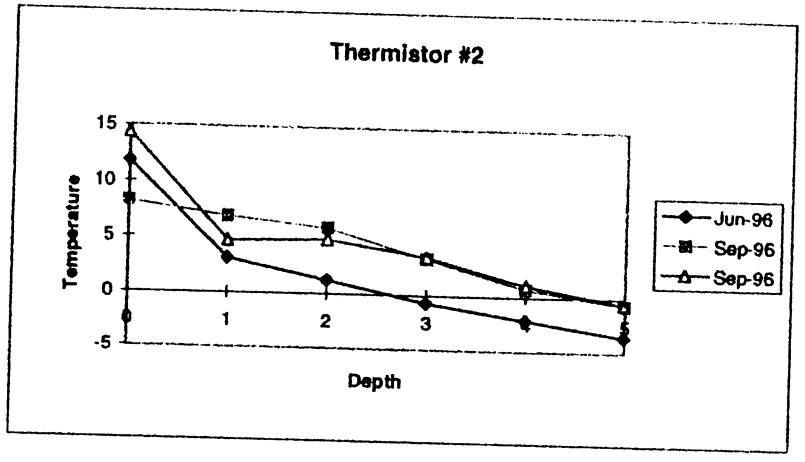
Date	TOTAL ARSENIC mg/l	TOTAL COPPER mg/l	TOTAL CYANIDE mg/l	TOTAL LEAD mg/l	TOTAL NICKEL mg/l	TOTAL ZINC mg/l	SUSPENDED SOLIDS mg/l
07/04/96	0.001	<0.01	0.007	<0.05	<0.05	<0.01	3.8
JUN 1996 - SEP 1996							
Mean	0.001	0.01	0.007	0.05	0.05	0.01	3.8
Minimum Value	0.001	0.01	0.007	0.05	0.05	0.01	3.8
Maximum Value	0.001	0.01	0.007	0.05	0.05	0.01	3.8

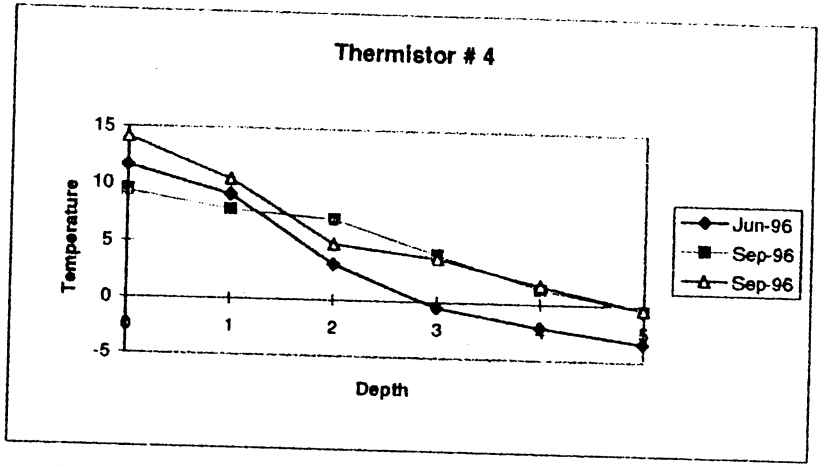
	TEMP. AT	CULLATON LAKE THERMISTORS (1991 TO 1996)													
No.1	0	1	2	3	4	5			No.2	0	1	2	3	4	5
Aug-91	13.2	12.8	10.8	7.2	5.2	0.8			Aug-91	13	13	13.2	10.2	6	0.5
Sep-91	11	11.2	8.8	5.4	3	0.5			Sep-91	10.8	11	10	5.2	3	0.4
Jul-92	13.5	13.6	13.5	4.4	-0.9	-2.1			Jul-92	13.3	13.6	13.4	6.2	-0.5	-2
Aug-92	6.2	5.1	5.1	3.6	0.9	-0.4			Aug-92	6.5	5.5	5.2	4.7	2.3	-0.2
Jul-93	33.1	16	6.8	0	-1.3	-2.1			Jul-93	34.5	29.4	12.4	5.2	-0.5	-1.8
Jul-93	13.7	12	7.6	1.5	-1	-1.8			Jul-93	13.7	13.4	12.3	7.8	0.6	-1.4
Jun-94	15.6	11.3	5	-0.2	-2.1	-3.3			Jun-94	15.4	15.3	9.3	2.4	-1.1	-3
Jul-94	15.6	11.3	4.6	-0.7	-2.6	-3.6			Jul-94	15.4	15.2	8	1.7	-1.8	-3.4
Jul-94	19.6	14	9.2	4.9	-0.2	-1.3			Jul-94	20.2	19.3	11.1	9.1	2.2	-1
Sep-94	23	14	8.4	4.7	1.1	-0.9			Sep-94	16.9	9.4	7.7	5.5	2.6	-0.2
Jun-95	35.99	18.51	3.74	-0.76	-2.18	-3.13			Jun-95	29.36	7.07	0.64	-1.15	-2.16	-3.43
Sep-95	7.36	5.25	2.97	1.44	0.32	-0.27			Sep-95	7.45	3.33	2.16	0.82	0.08	-0.6
Oct-95	3.42	1.64	1.73	1.25	0.41	-0.26			Oct-95	3.11	1.23	1.51	0.84	-0.38	-0.56
Jun-96	12.06	7.36	2.05	-0.32	-1.95	-3.22			Jun-96	11.81	3.12	1.23	-0.74	-2.15	-3.56
Sep-96	7.9	6.4	7.7	4.8	1.8	-0.2			Sep-96	8.12	6.89	5.93	3.26	0.72	-0.64
Sep-96	10.1	8.6	5.3	4.5	2.2	-0.1			Sep-96	14.37	4.71	4.89	3.48	1.07	-0.57
No.3	0	1	2	3	4	5			No.4	0	1	2	3	4	5
Aug-91	12.8	13	12.8	11	6.5	0.8			Aug-91	15	14.2	16.8	12	6.2	1
Sep-91	9.8	9.2	8.4	5.8	3.2	0.5			Sep-91	11	11.5	11	6.8	4	0.6
Jul-92	12.8	12.6	12.5	5.2	-0.6	-1.9			Jul-92	12.9	13.3	12.7	5.2	-0.7	-1.7
Aug-92	6.2	4.7	4.6	4.1	2	-0.2			Aug-92	6	4.8	4.6	4.5	2	-0.2
Jul-93	32.5	22	9.2	1.2	-0.9	-1.9			Jul-93	32.9	22	9.2	1	-1	-1
Jul-93	13.8	13.1	10	3.4	-0.6	-1.5			Jul-93	13.4	12.9	10.5	-3	-0.7	-1.5
Jun-94	15.3	13.6	7	0.1	-1.7	-3.3			Jun-94	15.4	13.3	6.7	-0.1	-2	-3.1
Jul-94	15.3	13.6	6.8	0	-1.8	-3.5			Jul-94	15.4	13.2	6.7	-0.2	-2	-3.2
Jul-94	20.2	18.5	10.1	5.7	0.1	-1.3			Jul-94	19.5	14.5	6.8	4.2	-0.4	-1.5
Sep-94	21.3	10	7.3	4.5	1.6	-0.4			Sep-94	23.1	17.5	6.8	4.5	1	-0.6
Jun-95	32.39	8.71	-0.2	-1.93	-3.23	-4.2			Jun-95	36.25	25.04	5.79	-1.02	-2.38	-3.53
Sep-95	7.53	4.34	2.25	0.89	0.12	-0.48			Sep-95	7.29	4.79	3.43	1.13	0.18	-0.39
Oct-95	3.45	1.76	1.57	1	0.12	-0.44			Oct-95	3.57	2.16	1.29	0.95	0.22	-0.39
Jun-96	11.65	4.86	1.33	-0.84	-2.47	-3.82			Jun-96	11.6	9.17	3.19	-0.51	-2.13	-3.42
Sep-96	8.5	7.51	6.49	3.33	0.7	-0.48			Sep-96	9.33	7.83	7.16	4.18	1.29	-0.43
Sep-96	13.25	6.4	5.19	3.65	1.09	-0.39			Sep-96	14.11	10.54	4.95	3.85	1.63	-0.35

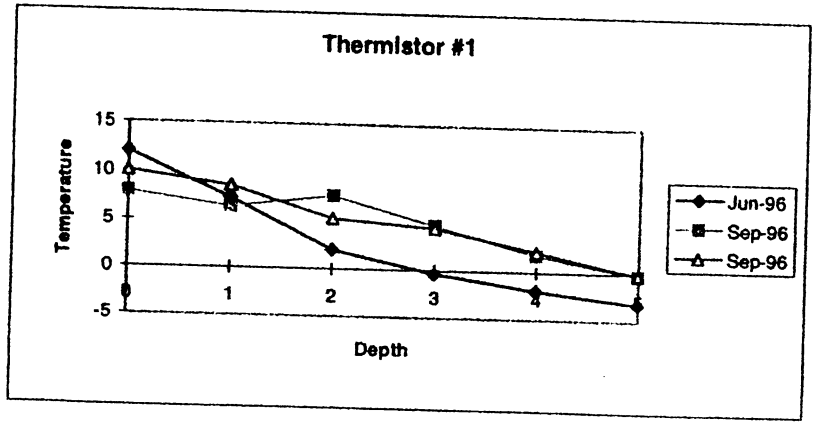


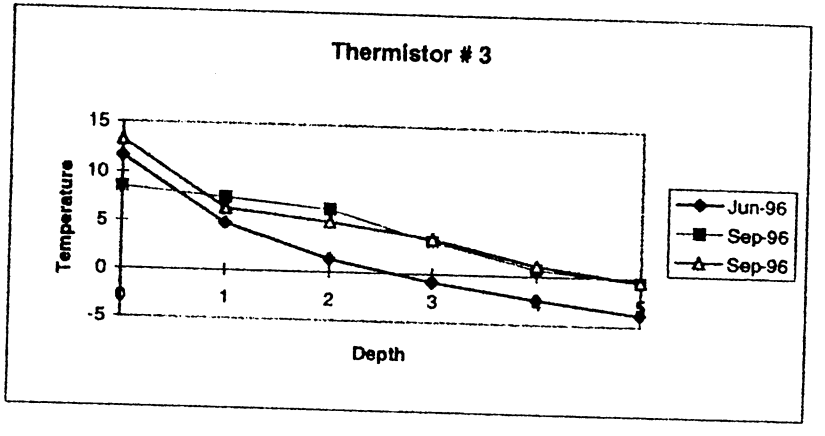
THERMISTOR STRING CONFIGURATION

INSTALLED AUGUST 23, 1991


Thermistor #2
Temperature
15
10
5
0
-5
0
1
2
3
4
5
Depth
Jun-96
Sep-96
Sep-96


Thermistor # 4
Temperature
15
10
5
0
-5
0
1
2
3
4
5
Depth
Jun-96
Sep-96
Sep-96


Thermistor #1
Temperature
15
10
5
0
-5
0
1
2
3
4
5
Depth
Jun-96
Sep-96
Sep-96


Thermistor # 3
Temperature
15
10
5
0
-5
0
1
2
3
4
5
Depth
Jun-96
Sep-96
Sep-96

APPENDIX 2

Oxidation Study
Geotechnical Inspection Report
DIAND Inspection Report

AN OXYGEN CONSUMPTION SURVEY OF THE SULPHIDE TAILINGS AT CULLATON LAKE, N.W.T.

Final Report to:

HOMESTAKE CANADA INC.

Prepared by:

BEAK INTERNATIONAL
INCORPORATED
14 Abacus Road
Brampton, Ontario
L6T 5B7

November 1996
BEAK Ref. 20532.1

PRINTED ON RECYCLED PAPER

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	FIELD SITE BACKGROUND	2
3.0	METHODS AND MEASUREMENTS	3
	3.1 Oxygen Consumption Data Collection	4
	3.2 Correction of Temperature Induced Sensor Drift	5
	3.3 Calculation of Oxidation Rates and Loadings	5
4.0	RESULTS	7
5.0	DISCUSSION	8
	5.1 Effect of Cover	8
	5.2 Implications for Water Quality	8
	5.3 Contrasts Between the Shear and "B" Zone Tailings	9
6.0	CONCLUSIONS	11
7.0	RECOMMENDATIONS	12
8.0	REFERENCES	13

APPENDIX A

PRINTED ON RECYCLED PAPER

1.0 INTRODUCTION

The Cullaton Lake property is a former gold mine that has been decommissioned. The focus of this investigation is the non-flooded portion of the tailings impoundment that occupies an area of approximately 6 hectares adjacent to the former mill site. The tailings were covered by a coarse-grained layer of gravel-boulder sandy till mixed with blast rock. The purpose of the cover was two-fold: firstly, to decrease oxygen migration into the tailings and, secondly, to provide thermal insulation to encourage the development of permafrost conditions in the tailings. It was expected that permafrost conditions in the tailings would prevent oxidation of the sulphide minerals and subsequent impact on the quality of water adjacent to the tailings. BEAK was contracted by Homestake Canada Inc. to provide a rapid assessment of the oxidation status of the non-flooded tailings using a newly developed field technique referred to as an Oxygen Consumption Measurement.

The purpose of this investigation was to measure the rates of oxidation of the existing tailings under the coarse-grained cover. These measurements were made over a one week period in July 1996 at 17 locations across the covered tailings. Control measurements were also made on a small area of uncovered tailings and on tailings with the cover temporarily removed by excavating a small diameter hole through the cover material. The resulting oxygen consumption measurements were used to calculate the rate of sulphide mineral oxidation in the tailings. The effects of the present cover were compared to the probable condition in uncovered tailings. The implications of the existing conditions and recommendations for further action are discussed.

PRINTED ON RECYCLED PAPER

2.0 FIELD SITE BACKGROUND

The Cullaton Lake tailings impoundment is located at the former Cullaton Lake Gold Mines Ltd. location in the district of Nunavut, Keewaitin Sub-District of the Northwest Territories. The property is located approximately 620 km north of Thompson, Manitoba and 416 km northwest of Churchill, Manitoba. The site is underlain by continuous permafrost that develops a moderate active zone during the summer season. The property is owned by Homestake Canada Inc. and has been under care and maintenance since September 1985 when production ceased. As part of their Abandonment and Restoration Plan, the tailings impoundment was covered with a waste rock and overburden cover to act as an oxygen diffusion barrier and to promote the development of permafrost conditions in the tailings and subsequently limit sulphide mineral oxidation.

The tailings impoundment consists of two tailings derived from two distinct ore bodies, the Shear Zone and the "B" Zone ores. The "B" Zone deposit is a gold bearing iron formation located in a turbiditic sedimentary basin that forms part of the Rankin Inlet - Ennadi Archean greenstone belt . Pyrrhotite and pyrite are the dominate sulphide minerals present, with minor amounts of arsenopyrite and chalcopyrite. The Shear Zone is a discontinuous ridge of orthoquartzite with gold mineralization found in altered shears, breccias, pyritic shears, and pyritic sericitic impure quartzite. The dominate sulphide mineral in the Shear Zone is pyrite (Clulow 1996).

PRINTED ON RECYCLED PAPER

3.0 METHODS AND MEASUREMENTS

On site work was conducted during the period of July 25th through July 31st. During this time testing equipment was installed and oxygen consumption method measurements were conducted.

The Oxygen Consumption Method testing procedure consists of the installation of 7" O.D., thin-wall aluminum tubing vertically through the tailings cover and into the tailings below (see Appendix A for a detailed description of the method). This establishes a well defined testing area on the tailings. Aluminum tubes are usually installed by pounding with a sledge and collar system but the cobbley nature of the cover precluded tube installation using this method. To facilitate installation, the cover was manually excavated and the underlying tailings exposed. The tubes were then pounded into the tailings until remaining stick-up was approximately equal to the cover thickness at that location. The cover was replaced both around and in the tube and compacted to approximate the original cover composition. The tube was then left approximately 48 hours to allow for the re-establishment of steady-state oxygen profiles.

A small headspace (0.01 to 0.02 m) above the cover surface was maintained in the tube. This headspace was capped for a short period of time, usually 1 to 2 hours, for the actual oxygen consumption determination. Time series data for oxygen concentration in the headspace and ambient temperature were collected using a laptop computer and datalogger system. Ambient temperature data was recorded to allow for data correction of errors induced due to temperature fluctuations.

The cover thickness at the Cullaton Lake site has been reported at 1.5 m. However during this visit and the installation of 17 oxygen consumption method test points the greatest cover thickness encountered was 0.90 m. Table 1 details the cover thickness at the testing point locations.

PRINTED ON RECYCLED PAPER

TABLE 1: COVER THICKNESS AT TESTING LOCATIONS

	Thickness (m)
TRANSECT 1	
A	61
B	89
C	71
D	70
E	62
F	68
G	69
H	58
J	62
Average	**68**
TRANSECT 2	
A	72
B	67
C	60
Average	**76**
TRANSECT 3	
A	90
B	90
C	88
Average	**89**

The overall average cover thickness based on observed data is considerably less than the designed thickness of 1.5 m. Two small areas located on the tailings impoundment exhibited bare tailings with no cover. One area was comprised of exposed tailings with partially established vegetation. This area was located on the "B" Zone tailings. The second area was located on the Shear Zone tailings and was comprised of exposed tailings with minor water ponding.

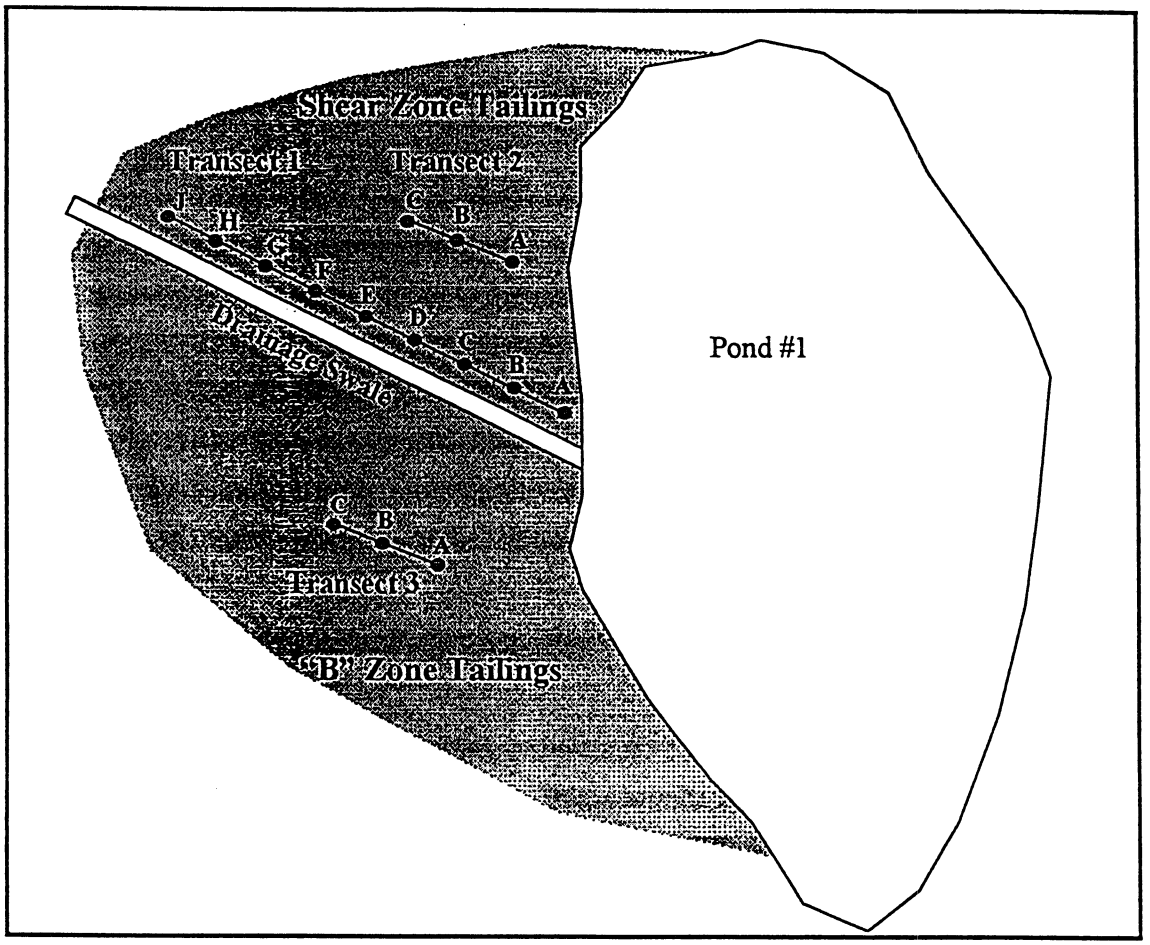
Three transects were installed on the Cullaton Lake tailings impoundment and are shown in Figure 1. Transect #1 is parallel to the drainage swale that bisects the impoundment. Transect #1 is located on Shear Zone tailings covered by cobbley till cover and consists of nine testing points at a 15 m spacing. These are labeled 1A-1J (to prevent possible confusion the letter "i" was not used). Tube 1A is located 3 m from the shore of Pond #1. Transect #2 is also located on the covered Shear Zone tailings. This transect consists of three testing points with a spacing of 15 m. These are identified as 2A, 2B, and 2C. Tube 2A is 25 m from the shore of pond #1. Transect #2 is parallel to Transect #1 at a distance of approximately 100 m. Transect #3 is located on the covered "B" Zone tailings. This transect also consists of three testing points with a spacing of 15 m. These are identified as 3A, 3B, and 3C. Tube 3A is approximately 50 m from the shore of pond #1. Transect #3 is also parallel to the drainage swale and is located approximately 200 m from Transect #1. In addition to the three transects two tests were performed on Shear Zone tailings without cover. One of there tests was conducted on the area of exposed tailings with minor water ponding. Despite the high moisture content evident by local ponding, this test yielded a high oxidation rate. This testing point is referred to as the control for Transect 1 and was located near testing point F. The second test on uncovered Shear Zone tailings was conducted by the manual removal of the cover and the installation of a testing point. This testing point is referred to as the control of Transect 2 and was located at Transect 2 testing point C.

3.1 Oxygen Consumption Data Collection

The sampling tubes were temporally closed with an air tight cap to measure the flux of oxygen into the tailings. Sensors located in the cap measure gaseous oxygen content in the sealed headspace of the tube as well as temperature. The measurement is conducted over 1 to 2 hours with readings recorded every minute. The resultant time series of oxygen content values are corrected for sensor drift induced by temperature fluctuations

PRINTED ON RECYCLED PAPER

FIGURE 1: LOCATION OF OXYGEN CONSUMPTION METHOD TRANSECTS AND TEST POINTS



and reduced to provide a value corresponding to flux of oxygen across the air-tailings boundary.

Due to the brevity of the field visit duplicate testing was not possible. Valid test data were collected on 13 of the 15 tubes installed in the cover and on both control testing points located on the Shear Zone tailings. An example of a plot of oxygen log normalized concentration over time in the headspace of the tube is shown in Figure 2.

3.2 Correction of Temperature Induced Sensor Drift

The oxygen sensors exhibit an inverse relationship between temperature and oxygen concentration reading due to the exothermic nature of the electrolytic reaction employed by the sensor in the measurement of oxygen. A decrease in ambient temperature during the test could cause a false low to be calculated for the oxygen consumption rate and conversely, warming during a test could cause a false high calculation of flux. A temperature correction factor for the sensor was developed in the laboratory. The average temperature fluctuation measured during flux measurements was always less than 3^0C for any individual test. The temperature correction factor was employed on all data collected.

3.3 Calculation of Oxidation Rates and Loadings

Data derived from the oxygen consumption method provide flux values with the units of moles O_2 consumed per unit area of tailings surface per unit time. This can be converted to a mass flux of products per area of tailings surface per time based on the oxidation equations for the sulphide minerals present, and further converted into an equivalent mass of $CaCO_3$ required for neutralization.

The oxidation of pyrite can be described by the following two equations

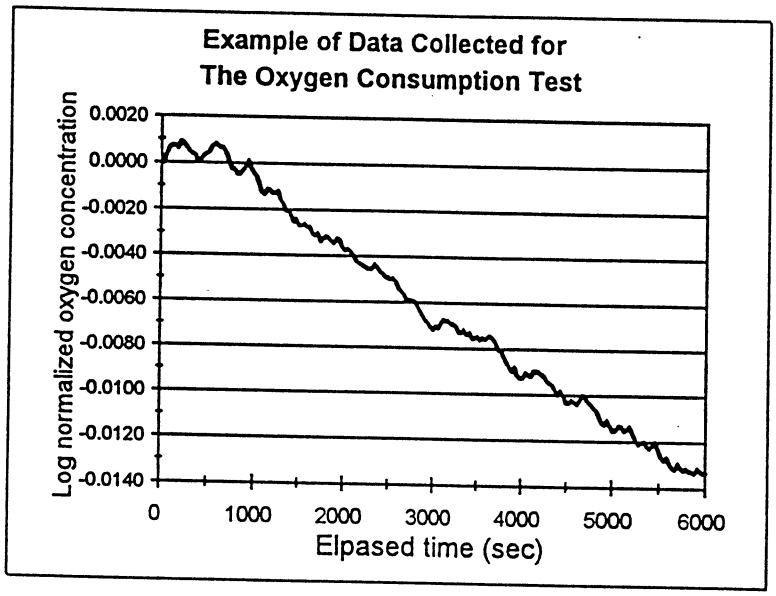
$$FeS_2 + {}^7/_2O_{2(g)} + H_2O \longrightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad (1)$$

$$Fe^{2+} + {}^1/_4O_{2(g)} + {}^5/_2H_2O \longrightarrow Fe(OH)_3 + 2H^+ \quad (2)$$

Assuming that complete oxidation occurs as described in equations 1 and 2 the overall reaction can be written as:

PRINTED ON RECYCLED PAPER

FIGURE 2: PLOT OF LOG NORMALIZED OXYGEN CONCENTRATION VERSUS TIME FOR A TYPICAL OXYGEN CONSUMPTION TEST



$$FeS_2 + {}^{15}/_4O_{2(g)} + {}^{7}/_2H_2O \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4H^+ \quad (3)$$

Similarly the oxidation of pyrrhotite can be described as:

$$Fe(1-x)S + (2-({}^{x}/_2))O_{2(g)} + xH_2O \longrightarrow 2SO_4^{2-} + (1-x)Fe^{2+} + 2xH^+ \quad (4)$$

Where x varies between 0 and 0.125 depending on the crystallographic structure. For the purposes of calculating acid production estimates for this study the oxidation of pyrrhotite can be described by the sulphide reaction:

$$FeS + 2O_{2(g)} \longrightarrow SO_4^{2-} + Fe^{2+} \quad (5)$$

Similar to the Fe^{2+} generated by the oxidation of pyrite, the Fe^{2+} generated in equation (5) can be further oxidized as described in equation (2). Thus the overall oxidation of pyrrhotite can be written as:

$$FeS + {}^{9}/_2O_2 + {}^{5}/_2H_2O \longrightarrow SO_4^{2-} + Fe(OH)_3 + 2H^+ \quad (6)$$

From Equation (3) it can be seen that the consumption of 1 mole of O_2 through pyrite oxidation can ultimately generate 1.07 moles of acid. Similarly one mole of O_2 consumed through pyrrhotite oxidation can generate 0.44 moles of acid. It is this generated acid that can lead to the degradation of receiving waterbodies due to acidification and mobilization of trace metals such as zinc and nickel that are often associated with mine tailings.

The buffering of the acid generated from the above equations is usually reported as the mass of equivalent calcite ($CaCO_3$) required for neutralization. The equation that governs this buffering can be expressed as:

$$CaCO_3 + H^+ \longrightarrow Ca^{2+} + HCO_3^- \quad (7)$$

From equation (7) we see that one mole of calcite is required for the neutralization of one mole of acid generated under near neutral conditions.

PRINTED ON RECYCLED PAPER

4.0 RESULTS

Data derived from the oxygen consumption method provide a measurement of the flux of oxygen with the units of moles O_2 consumed per unit area of tailings surface per unit time. This can be converted to a mass flux of products per area per time based on the oxidation equations for the sulphide minerals present (equations 3, and 6), and further converted into an equivalent mass of $CaCO_3$ required for neutralization. Based on these manipulations the results for the Cullaton Lake tailings impoundment are listed in Tables 2a-c. Results for the "B" Zone tailings were calculated assuming the sulphide minerals oxidizing are 1) pyrite only and 2) a mixture of pyrite and pyrrhotite in equal proportions.

PRINTED ON RECYCLED PAPER

TABLE 2a: OXYGEN CONSUMPTION VALUES AND EQUIVALENT RATES OF ACID GENERATION GIVEN AS $CaCO_3$ IN TONNES PER HECTARE PER YEAR FOR TRANSECT 1, SHEAR ZONE TAILINGS

Test Location	Moles $O_2/m^2/a$	Equiv. $CaCO_3$ (tonnes/ha/a)
Control	128	73-137
Tube A	33	19-35
Tube B	22	13-24
Tube C	14	8-15
Tube D	12	7-14
Tube E	3	2-3
Tube G	7	4-8
Tube H	3	2-3

TABLE 2b: OXYGEN CONSUMPTION VALUES AND EQUIVALENT RATES OF ACID GENERATION GIVEN AS $CaCO_3$ IN TONNES PER HECTARE PER YEAR FOR TRANSECT 2, SHEAR ZONE TAILINGS

Test Location	Moles $O_2/m^2/a$	Equiv. $CaCO_3$ (tonnes/ha/a)
Control	82	47-88
Tube A	2	1-2
Tube B	<0.1	<0.09
Tube C	7	4-7

Note: The calculated range for equivalent $CaCO_3$ is based on the oxidation of pyrite as described in equations 1 and 2.

TABLE 2c: OXYGEN CONSUMPTION VALUES AND EQUIVALENT RATES OF ACID GENERATION GIVEN AS $CaCO_3$ IN TONNES PER HECTARE PER YEAR FOR TRANSECT 3, "B" ZONE TAILINGS

Test Location	Moles $O_2/m^2/a$	[1]Equiv. $CaCO_3$ (tonnes/ha/a)	[2]Equiv. $CaCO_3$ (tonnes/ha/a)
Tube A	9	5-10	5-7
Tube B	9	5-10	5-7
Tube C	12	7-13	7-10

Note: [1] Assumes only pyrite present.
[2] Assumes equal parts of pyrrhotite and pyrite present.

5.0 DISCUSSION

5.1 Effect of Cover

The application of the waste rock and overburden cover can potentially lower oxidation rates and subsequent acid generation by acting as a thermal blanket promoting permafrost development in the tailings, by acting as a diffusion barrier for oxygen transport, and by limiting evapotransporation and providing a higher moisture content in the underlying tailings. The effectiveness of the applied cover to limit oxidation of the "B" Zone and Shear Zone tailings can be examined by comparing the test results on covered tailings to that for the control tests. The cover reduced the oxygen consumption rates by approximately one order of magnitude for the Shear Zone tailings area. While no control test was available for comparison in the "B" Zone tailings area it can be assumed that a similar reduction in rates is occurring there. The cover thickness on the "B" Zone tailings was, on average, slightly thicker than that of the Shear Zone area. This might imply a greater effectiveness due to the increased diffusion resistance caused by a thicker cover. Local variation in the measured oxygen consumption rate are dominantly due to variation in cover thickness, tailings mineralogy, and moisture profiles within the tailings and the cover.

5.2 Implications for Water Quality

The oxidation of Shear and "B" Zone tailings have been investigated by column leach studies at 25°C (Davé 1992), and later at cooler temperatures of 2°C and 10°C (Clulow 1996). The data from Clulow (1996) provides correlation between sulphate and selected metals released during the laboratory leaching test. Nickel and zinc were selected for comparison because of the good correlation with sulphate shown in the data reported by Clulow (1996) and because these metals are relatively mobile and less affected by neutralization of low pH waters. Other dissolved species such as ferrous iron, copper and arsenic may also be of concern but were not considered here. A summary of sulphate to metal ratios for nickel and zinc for both "B" Zone and Shear Zone tailings are given in Table 3.

PRINTED ON RECYCLED PAPER

TABLE 3: CORRELATION BETWEEN SULPHATE AND SELECTED METALS FOR COLUMN LEACH EXPERIMENTS REPORTED BY CLULOW (1996)

	Shear Zone	"B" Zone
*SO_4/Ni No. of Points R^2	1,600 22 0.83	15,000 8 0.3
SO_4/Zn No. of Points R^2	3,200 22 0.73	N/A

* Concentrations reported in mg/L

N/A - Zinc concentrations below detection limit of 0.002 mg/L

To project these ratios to actual field conditions the sulphate loadings resulting from sulphide mineral oxidation are estimated from the measured oxygen consumption rates and the stoichiometry of the sulphide mineral oxidation reactions. The estimated loading rates can be converted to approximate annual pore water concentrations by dividing the loading rate by an estimated annual infiltration rate appropriate for the site. This calculation provides an indirect indication of maximum potential pore water concentrations. It is important to remember that these values represent a theoretical possible loading and that they only consider chemical interactions as present in the column leach studies of Clulow (1996). These concentrations are not predictions of actual pore water concentrations but are to be viewed as comparative scenarios to gain insight into the effectiveness of the applied cover and possible future impacts only. Estimated maximum potential pore water concentrations are listed in Tables 4 and 5. These values are based on the measured oxygen consumption rates and correlation between sulphate and selected metal concentration reported by Clulow (1996) for column leach tests conducted in the laboratory at 10°C.

The range of concentrations are based on the two tests performed on two sites of uncovered tailings located on the Shear Zone section of the tailings impoundment. These estimated values suggest that the cover may be reducing pore water metal concentrations by more than an order of magnitude in the Shear Zone tailings.

Similar calculations were conducted on data collected from the "B" Zone tailings. The ranges reported in Table 5 represent two scenarios 1) the sulphide mineral component of the "B" Zone tailings is a mixture of pyrite and pyrrhotite in equal proportions and 2) the sulphide mineral component is pyrite only. A control test was not conducted on the "B" Zone tailings. Estimated potential pore water concentration values reported for exposed "B" Zone tailings were calculated using the ratio of exposed to covered oxygen consumption rates measured for the Shear Zone tailings. From values reported in Table 5 it can be seen that the cover may be responsible for decreasing the estimated maximum potential pore water concentrations by approximately an order of magnitude.

5.3 Contrasts Between the Shear and "B" Zone Tailings

The depositional history of the Shear Zone and "B" Zone ore deposits and the resulting tailings mineralogy have been reported by Davé (1992) and by Clulow (1996). From the

PRINTED ON RECYCLED PAPER

TABLE 4: ESTIMATED MAXIMUM POTENTIAL PORE WATER CONCENTRATIONS FOR SHEAR ZONE TAILINGS

Species	SHEAR ZONE TAILINGS	
	Exposed (mg/L)	Covered (mg/L)
Ni	263-411	14-38
Zn	129-202	7-19

TABLE 5: ESTIMATED MAXIMUM POTENTIAL PORE WATER CONCENTRATIONS FOR "B" ZONE TAILINGS

Species	"B" ZONE TAILINGS	
	Exposed (mg/L)	Covered (mg/L)
Ni	26-37	2.4-3.4
Zn	0.10-0.15	<0.015

material characterization for column leaching tests by Clulow (1996) the "B" Zone tailings contain, on average 2.31% S and the Shear Zone tailings contain, on average 0.4% S. The higher sulphur content, an indication of higher sulphide mineral content in the "B" Zone would suggest that it is this portion of the impoundment that would be experiencing greater oxidation rates and therefore contributing greater loadings to the pore water. However, the column leaching experiments of Clulow (1996), and data from this study indicate that the Shear Zone tailings represent a more important concern for metal loadings. The average measured oxygen consumption rate for all tests on the covered Shear Zone tailings was approximately 12 moles O_2 / m^2 / year. This is very similar to the average value measured for the "B" Zone tailings of 10 moles O_2 / m^2 / year. This finding indicates that despite the notably higher sulphide mineral content of the "B" Zone tailings the oxygen consumption rates are approximately equal. This may be explained by the presence of a slightly thicker cover on average, over the "B" Zone tailings. The average cover thickness for test points on the "B" Zone tailings was 0.89 m. The average cover thickness for the test points located on the Shear Zone tailings was 0.69 m. This increased cover thickness on the "B" Zone tailings may have contributed to a greater cover effectiveness by increased diffusion resistance.

Despite the variable cover thickness on the Shear and "B" Zone tailings, an overall decrease in oxygen consumption rates of approximately one order of magnitude was observed for all tests conducted compared to the uncovered Shear Zone tailings.

PRINTED ON RECYCLED PAPER

6.0 CONCLUSIONS

The existing cover on the tailings at Cullaton Lake is on the order of 0.70m thick. The cover material is a cobbely till with the finest fraction being a sandy loam. In theory, this type of material would not be expected to act as an efficient oxygen barrier to reduce sulphide mineral oxidation in the underlying tailings. The measured oxygen consumption rates, however, suggest that the oxidation rates below the cover are about a factor of ten lower than those measured for exposed tailings. This reduction in oxidation rates may be the result of decreased oxygen diffusion through the cover but may also be from the lower temperatures in the tailings due to the thermal insulating properties of the cover or due to increased moisture in the tailings resulting from decreased evaporation rates through the cover. It is probable that the lower oxidation rates result from a combination of all these processes. The data do suggest, however, that a thicker layer of cover material would result in lower rates of oxidation and hence lower rates of metal loadings to the local subsurface water.

PRINTED ON RECYCLED PAPER

7.0 RECOMMENDATIONS

It is suggested that the cover thickness be increased to meet the original specification of approximately 1.5m if better thermal insulation and increased resistance to diffusive transport of oxygen are to be achieved. Additional oxygen consumption measurements could be conducted after construction of the final cover to confirm the increased effectiveness of the thicker cover.

PRINTED ON RECYCLED PAPER

8.0 REFERENCES

Clulow, V. (1996). Column leaching characteristics of Cullaton Lake B and Shear Zone Tailings. Phase 2: Cold temperature leaching Final Report. Final Report to Homestake Canada Ltd.

Davé, N. K. (1992). Column Leaching Characteristics of Cullaton Lake B and Shear Zone Tailings. Phase I: Room Temperature Leaching. Division Report MSL 92-4. Prepared for International Corona Corporation.

PRINTED ON RECYCLED PAPER

Trow Thunder Bay Branch

Trow Consulting Engineers Ltd.
807 Harold Crescent, Thunder Bay
Ontario, Canada. P7C 5H8
Telephone: (807) 623-9495
Facsimile: (807) 623-8070

December 5, 1996

Reference No. F-90132-B/E

Homestake Canada Ltd.
1000-700 West Pender Street
Vancouver, B.C.
V6C 1G8

Attention: Sharon Meyer

RE: Cullaton Lake Gold Mine

Dear Ms. Meyer:

At your request, Trow Consulting Engineers Ltd. visited the Cullaton Lake Gold Mine property during the period of September 15 - 18, 1996 to examine the tailings containment areas.

TAILINGS POND AREA NO. 1

A visual examination around Tailings Area No. 1 was carried out. The containment dam appears to be in good condition with no signs of distress or erosion. Some small wet areas were present on the downstream toe at the south end of the tailings area. However, it is unclear if the wet areas are due to seepage or the large amount of rainfall which had fallen prior to this site visit. There is no evidence of soil loss in these wet areas and they do not appear to present any instability to the dam. The approximate location of these wet areas are shown on Drawing No. 1.

The spillway appears to be in good condition with the exception of a small area on the south upstream side where the liner is exposed. A trickle of water was flowing over the spillway during this time. The water elevation was approximately 94.0 m[1], which is at the same level it was during our site visit in June of 1994. Although this only compares two time periods, it is an indicator that the drainage area has a positive water balance.

There were no exposed tailings in the pond, shoreline, or covered areas. However, the tailings were within approximately 150 mm of the water surface on the western shoreline, adjacent to the covered

---

[1] Elevations are referenced to a temporary benchmark located on a concrete slab at the east corner of the mill building with a local elevation of 100.00 m, previously established by HIW Surveys Ltd. in 1990.

tailings area near the interface between the B-zone and Shear zone tailings. Photographs 1 and 2 show evidence of the tailings being close to the surface of the water.

A surface depression was ponded with reddish brown water in the B-zone covered tailings area. This area is shown on Photographs 3 and 4 and on Drawing No. 1.

TAILINGS AREA 2

Since the dams in Tailings Area 2 are not required, much of the material which was used for the dams has been removed and was used for cover over the former tailings beach near the former mill building in Tailings Area 1. There was some material still available which could be used for additional cover material, if needed.

The water level in Tailings Pond No. 2 was low during this site visit and appeared to be at a similar elevation to what was measured in 1994 (elev: 89.4 m). It is expected that the water level will remain low under the present conditions.

A long stretch of liner (approx. 75 m) in the dam has been exposed and damaged at the northwest end of Tailings Area 2. Since the amount of material in the dam has been reduced, it is expected that more of this liner could be exposed as a result of erosion. Consideration could be given to removing some of the exposed liner and filter cloth and burying it in the quarry to ensure it does not become air- borne and present a hazard to wildlife, for instance.

SUMMARY

The tailings dams appear to be stable under the current site conditions. Some minor repair work around the main spillway should be addressed to cover the exposed liner. Consideration should be given to removing the exposed and damaged sections of liner in Tailings Area 2.

The water level in Tailings Pond No. 1 was the same this year as it was in June, 1992 and there were no exposed tailings in the area.

If you have any comments or questions regarding this letter, please contact us at your convenience.

Yours truly,
TROW CONSULTING ENGINEERS LTD.

Don Kaluza, P. Eng.

R.B. Dodds, PhD., P. Eng.

Demetri Georgiou, MASc., P. Eng.
Branch Manager

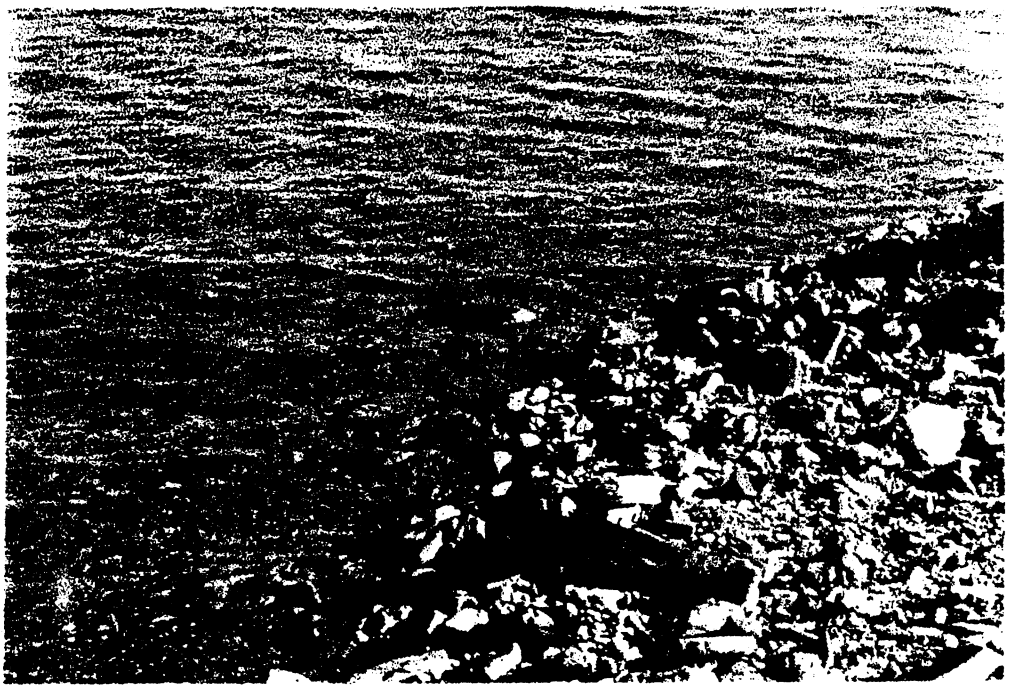


Figure 1: Tailings near surface at west shoreline.



Figure 2: Tailings near surface of water; aerial view looking west.

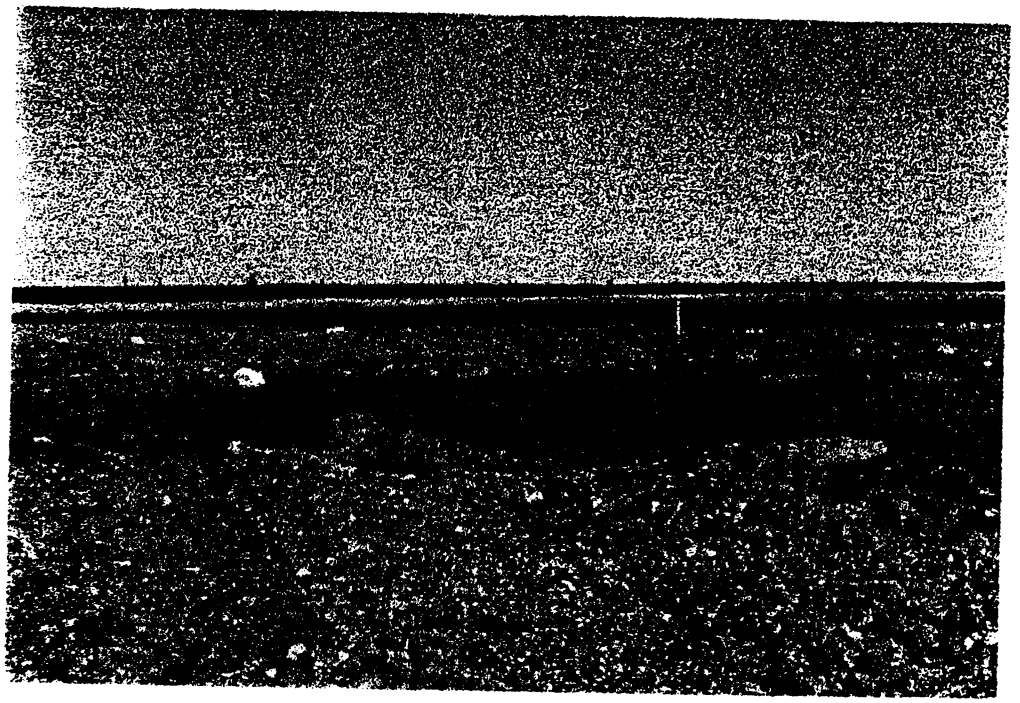


Figure 3: Surface depression in B-zone covered tailings area.



Figure 4: Aerial view of surface depression in B-zone covered tailings area.

1996 INSPECTION REPORT

ON

CONDITIONS OF LICENCE NUMBER N6L2-0940

HELD BY: 759290 ONTARIO INC.

OPERATED BY

HOMESTAKE CANADA INC., CULLATON LAKE GOLD MINES LTD.

BY

PAUL SMITH

INSPECTOR UNDER THE NORTHWEST TERRITORIES WATERS ACT

DIAND NWT REGION

NUNAVUT DISTRICT

IQALUIT, NT

DATE: November 4, 1996
WATER REGISTER: N6L2-0940
LAND LEASES: 65G/8-1-20, 65G/7-1, 65G/7-2-2

INSPECTION REPORT - 1996

CULLATON LAKE GOLD MINES LTD.

WATER LICENCE N6L2-0940

On August 17, 1996, a water licence inspection was carried out on the above noted water licence by Paul Smith, Water Resources Officer and Henry Kablalik, Resources Management Officer both of DIAND, Nunavut District.

No representatives of of Homestake Canada Inc. nor their contrators were on site during the inspection, although evidence was available to indicate that they had been there recently and that presumably would be returning at some point in the near future to continue with additional A+R work.

A walking inspection of the main camp site, tailings disposal area and quarry/burial pit was made. Low level fly-bys were made of the Kognak River, airstrip and Sheer Lake zone areas. A comprehensive photographic record was made of the site.

Water samples were collected at SNP Stations 0949-2, -3 and -7. Water samples were also collected on June 21 at these locations along with 0940-5. Both sets of results are attached and indicate that all discharges were well within licence limits. The flow rate from the final treatment pond was about 2L/s. The dam had been used as landfill material, but the remaining material had yet to be contoured (as indicated in the A+R plan).

Abandonment and Restoration activites were judged against photographs taken in August of 1995. It was apparent that some activity had been carried out as some buildings had been torn down. The quarry/burial pit had been drained, but perhaps had started to refill as it still had water within it. There is little evidence that the Licensee is making a concerted effort to compact materials being placed into the burial pit. While individual pieces may be compacted, the overall effect when material is being dumped into the pit is that there are a large number of voids. This will lead to frost heaving and the eventual exposure of buried material as it is forced to the surface.

Those areas identified in the 1995 inspection relating to hydrocarbon stained ground were inspected. The inspector would take issue with the statement made by Ms. Sharon Meyer in her September 25, 1995 letter to Dan Elliott providing an explanation to the cause of the oil stained ground. While on-site, there were indications that waste oil handling and storage techniques practiced by the Licensee's contractor is sloppy. Keeping in mind that the contractors were off site, there were open fuel containers and improper disposal practices

.../2

evident (including a 55 gal drum that had been cut in half to form a bucket. Within this bucket, and with about 2 cm of free board, was a reddish hydrocarbon material (brake or hydraulic fluid)). The practices obsevered need to be corrected as what was seen was not acceptable.

Many of the buildings and associated infrastructure was still on site and had not been salvaged nor torn down. Previous correspondence (1995 Annual Report) from the Licensee indicated that all A+R work was to be completed during the field season of 1996 (now passed). The Licensee is requested to provide this office with an update, prior to what is required in the Annual Report as required under Part B, Item 2 of the licence, with a list of A+R activities that was accomplished this field season and what is planned in terms of upcoming activities.

The Licensee is also requested to specifically address the activities it had planned to carry out in order to reduce it's land lease holdings so that the total land held under lease could include the area for the quarry/burial pit.

Paul Smith
Inspector under the NWT Waters Act

HOMESTAKE

December 3, 1996

Paul Smith
Water Resources Officer
DIAND Nunavut District
Box 100
Iqaluit, NT
X0A 0H0

Dear Mr. Smith:

Re: Your November 14, 1996 Letter Outlining the August 17, 1996 Cullaton Lake Inspection - Water Licence N6L2-0940

Thank you for the copy of the inspection report for the above noted water licence inspection. Please find below our response to the issues outlined in your letter.

2.a. Request for Abandonment & Restoration Plan Update. As per our Water Licence requirements, we will be submitting an annual report in March 1997 outlining the abandonment and restoration activities that occurred this past summer, as well as what remains to be completed in 1997. However, in summary, our reclamation crew was on site from June 26 to July 31 and again from August 28 to September 18. The crew returned to the site in early November for a 10 day period. All buildings at the minesite have been dismantled, with the exception of the service shop for the decommissioning equipment remaining on site. Salvageable materials have been removed from the site or are stored at the airstrip for removal next season. An ice train scheduled for mid-December will remove some salvaged materials this winter. Atco trailers remain at Shear Lake as an accommodation area for the reclamation crew.
As noted in the attached letter, we will be covering the tailings area with additional material in the spring of 1997. The non-salvageable materials observed in and around the quarry pit will be crushed and reburied in the quarry pit in 1997.

2.b. Hydrocarbon Handling. During my site inspection in September I noted that the handling and storage of hydrocarbon materials was adequate at that time and did not reflect the practices you observed earlier in the year. As well, the crew had removed the area of stained soil and disposed of it as agreed during our May 25, 1996 meeting with DIAND.

2.c. Land Exchange. The two areas of land being excluded from Lease 3600, in exchange for an area to include the quarry pit, did not require any reclamation activities. Therefore no work was undertaken there this summer. Please see attached map for the location of these excluded areas.

Homestake Canada Inc.
1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

3. A geotechnical inspection was completed in mid-September this year, as required by our Water Licence. This report has not yet been received in our office. When we receive the report, we will forward a copy to DIAND as well as to the Nunavut Water Board.

I trust this letter answers your questions regarding the activities at the Cullaton Lake site this past season. When you have finalized the dates of your 1997 inspection, please let us know so that we can arrange for one of our representatives to accompany you on your visit. Should you have any other questions or concerns please do not hesitate to contact me.

Yours truly,
HOMESTAKE CANADA INC.

Sharon Meyer

Sharon Meyer
Environmental Analyst

attachments

cc. Nunavut Water Board
Water Resources Division, DIAND
Land Resources, DIAND

1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

HOMESTAKE

November 29, 1996

Shelley Thibaudeau
Water Resources Division
DIAND
P.O. Box 1500
Yellowknife, NT
X1A 2R3

Philippe di Pizzo, Executive Director
Nunavut Water Board
P.O. Box 119
Goja Haven, NT
X0E 1J0

Dear Sir/Madam;

Re: Abandonment & Restoration Plan Update - Cullaton Lake Gold Mines

The reclamation crew on site this summer completed the majority of decommissioning work at our Cullaton Lake property. In our Abandonment and Restoration Plan (A & R Plan), we had anticipated that by the end of the 1996 season all dismantling, salvage and disposal of buildings and materials would have been completed. However, some additional work will need to be completed during the summer of 1997. This work is outlined below.

1. Some non-salvageable material placed in the quarry pit prior to 1996 had not been completely compacted. This material was removed from the pit in 1996 and will be crushed and placed back into the pit in 1997, along with any remaining non-salvageable materials from the 1996 decommissioning work.

2. During our September site inspection at our Cullaton Lake property, it was discovered that the cover on the tailings was not as deep as we had previously believed. In order to address this deficiency, we intend to remove more material from Dam 2 (our A & R Plan outlined the removal of material from Dam 2 and the placement of that material over the tailings in Pond 1) and cover the tailings with this additional material. This work was started in 1996 and will be completed during the 1997 work season.

3. In order to expedite the placing of additional cover on the tailings, we would like to remove some rocky material adjacent to the tailings area (see attached map) and use it as cover material, along with the material from Dam 2 referred to above. **Will we require any special permit or permission to remove this additional material?**

4. We are putting together a plan to seed and fertilize the tailings area and former mill site in 1997, using an arctic seed mix as selected by our vegetation consultants. If

1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

such a plan can be developed this winter, we intend to seed and fertilize many of the disturbed areas of the site in the late summer, 1997.

If you have any questions or comments on our 1997 plans, please do not hesitate to contact me.

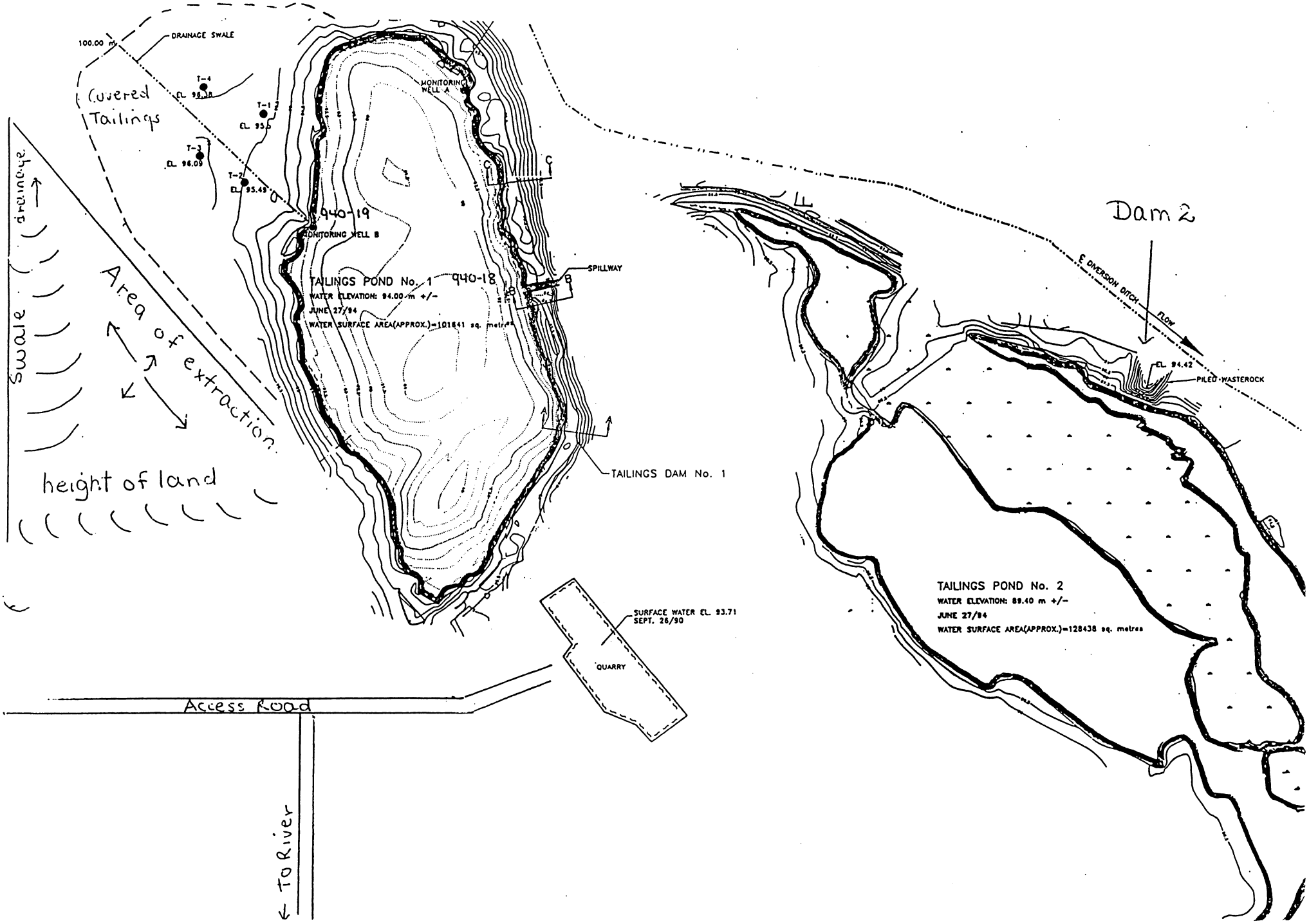
Yours truly,
HOMESTAKE CANADA INC.

Sharon Meyer

Sharon Meyer
Environmental Analyst

attachments

cc. S. Bradbury, DIAND Land Administration


100.00 m
DRAINAGE SWALE
Covered Tailings
T-4
EL. 98.08
T-1
EL. 95.5
T-3
EL. 96.09
T-2
EL. 95.48
MONITORING WELL A
940-19
MONITORING WELL B
940-18
TAILINGS POND No. 1
WATER ELEVATION: 94.00 m +/-
JUNE 27/94
WATER SURFACE AREA(APPROX.)=101841 sq. metres
SPILLWAY
TAILINGS DAM No. 1
swale drainage
Area of extraction
height of land
SURFACE WATER EL. 93.71
SEPT. 26/90
QUARRY
Access Road
To River
Dam 2
E DIVERSION DITCH
FLOW
EL. 94.42
PILED WASTEROCK
TAILINGS POND No. 2
WATER ELEVATION: 89.40 m +/-
JUNE 27/94
WATER SURFACE AREA(APPROX.)=128438 sq. metres

HOMESTAKE

VIA COURIER

March 12, 1996

DIAND - Land Administration
P.O. Box 1500
Yellowknife, NWT
X1A 2R3

Attention: Ms. Sandra Bradbury, Land Administrator

Dear Ms. Bradbury:

Re: NWT LEASE 3600 (File 65G/7-1)

With reference to that correspondence from Annette McRobert to William Napier dated February 6, 1996, and to our telephone discussions of late last year, this letter is to advise you that Homestake Canada Inc. still wishes to amend the above-referenced lease.

It is Homestake's intention to decrease the size of lease 3600 as follows: (1) by removing approximately 11.4 ha from the northwest corner of parcel "C", and (2) by removing parcel "E" in its entirety. It is then Homestake's wish to amend the area of parcel "D" by adding approximately 11.4 ha to the southwest corner of that parcel; this added area should more than adequately cover the area of disturbance surrounding the quarry pit which is situated in that location.

As requested, a copy of a portion of the lease map is enclosed, upon which we have sketched both the areas for exclusion and the area to be added. Approximate measurements have been provided in the sketch map, for your reference.

Please be further advised that it is Homestake's intention to renew NWT leases 65G/7-2-2 (Minesite), 65G/8-1-20 (Airstrip), and 3600 (File 65G/7-1 (Minesite)) shortly.

I shall be out of the office until the week of March 18th but I will call you on my return to discuss this matter. In the meantime, I thank you for your assistance in this matter.

Sincerely,
HOMESTAKE CANADA INC.

ORIGINAL SIGNED BY:

E.J. (Gene) Gulajec
Manager, Canadian Lands
KMC/kmc
encls
ORIGINALLY SENT VIA FACSIMILE

Homestake Canada Inc.
1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

610 m±

366 m±

293 m±

"C/i"

128 m±

29.3 m±

238 m±

Area of "C/i" = 366m x 293m = 107,238.00 m²
239m x 29.3m = 6,973.40 m²
TOTAL HA = 114,211.40 m²
11.4 ha

PARCEL "C"

PARCEL "D"

AREAS BEING EXCLUDED

450m±

1036 m±

488m

259m

~770m

AREA BEING ADDED.

213m

366m

PARCEL "E"

244m

Local

65G/8-1-3

(6300)

31m± width

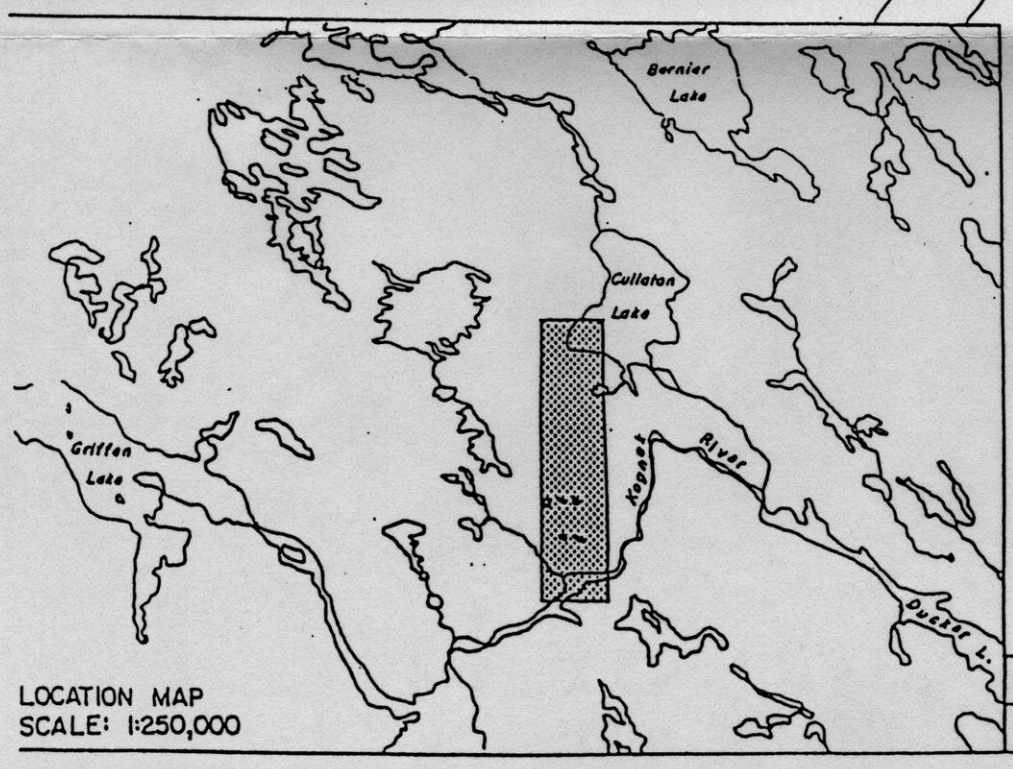
1170m±

592m±

KOGNAK RIVER

ANNEXED HERETO AND FORMING PART OF
LEASE 65-G-8-1-13 & 65G/1-2-2
QUADS 65-G-7 & 65-G-8
SCALE: 1:9500 (approx.)

0 500 m
Scale (approx)



LOCATION MAP
SCALE: 1:250,000

* AREA OF NW CORNER OF PARCEL "C" BEING EXCLUDED = 11.4 ha ±
* AREA OF PARCEL "E" = 8.9 ha ±
* AREA OF PARCEL "B" = 36.9 ha ±
* AREA OF ROAD ALLOWANCE = 21.5 ha ±
* AREA OF PARCEL "H" = 14.87 ha ±

LEASE 3600	MAR/96	KMC	27-05-'81		
REGIONAL MANAGER LAND RESOURCES	DATE:	DRAWN BY:	DATE:	REVISED:	DATE:

HOMESTAKE CANADA INC.

TAILINGS POND No. 2

Diversion Ditch

Spillway

Wet Area

TAILINGS POND No. 1
WATER ELEVATION: 94.00 m +/-
SEPT. 16/96

LIMIT OF EXPOSED TAILINGS
As per HIW Surveys Ltd. 1990 Survey

Shear Zone Tailings

B-Zone Tailings

Drainage Swale

Surface Depression

Area of Natural Vegetation

Buildings Now Demolished

TBM

Quarry

T1 T2 T3 T4

50 0 50 100
IN METRES

TROW CONSULTING ENGINEERS LTD.
Thunder Bay, Ontario, Canada

LEGEND

+TBM	Temporary Benchmark
•T2	Thermistors
95.03	Elevation from HIW Survey (1990)

NOTES:

1) Elevations are in metres and referenced to a TBM located on concrete slab at North East corner of mill. Assumed Elevation 100.00m

2) Limit of Covered Tailings from HIW Surveys Ltd., Sketch Plan Showing Tailings Pond Survey, Drawing No. 5, dated 11/10/90.

3) Contours are shown in 1m intervals and represent 1996 conditions. Spot elevations represent conditions in 1990.

Client:	Homestake Canada
Project:	Cullaton Lake Gold Mine
Title:	Tailings Pond Area No. 1
Project No.	F-90132-B/E
Dwg. No.:	1
Drawn By:	DT
Reviewed By:	
Date:	Nov. 27/96
Scale:	1:3000

HOMESTAKE

INDIAN AND NORTHERN AFFAIRS — CANADA
N.W.T. REGION
APR 0 3 1997
WATER RESOURCES DIVISION
YELLOWKNIFE, NT

940-1

March 25, 1997

Paul Smith
Water Resources Officer
DIAND
Box 100
Iqaluit, NT X0A 0H0

Dear Mr. Smith;

Re: Cullaton Lake 1996 Annual Report - Provision of SNP data - Your Facsimile of March 19, 1997.

Thank you for your letter of March 19, 1997. I have checked our files with reference to the incomplete SNP data. I have located the temperature and pH data and it is appended to this letter. Due to a series of communication errors, mercury analysis of our water samples was not completed this year (mercury analysis requires a special request and is not part of Barringer Laboratories' general metals analysis). I have now contacted the lab and have been assured that this problem will not reoccur in 1997.

During the transition from an A Licence to a B Licence in September 1995, it was noted that duplicate sampling would now be required (we were not required to perform duplicate sampling in previous years), however this was not emphasized to the project manager who would be completing the water sampling on site. Therefore one sample instead of two was taken at each site, during each sampling period in 1996. As you are aware, all past sampling has shown results well below the approved limits for all parameters. In 1997 we will take duplicate samples at each site for each sampling period. As well, we will begin water sampling at the quarry pit as agreed during the 1996 meeting with DIAND in Yellowknife.

If you have any further questions or comments, please do not hesitate to contact me. Homestake Canada Inc. intends to complete the restoration of the Cullaton Lake site to meet or exceed the requirements of our A & R Plan. Any assistance you can give us is appreciated.

Yours truly,
HOMESTAKE CANADA INC.

Sharon Meyer

Sharon Meyer
Environmental Analyst

cc. Nunavut Water Board, Gjoa Haven
DIAND, Water Resources Division, Yellowknife

SP

Homestake Canada Inc.

P.O. Box 11115 • 1100 - 1055 West Georgia Street • Vancouver, BC V6E 3P3 • Phone (604) 684-2345 • Fax: (604) 684-9831

Cullaton Lake 1996

Station	Date	pH	Temperature ° C
940-2	July	7.8	15.2
940-2	September	7.9	8.0
940-3	July	7.9	16.4
940-3	September	7.7	8.2
940-18	July	7.8	13.0
940-18	September	7.8	7.9
940-19	July	8.0	13.0
940-19	September	7.9	8.0
940-20	July	7.8	10.0
940-20	September	7.9	7.9
940-22	July	7.8	10.5
940-22	September	no seepage	

~~H403~~
940-1

facsimile
TRANSMITTAL

to: Ms. Sharon Meyer, Homestake Canada Inc.
fax #: (604)-684-9831
re: 1996 Annual Report
date: March 19, 1997
pages: 1, including this cover sheet.

FAXED
MAR 25 1997

1996 Annual Report - Provision of SNP data

Dear Ms. Meyer,

I am in receipt of the 1996 Annual Report and am presently reviewing it in terms of completeness.

I bring to your attention the matter of incomplete SNP data. Within Appendix 1 of the 1996 Annual Report, SNP data for stations 940-2, -3, -18, -19, -20 and -22 is presented. However, it would appear that incomplete data is provided. The SNP of the water licence requires duplicate samples to be collected in both June and later than August 1st. From the data provided, it appears that this sampling has not been completed in full. In addition, no analysis for mercury, temperature and pH is provided for any of the SNP stations at which sampling is required.

I thank you for your attention to this matter and I will await your reply prior to continuing my review.

Sincerely,

Paul Smith

cc. - Nunavut Water Board, Gjoa Haven
- DIAND Water Resources Division, YK
- RMO, DIAND, Rankin Inlet

From the desk of...

Paul Smith
Water Resources Officer
DIAND
Box 100
Iqaluit, NT XOA OHO

819-979-4405
Fax: 819-979-6445

SF



BOARD. 1
G.W. 1
E.A. 1
W. RES. orig
File - 0940

INDIAN AND NORTHERN AFFAIRS -- CANADA
N.W.T. REGION
APR - 2 1996
WATER RESOURCES DIVISION
YELLOWKNIFE, NT

NORTHWEST TERRITORIES WATER BOARD
MAR 29 1996
YELLOWKNIFE, N.W.T.

0940
0940-1
NUNAVUT
DFSI

March 27, 1996

Gordon Wray, Chairman
N.W.T. Water Board
P.O. Box 1500
Yellowknife, N.W.T.
X1A 2R3

Dear Mr. Wray;

Re: Water Licence N6L2-0940 Cullaton Lake Mine Site

Homestake Canada Inc. is pleased to submit 4 copies of the Cullaton Lake Gold Mines Ltd. Annual Water Licence Report, outlining the abandonment and restoration work completed during 1995 at the Cullaton Lake site, and containing summaries of water quality and thermistor data. Appendix 2 of our report contains the Executive Summary and relevant tables from the Phase 2 Report requested last July (G. Wray to W. Napier, July 27, 1995). As discussed with S. Thibaudeau, the final document will be submitted to you as soon as it is received by Homestake Canada Inc.

Also enclosed are 4 copies of the revised Abandonment and Restoration Plan for the Cullaton property as requested in Part F Item 1 of our water licence. This plan includes a detailed description of our planned restoration and a work schedule for completion of these activities.

I trust these reports are satisfactory.

Sincerely.
HOMESTAKE CANADA INC.

Sharon Meyer

Sharon Meyer
Environmental Analyst

cc. S. Thibaudeau
J. Witteman
A. McRobert

H:\USER\SMEYER\CULLATON\TRANS95.LTR

Homestake Canada Inc.
1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

C-10

NORTHWEST TERRITORIES WATER BOARD
MAR 29 1996
YELLOWKNIFE, N.W.T.

CULLATON LAKE GOLD MINES LTD

WATER LICENCE N6L2-0940

0940-1
NUNAVUT
DIST

INDIAN AND NORTHERN AFFAIRS CANADA
APR - 2 1996
NORTHERN AFFAIRS
YELLOWKNIFE, NT

ANNUAL WATER LICENCE REPORT 1995

PREPARED BY:
HOMESTAKE CANADA INC
1000 - 700 WEST PENDER STREET
VANCOUVER, B.C.
V6C 1G8

TABLE OF CONTENTS

PREAMBLE

1.0 HIGHLIGHTS

2.0 SUMMARY

2.1 WATER LICENCE RENEWAL

2.2 WATER QUALITY MONITORING

2.3 TAILINGS

2.4 THERMISTORS

2.5 PHASE 2 OF THE COLD STORAGE KINETIC TESTS

2.6 ROCK QUARRY

2.7 MILL COMPLEX DISMANTLING

2.8 SHEER LAKE

2.9 MISCELLANEOUS

3.0 1996 TENTATIVE WORK PROGRAM

APPENDIX 1 Map of Tailings Area Water Sampling Locations
Water Quality Data
Thermistor Data
Inspection Report

APPENDIX 2 Excerpts from Phase 2: Cold Temperature Leaching

PREAMBLE

The Cullaton Lake Gold Mines property is located in the southern part of the District of Keewatin in the Northwest Territories. The property is 250 km west of Arviat, N.W.T., 400 km northwest of Churchill, Manitoba and 645 km north of Thompson Manitoba. The mine was in operation for four years, from 1981 to 1985. Since September 1985 the mine has remained in a care, maintenance and decommissioning phase.

Cullaton Lake Gold Mines Ltd. is wholly owned by Homestake Canada Inc.

The current water licence (N6L2 - 0940) from the Northwest Territories Water Board was renewed on September 1, 1995 and is effective until August 31, 1999.

As per this Water Licence, the Company is required to file a yearly report pursuant to Section 13(2) of the Northern Inland Waters Act and Section 15(1) of the Regulations, outlining details on water use or waste disposal at Cullaton Lake Gold Mine.

1.0 HIGHLIGHTS

The Draft Abandonment and Restoration Plan was submitted to DIAND in April 1995. In December 1995 the Company was requested to submit a revised plan to DIAND (A. McRobert to W. Napier, December 15, 1995).

The water licence was renewed as a B Licence on September 1, 1995 for a period of 4 years. It expires August 31, 1999. As part of this renewal a revised Abandonment and Restoration Plan must be submitted by March 31, 1996 (G. Wray to W. Napier, July 27, 1995). One document has been prepared to cover the requirements of both DIAND and the Water Board.

McKay Environmental Industries' crew was on site from June 13 to July 21, 1995 and again from September 23-29, 1995 to perform decommissioning work. Portions of the mill structure were dismantled. Non-salvageable materials were crushed and placed in the quarry pit and then covered with overburden. Some salvageable equipment was flown to Thompson, Manitoba, for storage.

Personnel from J. P. Consulting & Services, contracted by Homestake, visited the area to assess the remaining decommissioning work and inventory salvageable material.

Water samples were taken on June 24 and September 28, 1995. Thermistor readings were taken on June 17, September 20 and October 3 as part of ongoing monitoring of the temperature regime in the tailings.

Dan Elliott, Inspector under the Northwest Territories Water Act, carried out a water licence inspection on August 22, 1995.

The executive summary and tables from *Phase 2 of the Cold Storage Kinetic Tests* report is attached as Appendix 2.

2.0 SUMMARY

2.1 WATER LICENCE RENEWAL

Homestake applied for a water licence renewal on April 28, 1995. At this time the request included a change of category from an 'A' Licence to a 'B' Licence. A 'B' Licence was received this summer, effective September 1, 1995 expiring August 31, 1999. As part of the licence renewal, the Company is submitting, with this report, a Final Abandonment and Restoration Plan. Required revisions (G. Wray to W. Napier, July 27, 1995) include the following:

1. Estimates for volumes of non-salvageable materials and proposed locations for disposal;
2. Intentions for the disposal of sludges, petroleum residues, batteries, contaminated soils and other hazardous materials; and
3. A description of the removal of salvageable materials from the site.

2.2 WATER QUALITY MONITORING

Water sampling continued at Cullaton Lake Mine this year. Water was sampled three times during the summer season, in June, August, and early September. The June and September samples were collected, as in past years, by Mr. Rodney McKay of McKay Environmental Industries Ltd. The August samples were collected during the water licence inspection of August 22, 1995. The sampling results from this inspection were well within the limits prescribed in the Water Licence N6L2-0940. See Appendix 1 for water quality results, a copy of the inspection report and the Company's response.

2.3 TAILINGS

The Tailings area was inspected this summer; and no additional fill was required.

2.4 THERMISTORS

In order to prevent any possible acid generation, reclamation of the tailings area has involved two oxygen-limiting methods; a water cover overlying the eastern portion of the tailings impoundment area and a till/mine waste rock cover on the remaining Shear and B-Zone tailings area. The application of the till/mine waste rock cover was intended to reduce oxygen infiltration, and to raise the level of permafrost in the tailings. Raising the permafrost level in the tailings helps retain them in a permanently frozen condition which may prevent development and migration of acid drainage. Thermistors were installed in the covered tailings in August 1991 in order to monitor any rise in permafrost levels.

Thermistor readings have been taken during the spring and late summer months since 1991. Readings from 1992 to 1994 show an upward trend in the permafrost levels. The depth of the summer active zone has been observed to have decreased over the years from 2.8 m to approximately 2.3 m in depth.

In 1995 thermistor readings were taken at Thermistors # 1, 2, 3, and 4 in Tailings Area #1 in June, July and September (see Appendix 1). At the end of the 1995 summer season, the depth of the active zone remained at the 1994 level, maintaining the higher permafrost levels in the tailings.

2.5 PHASE 2 OF THE COLD STORAGE KINETIC TESTS

A draft copy of *Phase 2: Cold Temperature Leaching* was completed by CANMET and received by Homestake Canada early in 1996. The report requires revision by CANMET. As discussed with Water Board personnel, the executive summary and tables from that report have been attached as Appendix 2, and the revised report will be forwarded under separate cover when received by Homestake.

2.6 ROCK QUARRY

During the May 25, 1995 meeting with DIAND and the N.W.T. Water Board, agreement was reached regarding use of the quarry pit for disposal of non-salvageable materials. The quarry pit was de-watered before any of the non-salvageable materials were placed in the quarry. The primary mill building was dismantled and non-salvageable material was crushed and placed in the quarry pit. Fill was placed over this crushed material. The compacted debris filled approximately one third of the pit.

In September the quarry pit was de-watered again, and more fill was pushed over the material in the pit.

2.7 MILL COMPLEX DISMANTLING

The primary mill building was dismantled this summer and non-salvageable material was placed into the north end of the quarry pit.

A part of the infrastructure adjoining the milling facility for the new mill expansion and both air intakes were removed and buried.

The fuel distribution house was dismantled and hauled away. Salvageable equipment was flown to Thompson, Manitoba for storage (including a 250 HP

motor, transmission and fuel drums). Tanks, pumps, piping and cable trays remain on site.

2.8 SHEAR LAKE

Non-salvageable underground equipment from Shear Zone was placed in the quarry pit. The contouring of the Sheer Lake waste rock dump was completed in September.

2.9 MISCELLANEOUS

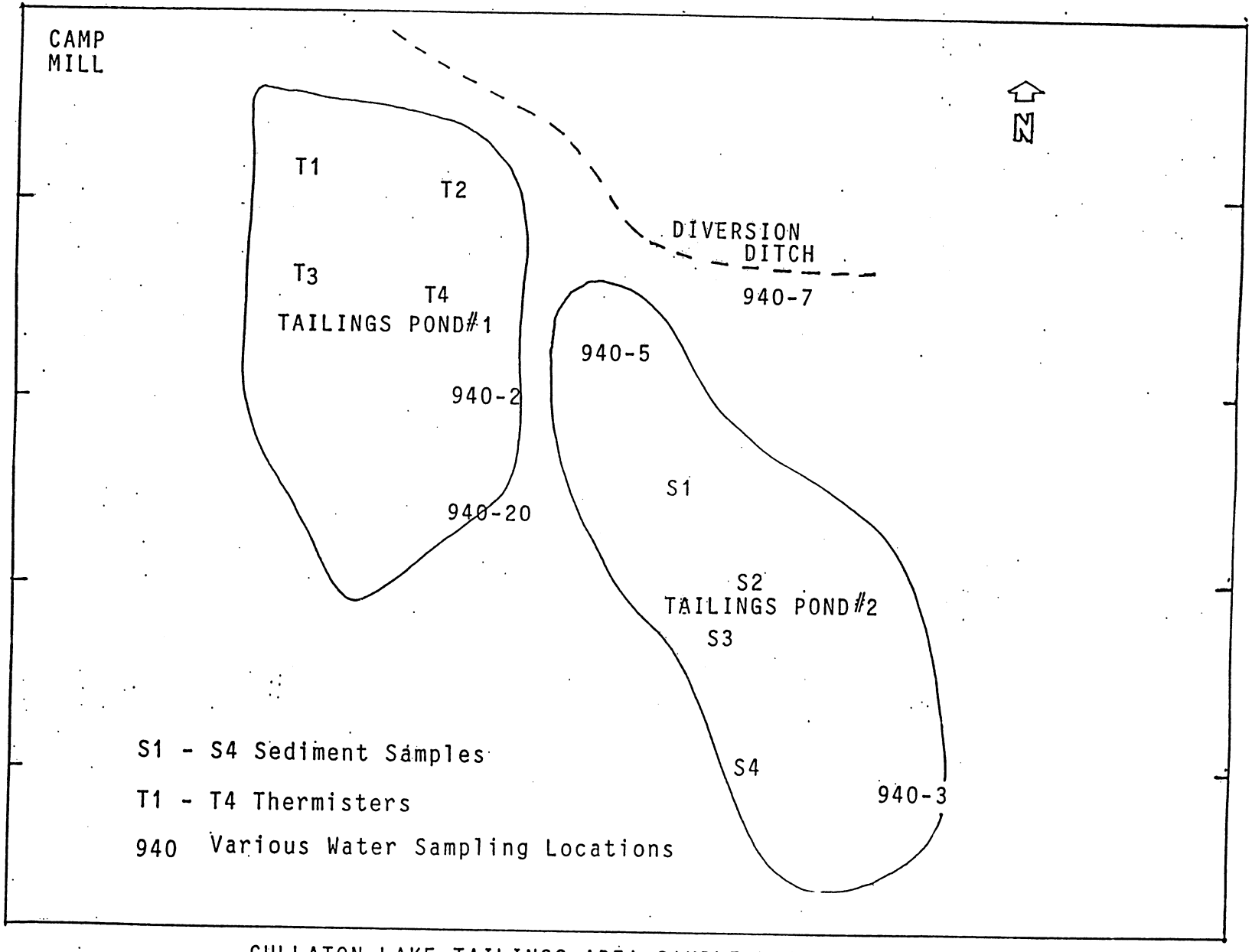
Equipment required for hauling and spreading fill, and for general maintenance remains at the site. This includes a 426 JCI truck, a D8K, 415 JCI truck, 966D loader, 950 loader, cargo truck, fuel truck and two jeeps.

3.0 1996 TENTATIVE WORK SCHEDULE

Homestake Canada Inc. intends to complete the remaining decommissioning work in 1996. This includes dismantling the fuel tank farm, dismantling the remaining buildings, removing all salvageable material and disposing of all non-salvageable material as per our revised 1995 Abandonment and Restoration Plan. Some mobile equipment will remain on site in case further reclamation work is required.

APPENDIX 1

Map of Tailings Area Water Sampling Locations
Water Quality Data
Thermistor Data
Inspection Report



CULLATON LAKE TAILINGS AREA SAMPLE LOCATIONS

CULLATON GOLD MINES LTD.

EFFLUENT WATER QUALITY REQUIREMENTS
(LICENCE N6L2-0940)

All wastes discharged by the Licensee from the Tailings Containment Area shall meet the following effluent quality requirements:

Parameter	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total Arsenic	0.30 mg/L	0.60 mg/L
Total Copper	0.20 mg/L	0.40 mg/L
Total Cyanide	0.80 mg/L	1.60 mg/L
Total Lead	0.20 mg/L	0.40 mg/L
Total Nickel	0.30 mg/L	0.60 mg/L
Total Zinc	0.30 mg/L	0.60 mg/L
Total Suspended Solids	25 mg/L	50 mg/L

The waste discharged shall have a pH between 6.0 and 9.5, and no visible sheen of oil and grease.

HOMESTAKE CANADA INC.
CULLATON LAKE WATER QUALITY
1994 - 1995 DATA

STATION: 940-2: POND #1 DISCHARGE

Date	LAB PH pH unit	SUSPENDED SOLIDS mg/l	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l
07/03/94	7.93	1	0.019	0.0019
07/31/94	7.89	1	0.023	0.0038
09/06/94	7.92	57	0.017	0.032
JAN 1994 - DEC 1994				
Mean	7.91	20	0.020	0.0126
Minimum Value	7.89	1	0.017	0.0019
Maximum Value	7.93	57	0.023	0.0320
06/21/95	7.47		.007	
08/22/95	7.87		.002	
09/27/95	7.93	1	.016	.002
JAN 1995 - DEC 1995				
Mean	7.76	1	0.008	0.002
Minimum Value	7.47	1	0.002	0.002
Maximum Value	7.93	1	0.016	0.002

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL MERCURY ug/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
07/03/94	0.002	0.003	0.05	0.005	0.005
07/31/94	0.002	0.005	0.05	0.005	0.005
09/06/94	0.005	0.004	0.05	0.005	0.005
JAN 1994 - DEC 1994					
Mean	0.003	0.004	0.05	0.005	0.005
Minimum Value	0.002	0.003	0.05	0.005	0.005
Maximum Value	0.005	0.005	0.05	0.005	0.005
06/21/95	.0025	.0045	0.02	.0009	.020
08/22/95	.0014	.0040	0.02	.0018	.005
09/27/95	<.0010	<.0010	0.05	<.0050	<.005
JAN 1995 - DEC 1995					
Mean	0.0016	0.0032	0.03	0.0026	0.010
Minimum Value	0.0010	0.0010	0.02	0.0009	0.005
Maximum Value	0.0025	0.0045	0.05	0.0050	0.020

HOMESTAKE CANADA INC.
CULLATON LAKE WATER QUALITY
1994 - 1995 DATA

STATION: 940-3: POND #2 DISCHARGE

Date	LAB PH pH unit	SUSPENDED SOLIDS mg/l	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l
07/03/94	7.73	1	0.002	0.0020
07/31/94	8.63	5	0.004	0.0049
09/06/94	7.82	26	0.004	0.0047
JAN 1994 - DEC 1994				
Mean	8.06	11	0.003	0.0039
Minimum Value	7.73	1	0.002	0.0020
Maximum Value	8.63	26	0.004	0.0049
06/21/95	7.34		.005	
08/22/95	8.13		.005	
09/27/95	7.84	3	.004	.0017
JAN 1995 - DEC 1995				
Mean	7.77	3	0.005	0.0017
Minimum Value	7.34	3	0.004	0.0017
Maximum Value	8.13	3	0.005	0.0017

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL MERCURY ug/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
07/03/94	0.007	0.007	0.05	0.005	0.005
07/31/94	0.005	0.009	0.05	0.005	0.007
09/06/94	0.007	0.005	0.05	0.005	0.011
JAN 1994 - DEC 1994					
Mean	0.006	0.007	0.05	0.005	0.008
Minimum Value	0.005	0.005	0.05	0.005	0.005
Maximum Value	0.007	0.009	0.05	0.005	0.011
06/21/95	.0042	.0044	0.02	.0003	.009
08/22/95	.0048	.0053	0.02	.0016	.006
09/27/95	.0030	.0010	0.05	<.0050	<.005
JAN 1995 - DEC 1995					
Mean	0.0040	0.0036	0.03	0.0023	0.007
Minimum Value	0.0030	0.0010	0.02	0.0003	0.005
Maximum Value	0.0048	0.0053	0.05	0.0050	0.009

HOMESTAKE CANADA INC.
CULLATON LAKE WATER QUALITY
1994 - 1995 DATA

STATION: 940-18: TAILINGS POND #1 SPILLWAY

Date	LAB PH pH unit	SUSPENDED SOLIDS mg/l	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l
06/21/94	7.9		0.004	0.002
08/09/94	8.3		0.005	0.0014
JAN 1994 - DEC 1994				
Mean	8.1		0.005	0.0017
Minimum Value	7.9		0.004	0.0014
Maximum Value	8.3		0.005	0.0020
06/21/95	7.53		.005	
08/22/95	7.83		.008	
JAN 1995 - DEC 1995				
Mean	7.68		0.007	
Minimum Value	7.53		0.005	
Maximum Value	7.83		0.008	

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL MERCURY ug/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
06/21/94	0.002	0.004	0.02	0.003	<0.005
08/09/94	0.007	0.005	0.02	0.001	<0.005
JAN 1994 - DEC 1994					
Mean	0.005	0.005	0.02	0.002	0.005
Minimum Value	0.002	0.004	0.02	0.001	0.005
Maximum Value	0.007	0.005	0.02	0.003	0.005
06/21/95	.0021	.0050	.02	.0008	.005
08/22/95	.0019	.0032	.02	.0016	.0005
JAN 1995 - DEC 1995					
Mean	0.0020	0.0041	0.02	0.0012	0.0027
Minimum Value	0.0019	0.0032	0.02	0.0008	0.0005
Maximum Value	0.0021	0.0050	0.02	0.0016	0.0050

HOMESTAKE CANADA INC.
CULLATON LAKE WATER QUALITY
1994 - 1995 DATA

STATION: 940-19: TAILINGS POND #1 PIESOMETER

Date	LAB PH pH unit	SUSPENDED SOLIDS mg/l	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l
06/21/94	7.9		0.004	0.002
07/03/94	8.0	1.0	0.016	0.004
07/31/94	7.9	1.0	0.022	0.003
08/09/94	8.3		0.005	0.001
09/06/94	8.0	2.0	0.013	0.003
JAN 1994 - DEC 1994				
Mean	8.0	1.3	0.012	0.003
Minimum Value	7.9	1.0	0.004	0.001
Maximum Value	8.3	2.0	0.022	0.004
09/27/95	7.89	1	.017	.0017
JAN 1995 - DEC 1995				
Mean	7.89	1	0.017	0.0017
Minimum Value	7.89	1	0.017	0.0017
Maximum Value	7.89	1	0.017	0.0017

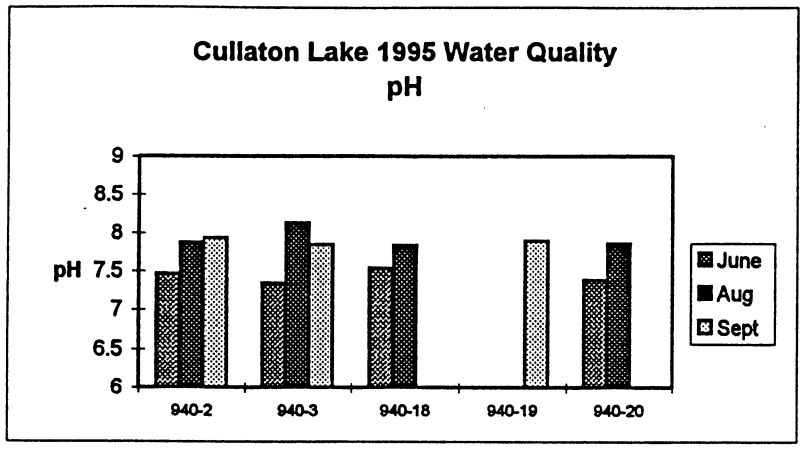
Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL MERCURY ug/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
06/21/94	0.002	0.004	0.02	0.003	0.005
07/03/94	0.001	0.002	0.05	0.005	0.005
07/31/94	0.003	0.004	0.05	0.005	0.009
08/09/94	0.007	0.005	0.02	0.001	0.005
09/06/94	0.002	0.001	0.08	0.005	0.022
09/27/94			0.05		
JAN 1994 - DEC 1994					
Mean	0.003	0.003	0.04	0.004	0.009
Minimum Value	0.001	0.001	0.02	0.001	0.005
Maximum Value	0.007	0.005	0.08	0.005	0.022
09/27/95	.0010	<.0010	<.05	<.0050	<.005
JAN 1995 - DEC 1995					
Mean	0.0010	0.0010	0.05	0.0050	0.005
Minimum Value	0.0010	0.0010	0.05	0.0050	0.005
Maximum Value	0.0010	0.0010	0.05	0.0050	0.005

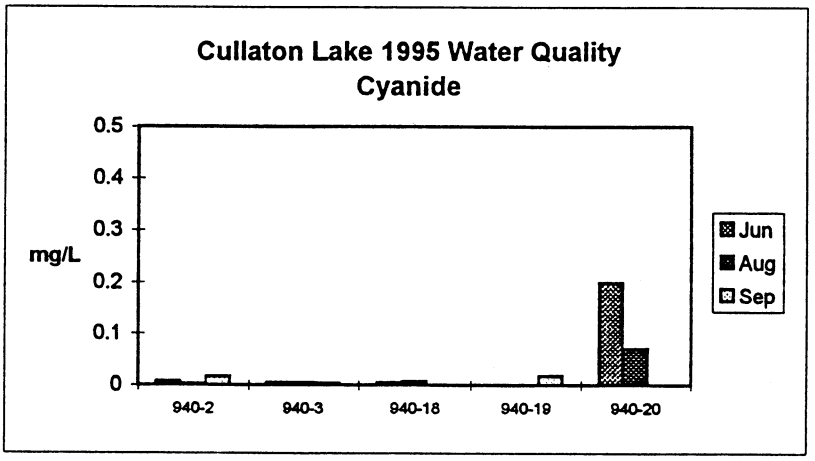
HOMESTAKE CANADA INC.
CULLATON LAKE WATER QUALITY
1994 - 1995 DATA

STATION: 940-20: EAST SIDE OF TAILINGS POND #1

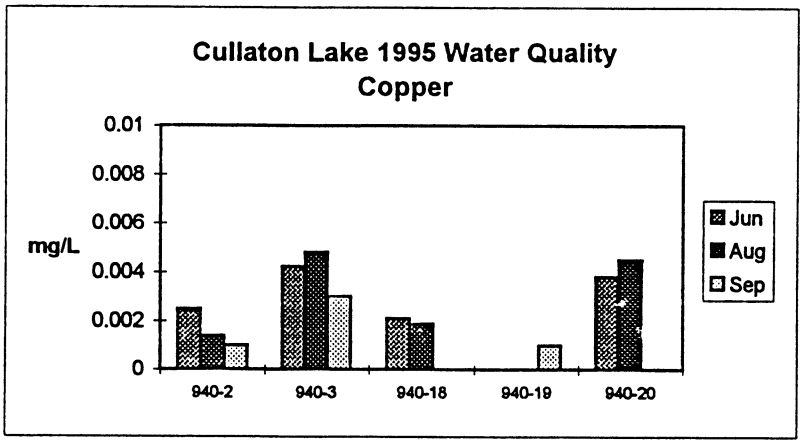
Date	LAB PH pH unit	SUSPENDED SOLIDS mg/l	TOTAL CYANIDE mg/l	TOTAL ARSENIC mg/l
06/21/94	7.9		0.081	0.002
07/03/94	7.9	1.0	0.017	0.003
07/31/94	8.1	3.0	0.005	0.002
08/09/94	8.4		0.004	0.002
09/06/94	8.0	13.0	0.008	0.004
JAN 1994 - DEC 1994				
Mean	8.1	5.7	0.023	0.003
Minimum Value	7.9	1.0	0.004	0.002
Maximum Value	8.4	13.0	0.081	0.004
06/21/95	7.38		.200	
08/22/95	7.86		.070	
JAN 1995 - DEC 1995				
Mean	7.62		0.135	
Minimum Value	7.38		0.070	
Maximum Value	7.86		0.200	

Date	TOTAL COPPER mg/l	TOTAL NICKEL mg/l	TOTAL MERCURY ug/l	TOTAL LEAD mg/l	TOTAL ZINC mg/l
06/21/94	0.005	0.011		0.003	0.005
07/03/94	0.002	0.004	0.05	0.005	0.005
07/31/94	0.008	0.009	0.05	0.005	0.005
08/09/94	0.010	0.011	0.02	0.001	0.005
09/06/94	0.009	0.008	0.05	0.005	0.005
JAN 1994 - DEC 1994					
Mean	0.007	0.009	0.04	0.004	0.005
Minimum Value	0.002	0.004	0.02	0.001	0.005
Maximum Value	0.010	0.011	0.05	0.005	0.005
06/21/95	.0038	.0176	0.02	.0007	.005
08/22/95	.0045	.0251	0.02	.0010	.005
JAN 1995 - DEC 1995					
Mean	0.0041	0.0214	0.02	0.0009	0.005
Minimum Value	0.0038	0.0176	0.02	0.0007	0.005
Maximum Value	0.0045	0.0251	0.02	0.0010	0.005

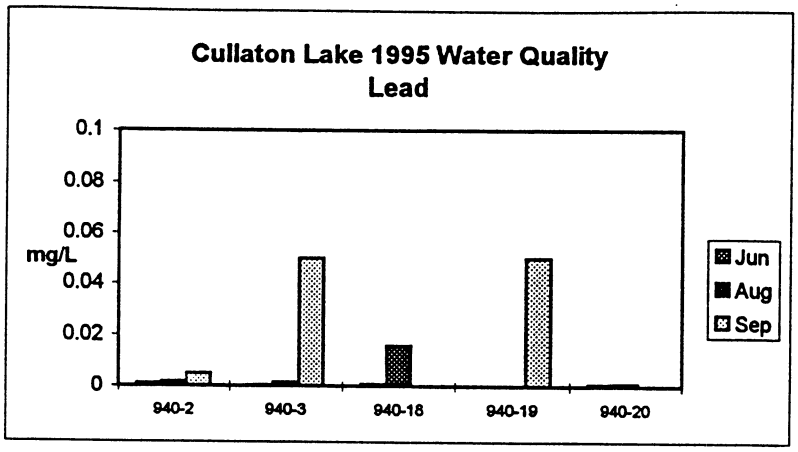




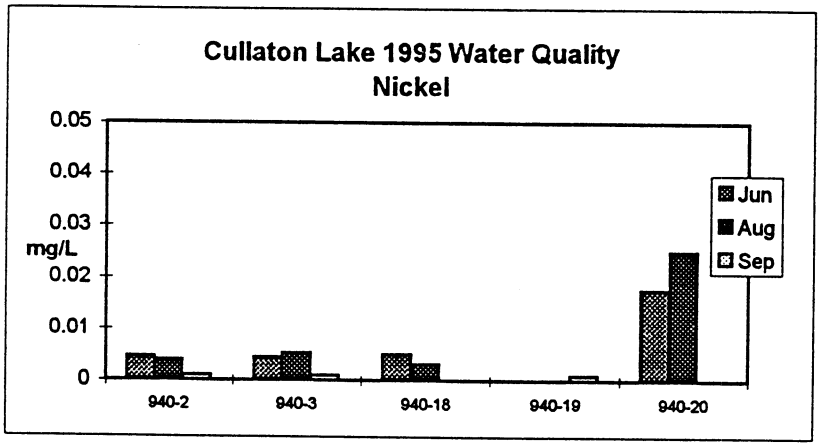
Permit Requirements - Max. Average concentration - 0.80 mg/L



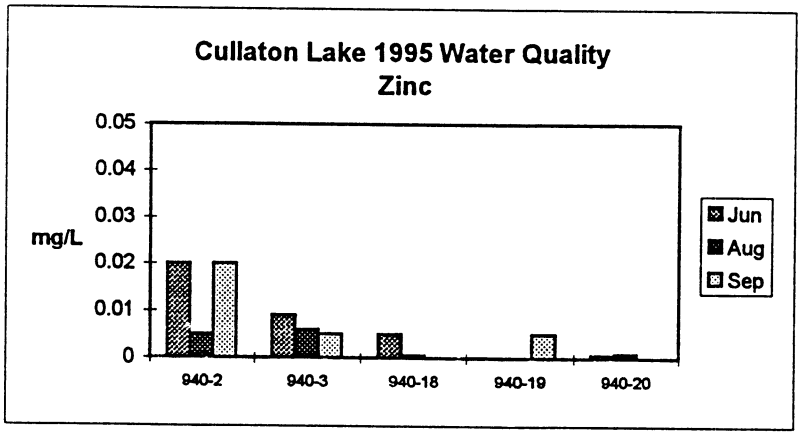
Permit Requirements - Max. Average concentration - 0.20 mg/L



Permit Requirements - Max. Average concentration - 0.20 mg/L



Permit Requirements - Max. Average concentration - 0.30 mg/L



Permit Requirements - Max. Average concentration - 0.30 mg/L

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Box 100
Iqaluit, NT.
X0A 0H0

Your file Votre référence

Our file Notre référence

October 12, 1995

N6L3-0940

Mr. W. Napier
Director Environmental Affairs
Homestake Canada Ltd.
1000 - 700 West Pender St.
Vancouver, BC. V6C 1G8

Dear Mr. Napier:

RE: CULLATON LAKE, SAMPLE ANALYSIS REPORTS FOR AUGUST 22, 1995

Enclosed are copies of the Sample Analysis Reports for the samples collected by the undersigned on August 22, 1995. The sample results are well within the limits prescribed in the Water Licence N6L3-0940.

The reports are self explanatory but should you have any questions please feel free to contact the undersigned at (819) 979-4405.

Sincerely,

Dan Elliott

Dan Elliott
A/District Manager
Nunavut District

encl: Analysis Reports

cc: Keewatin Area Office
Water Resources Division

Canada

Printed on recycled paper – Imprimé sur papier recyclé

RECEIVED
OCT 0 2 1995
D.I.A.N.D.
IQALUIT, NT

DIAN & NORTHERN AFFAIRS
WATER RESOURCES LABORATORY
Box 1500
Yellowknife, NT. X1A 2R3
Tel. (403) 920-8129
Fax. (403) 873-9300

To: Cullaton Lake Area
c/o INAC/NAP
Water Resources
Yellowknife District Office
==> Yellowknife NT
D.Elliott

SAMPLE INFORMATION

Our Lab # : 950865
Your Sample ID: 940-20
Sample Matrix : effluent

Account No.: N6L30940

Collection:
Location: Cullaton Lake Minesite
Date: 08/22/95
By: DE/HK

Report Date: 09/20/95
Approved by:

- SAMPLE ANALYSIS REPORT -

Lab#	Parameter	Result	Units	Detect Limit	Method Code
950865	T.Cadmium ICP-MS	0.2	ug/L	0.100	100133
	Conductivity	687.0	uS/cm	0.100	02041
	T.Cobalt ICP-MS	32.3	ug/L	0.100	100115
	T.Chromium ICP-MS	1.0	ug/L	0.200	100111
	T.Copper ICP-MS	4.5	ug/L	0.100	100119
	T.Manganese ICP-MS	3220.0	ug/L	0.100	100113
	Non-Filt Res.	16	mg/L	3.000	10406
	Ammonia-N	0.772	mg/L	0.002	07562
	T.Nickel ICP-MS	25.1	ug/L	0.100	100117
	NO3-N+NO2-N	1.590	mg/L	0.008	07110
	T.Lead ICP-MS	1.0	ug/L	0.200	100145
	pH	7.86	pH	0.050	10301
	T.Arsenic-Hyd.	3.5	ug/L	0.300	33011
	Tot.Cyanide	0.070	mg/L	0.004	06613
	T.Iron	811	ug/L	20.000	26004
	T.Iron	N/A	ug/L	3.000	26002
	T.Mercury-C/V	L0.02	ug/L	0.020	80011
	T.Zinc ICP-MS	5.0	ug/L	5.000	100121

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT
SEP 2 2 1995
YELLOWKNIFE, N.W.T.
YELLOWKNIFE DISTRICT

SEP 2 0 1995
WATER RESOURCES DIVISION
YELLOWKNIFE N.W.T.

DIAN & NORTHERN AFFAIRS
WATER RESOURCES LABORATORY
Box 1500
Yellowknife, NT. X1A 2R3
Tel. (403) 920-8129
Fax. (403) 873-9300

To: Cullaton Lake Area
c/o INAC/NAP
Water Resources
Yellowknife District Office
==> Yellowknife NT
D.Elliott

SAMPLE INFORMATION

Your Lab # : 950869
Your Sample ID: 940-18
Sample Matrix : effluent

Account No.: N6L30940

Collection:
Location: Cullaton Lake Minesite
Date: 08/22/95
By: DE/HK

Report Date: 09/08/95
Approved by:

- SAMPLE ANALYSIS REPORT -

Lab#	Parameter	Result	Units	Detect Limit	Method Code
950869	T.Cadmium ICP-MS	L0.1	ug/L	0.100	100133
	Conductivity	595.0	uS/cm	0.100	02041
	T.Cobalt ICP-MS	5.6	ug/L	0.100	100115
	T.Chromium ICP-MS	0.9	ug/L	0.200	100111
	T.Copper ICP-MS	1.9	ug/L	0.100	100119
	T.Manganese ICP-MS	57.3	ug/L	0.100	100113
	Non-Filt_Res.	L3	mg/L	3.000	10406
	Ammonia-N	0.079	mg/L	0.002	07562
	T.Nickel ICP-MS	3.2	ug/L	0.100	100117
	NO3-N+NO2-N	0.276	mg/L	0.008	07110
	T.Lead ICP-MS	1.6	ug/L	0.200	100145
	pH	7.83	pH	0.050	10301
	T.Arsenic-Hyd.	3.5	ug/L	0.300	33011
	Tot.Cyanide(low)	0.008	mg/L	0.001	06612
	T.Iron	201	ug/L	20.000	26004
	T.Iron	N/A	ug/L	3.000	26002
	T.Mercury-C/V	L0.02	ug/L	0.020	80011
	T.Zinc ICP-MS	L0.5	ug/L	0.500	100121

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT
SEP 22 1995
YELLOWKNIFE DISTRICT

INDIAN AND NORTHERN AFFAIRS — CANADA
N.W.T. REGION
SEP 19 1995
WATER RESOURCES DIVISION
YELLOWKNIFE, NT

DIAN & NORTHERN AFFAIRS
WATER RESOURCES LABORATORY
Box 1500
Yellowknife, NT. X1A 2R3
Tel. (403) 920-8129
Fax. (403) 873-9300

To: Cullaton Lake Area
c/o INAC/NAP
Water Resources
Yellowknife District Office
==> Yellowknife NT
D.Elliott

SAMPLE INFORMATION

Our Lab # : 950868
Your Sample ID: 940-7
Sample Matrix : effluent

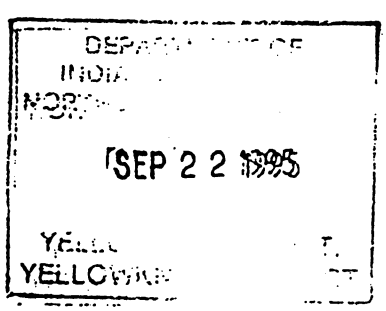
Account No.: N6L30940

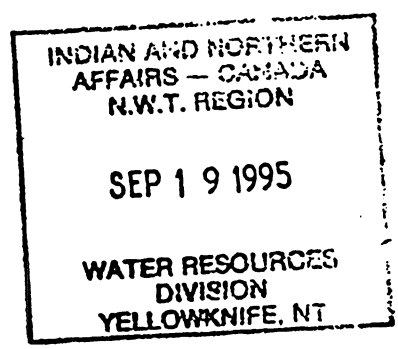
Collection:
Location: Cullaton Lake Minesite
Date: 08/22/95
By: DE/HK

Report Date: 09/08/95
Approved by:

- SAMPLE ANALYSIS REPORT -

Lab#	Parameter	Result	Units	Detect Limit	Method Code
950868	T.Cadmium ICP-MS	L0.1	ug/L	0.100	100133
	Conductivity	110.0	uS/cm	0.100	02041
	T.Cobalt ICP-MS	0.5	ug/L	0.100	100115
	T.Chromium ICP-MS	0.7	ug/L	0.200	100111
	T.Copper ICP-MS	1.6	ug/L	0.100	100119
	T.Manganese ICP-MS	19.6	ug/L	0.100	100113
	Non-Filt Res.	18	mg/L	3.000	10406
	Ammonia-N	0.013	mg/L	0.002	07562
	T.Nickel ICP-MS	3.9	ug/L	0.100	100117
	NO3-N+NO2-N	0.124	mg/L	0.008	07110
	T.Lead ICP-MS	0.7	ug/L	0.200	100145
	pH	7.09	pH	0.050	10301
	T.Arsenic-Hyd.	1.7	ug/L	0.300	33011
	Tot.Cyanide(low)	0.005	mg/L	0.001	06612
	T.Iron	209	ug/L	20.000	26004
	T.Iron	N/A	ug/L	3.000	26002
	T.Mercury-C/V	L0.02	ug/L	0.020	80011
	T.Zinc ICP-MS	7.0	ug/L	5.000	100121





DIAN & NORTHERN AFFAIRS
WATER RESOURCES LABORATORY
Box 1500
Yellowknife, NT. X1A 2R3
Tel. (403) 920-8129
Fax. (403) 873-9300

To: Cullaton Lake Area
c/o INAC/NAP
Water Resources
Yellowknife District Office
==> Yellowknife NT
D.Elliott

SAMPLE INFORMATION

Our Lab # : 950867
Your Sample ID: 940-3
Sample Matrix : effluent

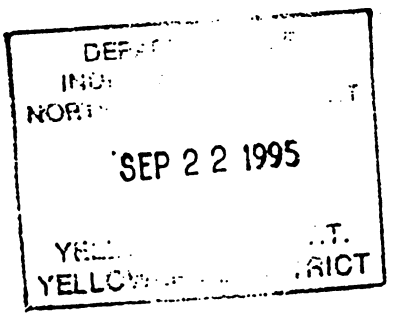
Account No.: N6L30940

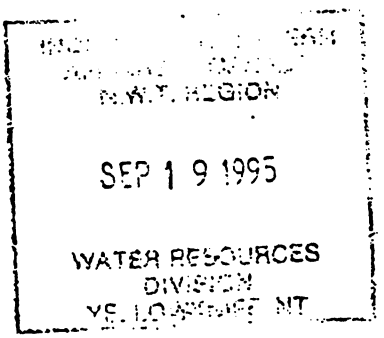
Collection:
Location: Cullaton Lake Minesite
Date: 08/22/95
By: DE/HK

Report Date: 09/08/95
Approved by: WTood

- SAMPLE ANALYSIS REPORT -

Lab#	Parameter	Result	Units	Detect Limit	Method Code
950867	T.Cadmium ICP-MS	L0.1	ug/L	0.100	100133
	Conductivity	373.0	uS/cm	0.100	02041
	T.Cobalt ICP-MS	2.2	ug/L	0.100	100115
	T.Chromium ICP-MS	1.0	ug/L	0.200	100111
	T.Copper ICP-MS	4.8	ug/L	0.100	100119
	T.Manganese ICP-MS	57.4	ug/L	0.100	100113
	Non-Filt_Res.	L3	mg/L	3.000	10406
	Ammonia-N	0.031	mg/L	0.002	07562
	T.Nickel ICP-MS	5.3	ug/L	0.100	100117
	NO3-N+NO2-N	0.086	mg/L	0.008	07110
	T.Lead ICP-MS	1.6	ug/L	0.200	100145
	pH	8.13	pH	0.050	10301
	T.Arsenic-Hyd.	2.3	ug/L	0.300	33011
	Tot.Cyanide(low)	0.005	mg/L	0.001	06612
	T.Iron	190	ug/L	20.000	26004
	T.Iron	N/A	ug/L	3.000	26002
	T.Mercury-C/V	L0.02	ug/L	0.020	80011
	T.Zinc ICP-MS	6.0	ug/L	5.000	100121





'DIAN & NORTHERN AFFAIRS
WATER RESOURCES LABORATORY
Box 1500
Yellowknife, NT. X1A 2R3
Tel. (403) 920-8129
Fax. (403) 873-9300

To: Cullaton Lake Area
c/o INAC/NAP
Water Resources
Yellowknife District Office
==> Yellowknife NT
D.Elliott

SAMPLE INFORMATION

Our Lab # : 950866
Your Sample ID: 940-2
Sample Matrix : effluent

Account No.: N6L30940

Collection:
Location: Cullaton Lake Minesite
Date: 08/22/95
By: DE/HK

Report Date: 09/08/95
Approved by:

- SAMPLE ANALYSIS REPORT -

Lab#	Parameter	Result	Units	Detect Limit	Method Code
950866	T.Cadmium ICP-MS	L0.1	ug/L	0.100	100133
	Conductivity	583.0	uS/cm	0.100	02041
	T.Cobalt ICP-MS	6.0	ug/L	0.100	100115
	T.Chromium ICP-MS	1.0	ug/L	0.200	100111
	T.Copper ICP-MS	1.4	ug/L	0.100	100119
	T.Manganese ICP-MS	47.1	ug/L	0.100	100113
	Non-Filt_Res.	3	mg/L	3.000	10406
	Ammonia-N	0.070	mg/L	0.002	07562
	T.Nickel ICP-MS	4.0	ug/L	0.100	100117
	NO3-N+NO2-N	0.265	mg/L	0.008	07110
	T.Lead ICP-MS	1.8	ug/L	0.200	100145
	pH	7.87	pH	0.050	10301
	T.Arsenic-Hyd.	4.2	ug/L	0.300	33011
	Tot.Cyanide(low)	0.002	mg/L	0.001	06612
	T.Iron	381	ug/L	20.000	26004
	T.Iron	N/A	ug/L	3.000	26002
	T.Mercury-C/V	L0.02	ug/L	0.020	80011
	T.Zinc ICP-MS	L5	ug/L	5.000	100121

SEP 2 2 1995

INDIAN AND NORTHERN AFFAIRS — CANADA
N.W.T. REGION
SEP 1 9 1995
WATER RESOURCES DIVISION
YELLOWKNIFE, NT

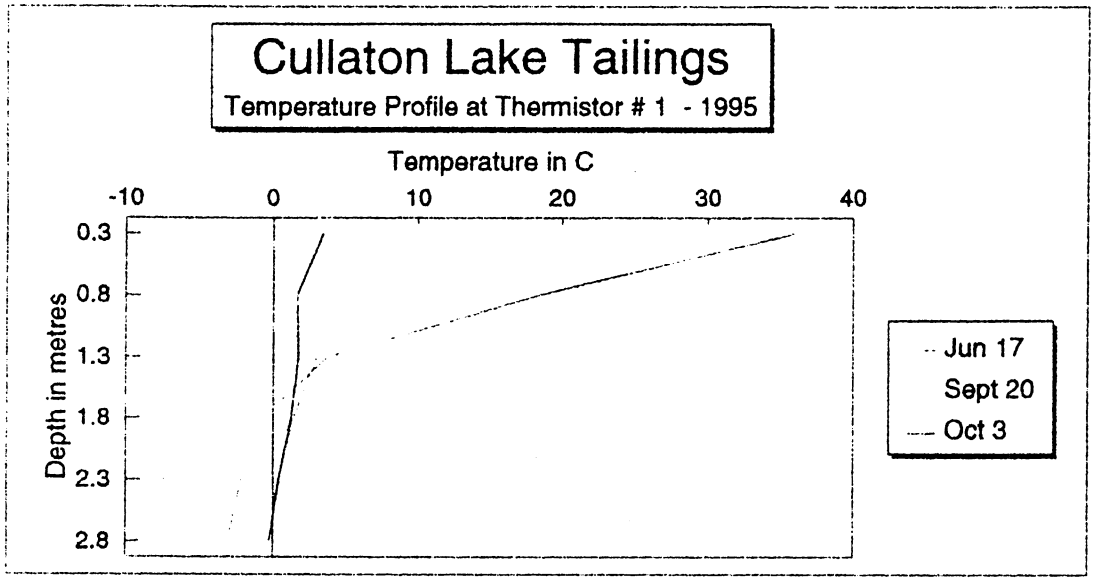
CULLATON LAKE TAILINGS AREA
THERMISTOR READINGS
1995

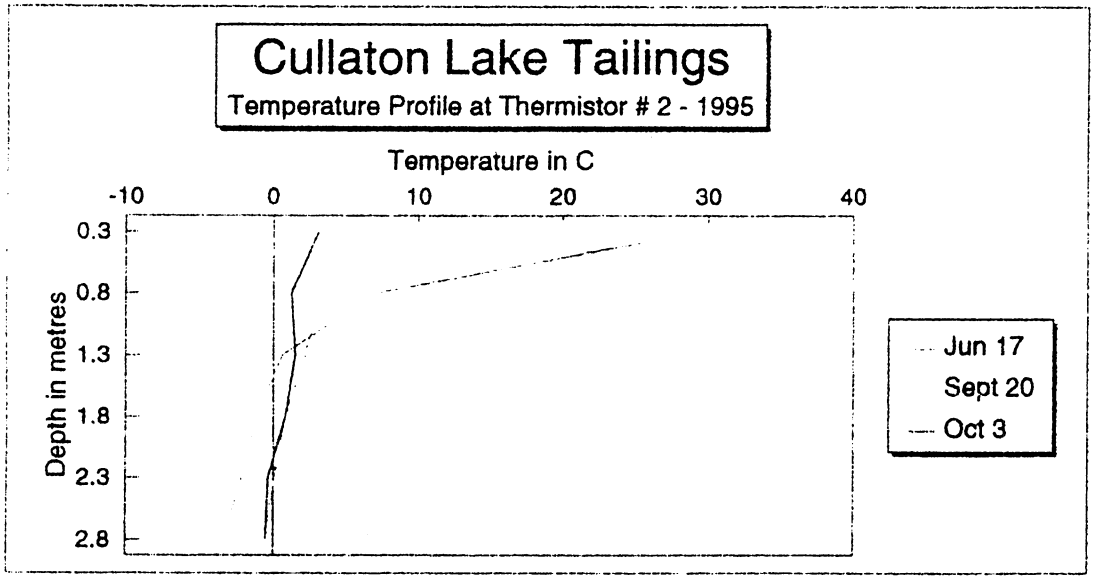
Readings In Kilohms

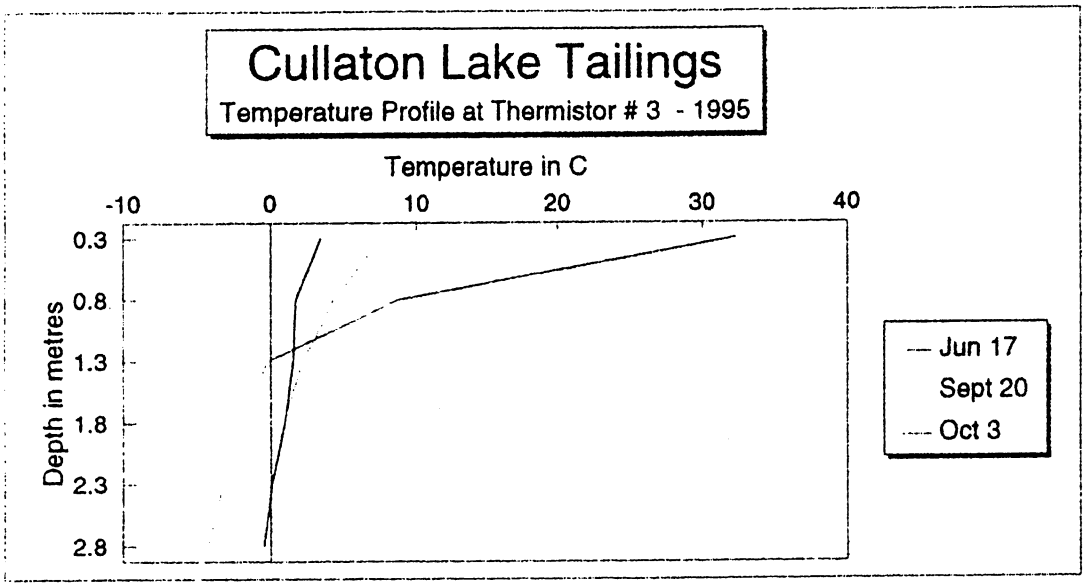
Date	Thermistor Number	Position 0	Position 1	Position 2	Position 3	Position 4	Position 5
17-Jun-95	#1	3.17	6.68	13.52	16.99	18.28	19.20
20-Sep-95	#1	11.31	12.55	14.03	15.19	16.07	16.56
3-Oct-95	#1	13.74	14.95	14.96	15.33	16.00	16.55
17-Jun-95	#2	4.14	11.47	15.81	17.33	18.25	19.50
20-Sep-95	#2	11.26	13.80	14.64	15.67	16.17	16.84
3-Oct-95	#2	13.96	15.35	15.13	15.65	16.66	16.81
17-Jun-95	#3	3.64	10.59	16.50	18.04	19.30	20.30
20-Sep-95	#3	11.22	13.12	14.57	15.61	16.23	16.74
3-Oct-95	#3	13.72	14.94	15.09	15.58	16.23	16.71
17-Jun-95	#4	3.10	4.99	12.22	17.21	18.47	19.60
20-Sep-95	#4	11.35	12.83	13.73	15.42	16.18	16.67
3-Oct-95	#4	13.64	14.64	15.30	15.56	16.15	16.67

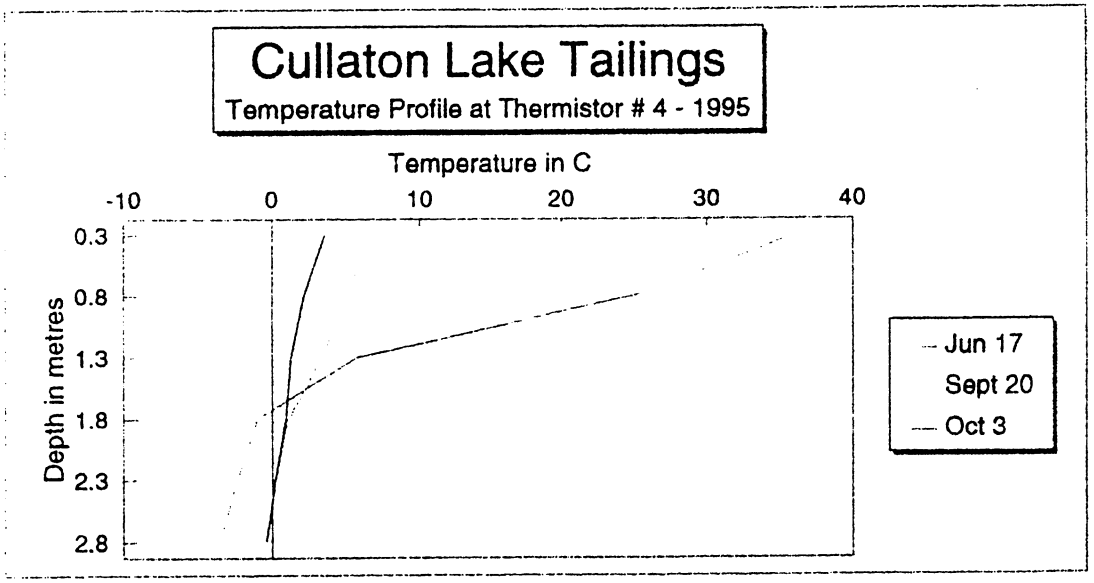
Readings in Celcius

Date	Thermistor Number	Position 0	Position 1	Position 2	Position 3	Position 4	Position 5
17-Jun-95	#1	35.99	18.51	3.74	-0.76	-2.18	-3.13
20-Sep-95	#1	7.36	5.25	2.97	1.44	0.32	-0.27
3-Oct-95	#1	3.42	1.64	1.73	1.25	0.41	-0.26
17-Jun-95	#2	29.36	7.07	0.64	-1.15	-2.16	-3.43
20-Sep-95	#2	7.45	3.33	2.16	0.82	0.08	-0.60
3-Oct-95	#2	3.11	1.23	1.51	0.84	-0.38	-0.56
17-Jun-95	#3	32.39	8.71	-0.20	-1.93	-3.23	-4.20
20-Sep-95	#3	7.53	4.34	2.25	0.89	0.12	-0.48
3-Oct-95	#3	3.45	1.76	1.57	1.00	0.12	-0.44
17-Jun-95	#4	36.25	25.04	5.79	-1.02	-2.38	-3.53
20-Sep-95	#4	7.29	4.79	3.43	1.13	0.18	-0.39
3-Oct-95	#4	3.57	2.16	1.29	0.95	0.22	-0.39


Cullaton Lake Tailings
Temperature Profile at Thermistor # 1 - 1995
Temperature in C
-10
0
10
20
30
40
Depth in metres
0.3
0.8
1.3
1.8
2.3
2.8
Jun 17
Sept 20
Oct 3

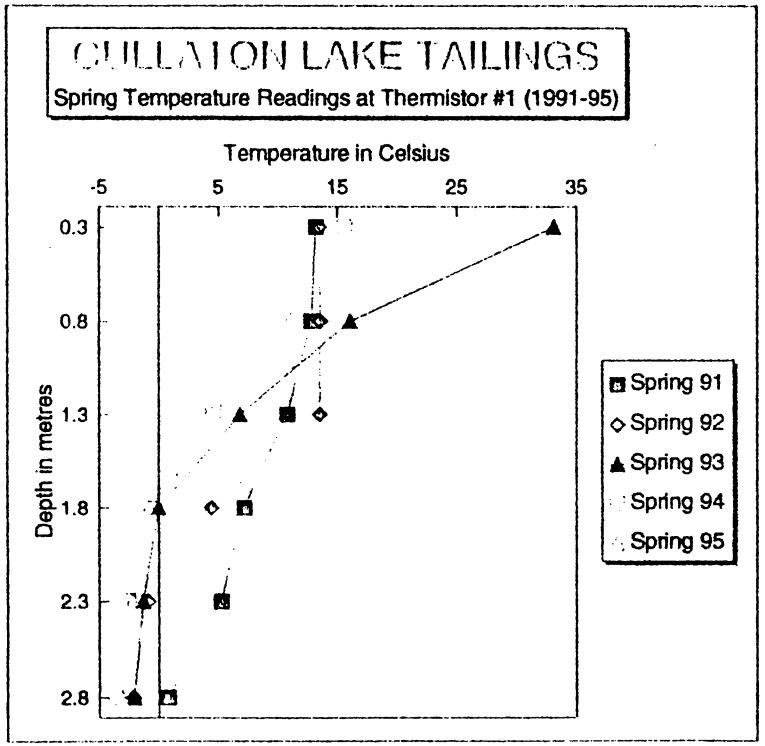

Cullaton Lake Tailings
Temperature Profile at Thermistor # 2 - 1995
Temperature in C
-10
0
10
20
30
40
Depth in metres
0.3
0.8
1.3
1.8
2.3
2.8
Jun 17
Sept 20
Oct 3

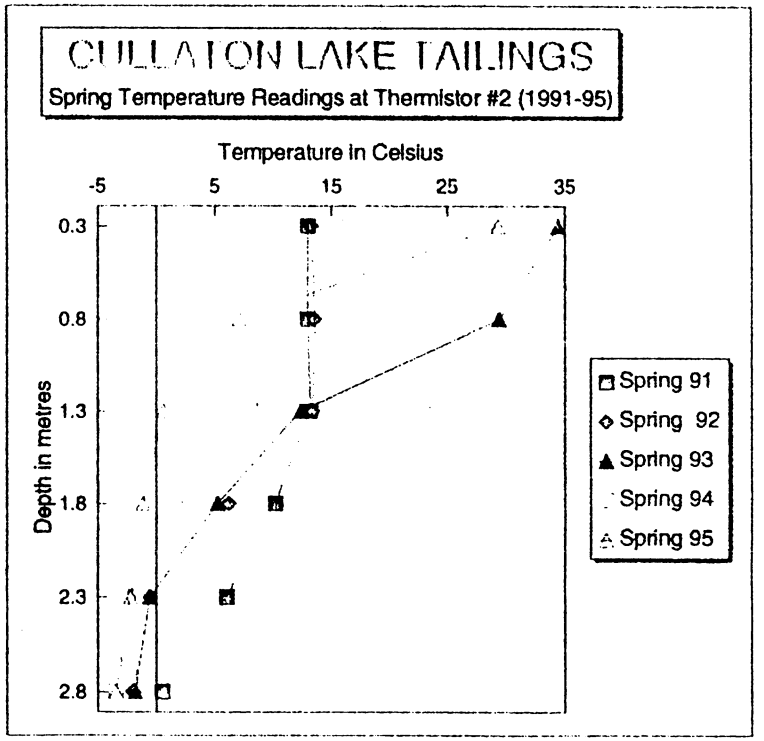

Cullaton Lake Tailings
Temperature Profile at Thermistor # 3 - 1995
Temperature in C
-10
0
10
20
30
40
Depth in metres
0.3
0.8
1.3
1.8
2.3
2.8
Jun 17
Sept 20
Oct 3

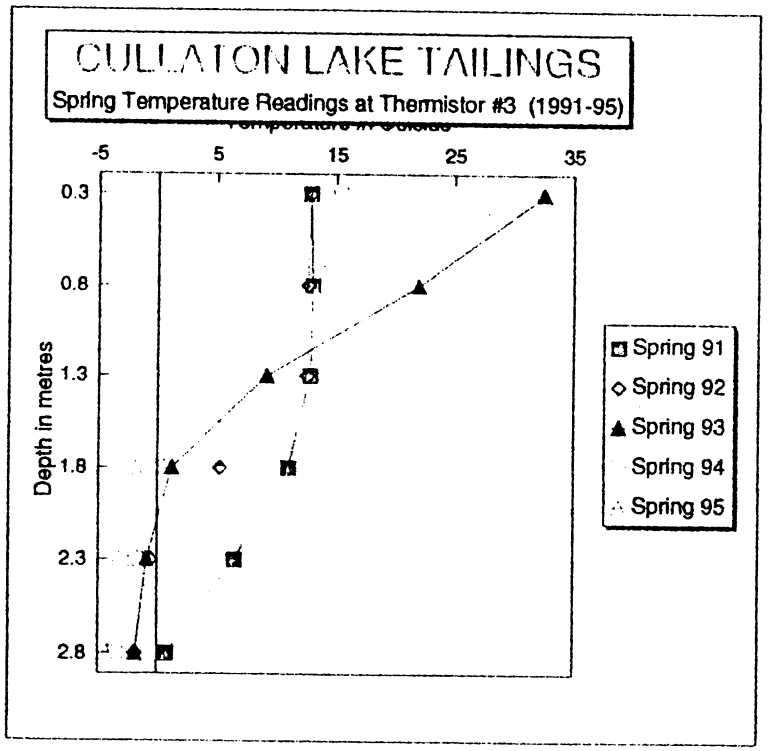

Cullaton Lake Tailings
Temperature Profile at Thermistor # 4 - 1995
Temperature in C
-10
0
10
20
30
40
Depth in metres
0.3
0.8
1.3
1.8
2.3
2.8
Jun 17
Sept 20
Oct 3

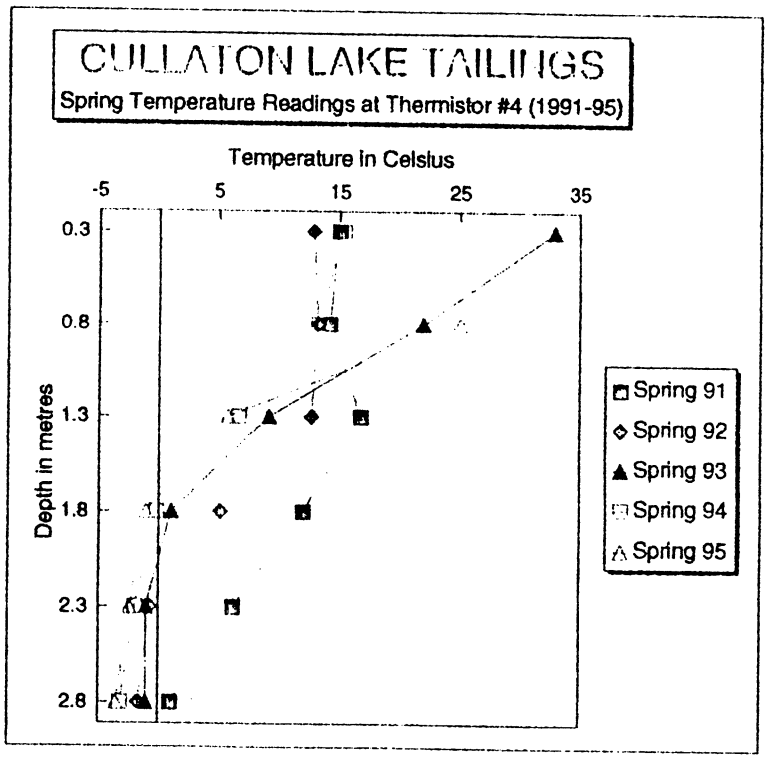
CULLATON LAKE

1995 THERMISTOR DATA



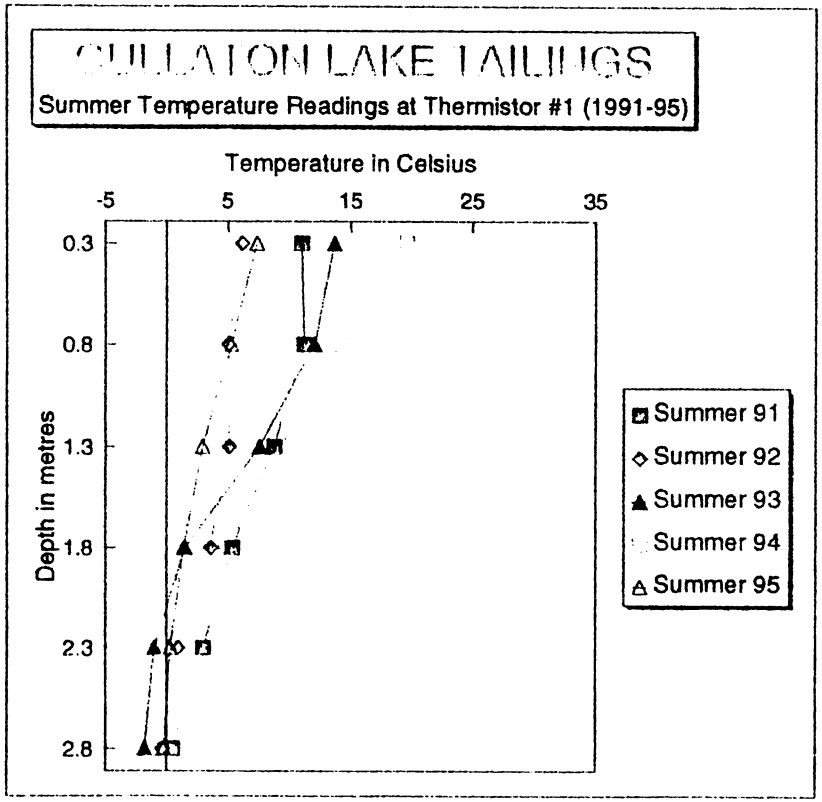


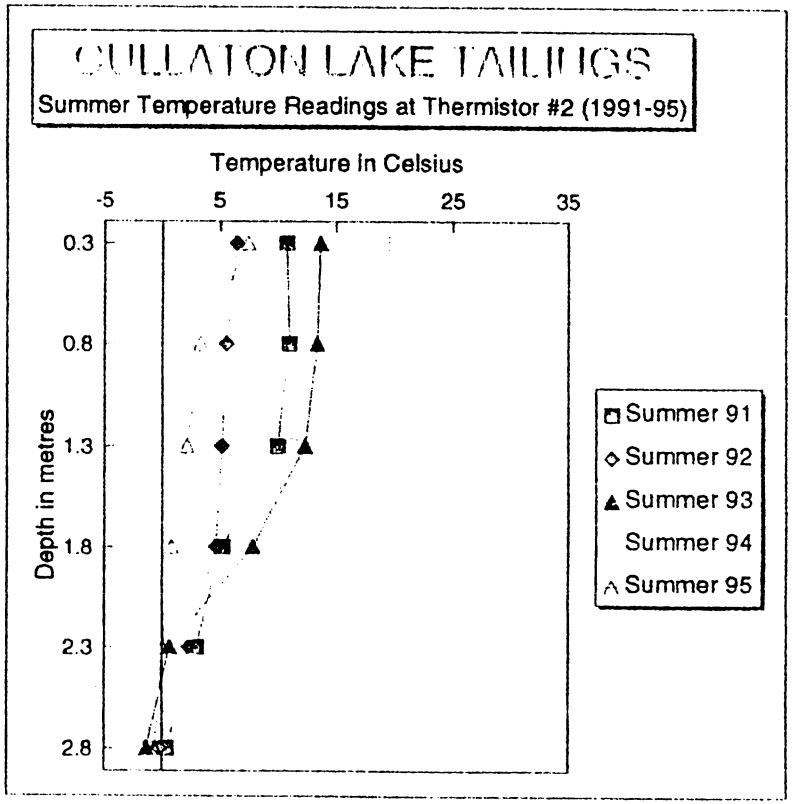

CULLATON LAKE TAILINGS
Spring Temperature Readings at Thermistor #3 (1991-95)
-5
5
15
25
35
0.3
0.8
1.3
1.8
2.3
2.8
Depth in metres
Spring 91
Spring 92
Spring 93
Spring 94
Spring 95


CULLATON LAKE TAILINGS
Spring Temperature Readings at Thermistor #4 (1991-95)
Temperature in Celsius
-5
5
15
25
35
0.3
0.8
1.3
1.8
2.3
2.8
Depth in metres
Spring 91
Spring 92
Spring 93
Spring 94
Spring 95

CULLATON LAKE

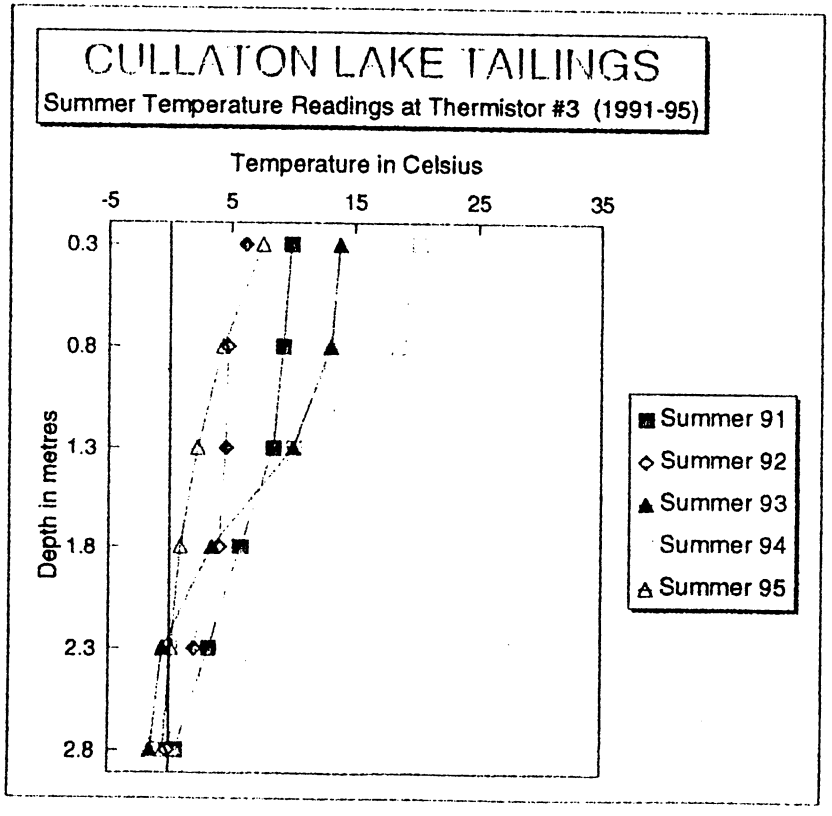
1995 THERMISTOR DATA

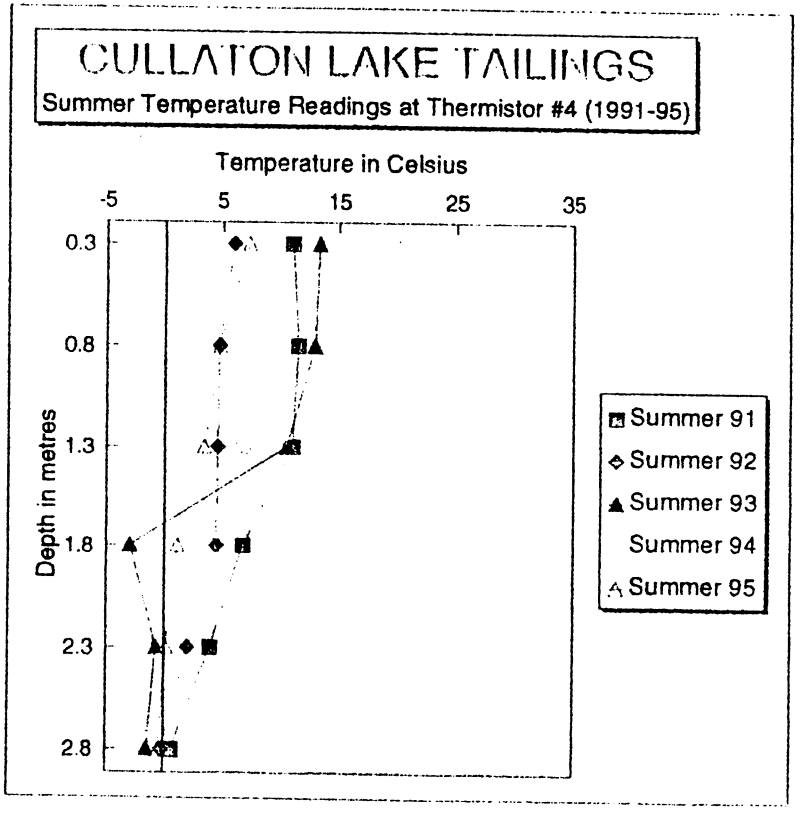




CULLATON LAKE

1995 THERMISTOR DATA





Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
P.O. Box 100
Iqaluit, N.W.T.
X0A 0H0

Your file Votre référence

Our file Notre référence

N6L3-0940

September 11, 1995

Mr. W. Napier
Director Environmental Affairs
Homestake Canada Ltd.
1000 - 700 West Pender St.
Vancouver, BC. V6C 1G8

Dear Mr. Napier:

RE: CULLATON LAKE, HOMESTAKE CANADA LTD. - AUGUST 22, 1995 INSPECTION REPORT - NORTHWEST TERRITORIES WATERS ACT - WATER LICENCE N6L3-0940

Enclosed is a copy of the inspection report prepared by the undersigned, an Inspector designated under the Northwest Territories Waters Act. The report is self explanatory as are the concerns raised in the text of the report. There are some concerns related to some minor spills on the site as well as the actual use/operation of the Quarry Pit as a bulky waste disposal area.

It is realized that due to recent storm events, there was a considerable increase in the precipitation in the area but the Inspector was concerned as to whether or not the pit was dewatered prior to its use as a disposal site and if not, why? There remains the concern, as stated in the TAC forum prior to the drafting of the renewed Water Licence, that, if water is allowed into the pit area prior to capping of the site, then frost heaving of materials due to the expansion of water as it freezes, was likely to happen. I was under the impression that the pit was to be drained or pumped out and the materials to be disposed of in the pit were to be made to lie flat and compacted. From the evidence I saw at the site, greater efforts are required to compact the materials prior to the abandonment of the pit area.

The samples taken while on site were forwarded to the Northern Analytical Lab for analysis. Once the results of this analysis have been received, they will be forwarded to your office for your consideration.

.../2

Canada

Printed on recycled paper – Imprimé sur papier recyclé

If you have an questions related to this report please feel free to contact the undersigned at (819) 979-4405.

Sincerely,

Dan Elliott

Dan Elliott
A/District Manager, Nunavut District
Department of Indian and Northern Affairs

DME/de

encl: Inspection Report

cc: Water Resources Division DIAND
Land Resources Division DIAND
Keewatin Area Office

Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

INDUSTRIAL WATER USE INSPECTION REPORT

DATE: 95-08-22 COMPANY REP.: Mr. B. Napier

LICENSEE: Homestake Canada Inc LICENCE #: N6L2-0940

WATER SUPPLY

Source: Kaguyak R. Quantity Used: minimal Meter Rdg.: N/A

Indicate: A - Acceptable U- Unacceptable N/A - Not Applicable

Intake Facilities	A	Storage Structures	N/A	Treatment Systems	N/A	Recycling	N/A
Flow Meas. Device	N/A	Conveyance Lines	N/A	Pumping Stations	N/A	Modifications	N/A

Comments: Minimal water used at present only for domestic purposes for very small camp. - Dock, constructed of Granular material remaining on site.

WASTE DISPOSAL

Tailings: Tailings Pond ☑ Natural Lake ☐ Underground ☐

Sewage: Sewage Treat. System ☐ Tailings Pond ☐ Natural Water Body ☐
Continuous Discharge ☐ Inter.Dischg. ☑

Solid Waste: Open Dump ☐ Landfill ☐ Burn & ~~Bury~~ ☑ Underground ☐

Indicate: A - Acceptable U- Unacceptable N/A - Not Applicable

Discharge Quality	A	Conveyance Lines	N/A	Disch. Meas. Dev.	N/A	Freeboard	A
Decant Structures	A	Pond Treatment	A	Dams, Dykes	A	Seepages	N/A
Dyke Inspections	N/A	Runoff Diversion	A	Erosion	A	Spills	✓

Effluent Discharge Rate: _____ Samples Collected: 0940-3, 0940-2, 0940-7, 0940-20, 0940-18

Comments: Dump site is, at present a concrete foundation where domestic wastes are burnt on an irregular basis - There was a flow of about 10-20 gpm at the spillway from pond 2 see pg 2 for note on spills

GENERAL CONDITIONS

Indicate: A - Acceptable U- Unacceptable N/A - Not Applicable

Ore & Waste Rock Stockpiles	A	Records & Reporting	A* note 1	Surv. Net. Prog.	A
Geotechnical Inspection	A	Posting, Signage	A	Contingency Plan	A
Restoration Activities	A ongoing	New Construction	N/A	Fuel Storage	A
Mine Water Discharge	N/A	Chemical Storage	N/A	Annual Report	A* note 1

Comments: Note 1. Annual Report was very complete but missing some cold weather ARD data/report - report was not complete at time of submission - Licensee also provided a small report on progress of Restoration which deals mainly with land issues

Violations of Act or Licence: spills - see next page

General Comments: As far as water related concerns go. all is well with the exception of some minor spills to be reported.

Page 2 attached ☑ Yes ☐ No

NOT AVAILABLE
Licensee Representative's Title

DAN ELLIOTT
Inspector's Name

Licensee Representative's Signature

Dan Elliott
Inspector's Signature

Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

WATER USE INSPECTION REPORT
(continued)

Date: 95-08-22 Licence #: 11612-0940

General Comments: (Continued)

All restoration activities as they relate to water issues are progressing.

Spills: While on site there were a few minor spills and they cause some concern over the methods of dealing with the disposal of the equipment and facilities on site

① by area of Quarry pit there was an area beside one of the underground mining pieces of equipment that exhibited an area of spilled oil on the ground. The equipment was on its side and it appears as if they had tipped the machine over on it side to drain the oil - If this is the case it is an unacceptable method of draining the equipment - care should be made to collect and properly dispose of the oil and Hydraulic Fluids from the equipment

② By Generators - evidence of oil in a trough that went around the generator engines - this oil is to be cleaned up as it one the trough (floor sump) is near full and exposed to the outside therefore precipitation could increase the level to over flowing.

③ By Garage - considerable amount of staining in front that is to be expected this material is to be scraped up & disposed of properly - As well, at side of building there is evidence of a spill not noted before (side of building going towards B Zone Portal). This "spill" is located in a trench below the utilidor - it could be just compressor blowby that has escaped below the pipes in the utilidor. First noted this time because part of wooden utilidor structure was open. This will also have to be properly restored.

- Concerns are quarry pit disposal areas are as follows

Dan Elliott
Water Inspector

Copy 1 - Inspectors File Copy Copy 2 - Field Rep. Copy 3 - Licensee Copy 4 - Water Resources Copy

Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

WATER USE INSPECTION REPORT
(continued)

Date: 95-08-22

Licence #: N6L2-0940

General Comments: (Continued)

Quarry Pit continued

There are some concerns that stem from the Quarry pit Disposal site. They are as follows:

① considerable volume of water present in the pit at time of inspection. Syphon lines still in place but were they used this year? With the volume of water present how are materials carefully made to lie flat so as to minimize frost heaving (materials were to be compacted so as to minimize voids and thus chances for water to get into voids and thus minimize water entrainment and "jacking" upon freezing")

② As well, while on site, there was evidence that not all materials in the pit were compacted as well as could be expected. What effort will be made to take some of the equipment lie flat? Will the pit be dewatered next season to reduce the water entrainment?

Water related concerns associated directly with the A & R of the site progress in a satisfactory manner.

It was unfortunate that no one was on site to accompany the Inspector during his inspection, however scheduling of time for the Inspector was difficult and thus being on site when company representative were on site was difficult

Dan Elliott
Water Inspector

Copy 1 - Inspectors File Copy Copy 2 - Field Rep. Copy 3 - Licensee Copy 4 - Water Resources Copy

HOMESTAKE

September 25, 1995

Mr. D. Elliott A/District Manager
Nunavut District
Department of Indian and Northern Affairs
P.O. Box 100
Iqaluit, N.W.T.
X0A 0H0

Dear Mr. Elliott;

Re: Response to Cullaton Lake Inspection Report
Water Licence N6L3-0940

This is to acknowledge the receipt of your inspection report dated September 11, 1995 summarizing your inspection of the Cullaton Lake site on August 22, 1995.

Our response to the issues identified in your letter of transmittal and inspection report is as follows:

1. *Quarry Pit - Syphoning.* The quarry pit was syphoned in early June 1995, prior to the deposition of non-salvageable material into the pit. During the deposition of material into the quarry pit there was no discharge of water. However, during the 5-week dismantling period this summer, over 80 cm of rainfall was measured and, prior to the crew departing the site, approximately 0.5 metres of water was measured in the quarry pit. During the period of September 23 to September 28, 1995, M.E.I. staff will be at Cullaton Lake and the quarry pit will be syphoned out at this time. Prior to the transport of material during the 1996 dismantling season, the quarry pit water will be syphoned once again.

2. *Quarry Pit - Placement of Material.* Both the Company and the decommissioning contractor are aware of the necessity of compacting the material placed in the quarry pit. The material placed in the pit this summer was crushed prior to the placement of a cap. For example, all tanks were opened at both ends, and crushed by the D-8 cat prior to the placement of the capping material.

The uncovered material currently in the quarry pit will be crushed once sufficient material has been placed in the pit and prior to the placement of a cap. This work will be completed in the summer of 1996 with the commencement of further decommissioning.

3. *Quarry Pit - Oil Contaminated Soil.* The underground equipment located near the quarry pit originated from Shear Zone, part of the area that was decommissioned this year. Prior to the transport of the material to the quarry pit, the drain plugs were removed and the oil was drained from the

Homestake Canada Inc.
1000 - 700 West Pender Street • Vancouver, British Columbia • V6C 1G8 • Phone: (604) 684-2345 • Fax: (604) 684-9831

engines. The oil was collected in a 0.3 m high oil pan and was incinerated. As discussed during our May 25, 1995 meeting, oil-stained areas will be identified and the material will be collected and transported to either B-Zone or S-Zone for placement in the collar.

4. *Generators - Oil Contaminated Soil.* During the fall work period, September 23 to September 28, 1995, oil located in the generator trough will be collected and disposed of, and gravel will be placed in the trough.

5.*Garage - Oil Stained Area.* The oil staining identified by the side of the garage was a result of the compressor blow-by during operations (as you are aware this was part of the Utilidor servicing the fuel air-lines for the B-Zone). The Utilidor was dismantled of 1992. We are not aware of any new oil spills in this area during the past year. As indicated in the previous section, it is our intention to collect the oil-stained material and place it in the collar of one of the mine portals.

We agree it is unfortunate that no Company representative was able to accompany you during the site inspection. Homestake Canada intends to have a project manager at the site for the duration of the decommissioning work in 1996. Once a contractor has been selected and the schedule for work completed, we will inform your office of the period when personnel will be at the site. Perhaps the next inspection will coincide with the presence of Homestake staff.

I trust this response addresses your concerns. Should you have any questions or queries, or wish to discuss these matters further, please do not hesitate to contact me.

Yours truly,
HOMESTAKE CANADA INC.

Sharon Meyer

for W. A. Napier
Manager, Environmental Affairs

INTERNATIONAL
CO..JNA
CORPORATION
Tel: (604) 669-1011
Fax: (604) 669-7177
666 Burrard Street, Suite 2500, Vancouver, BC V6C 2X8

February 27, 1992

Mr. Kevin McDonnell
Head
Regulatory Approvals
Water Resources Division
Renewable Resources and Environment
7th Floor, Bellanca Building
Yellowknife, Northwest Territories
X1A 2R3

0940-1
IN
NWB
KEEWATIN
DISTRICT

Dear Mr. McDonnell:

RE: CULLATON LAKE GOLD MINE 1991 ANNUAL REPORT

Enclosed is the 1991 Annual Report for Cullaton Lake Gold Mine.

Ownership and control of the property remains the responsibility of International Corona Corporation.

During the summer of 1991 work on decommissioning the tailings area of the property was initiated. This work will continue during the summer of 1992 as outlined in a submission to you in January.

Results of all environmental monitoring conducted during 1991 are included in appendix I of the report. Water quality at the discharge from the tailings area remained very good.

There were no environmental problems at the site during 1991.

If you have any questions regarding the report, please call me at 306-425-3529 or you may contact Bill Napier at our Vancouver office.

Yours truly,

Garry Biles, P.Eng.
Cullaton Project Manager

DEPAR... AFFAIR...
MAR 0 2 1992
DI

CULLATON LAKE GOLD MINE

WATER LICENCE N6L3-0940

ANNUAL

ENVIRONMENT REPORT

1991

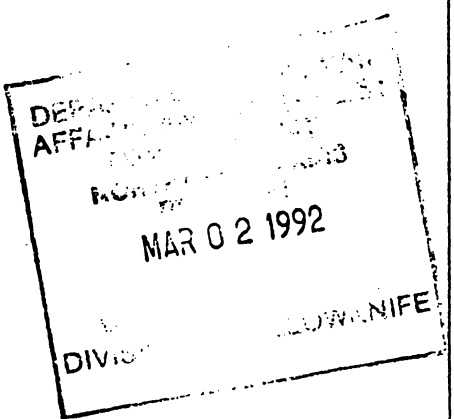


TABLE OF CONTENTS

1. 1991 HIGHLIGHTS

2. SUMMARY

3. SAMPLING RESULTS DISCUSSION

4. 1992 WORK PROGRAM

5. APPENDIX I - SAMPLING RESULTS

6. APPENDIX II - LAB QUALITY ASSURANCE

7. APPENDIX III - DRAWINGS AND PHOTOGRAPHS

1.0 1991 HIGHLIGHTS

MAY - Submitted the Abandonment and Restoration Plan.

JUNE - Released 80,000 cubic meters of water from tailings pond #1.
- Collected daily water samples as outlined in the Surveillance Network Program.
- Collected sediment samples from tailings pond #2.
- Collected tailings spilled outside #1 tailings pond and placed along tailings beach inside pond #1.
- Prepared site equipment and began depositing mill reject material along B-zone tailings beach.
- Crew was on site from June 14th to 22nd.

JULY - Crew returned to site on July 23rd.
- Continued moving mill rejects to B-zone tailings beach.
- Released additional 95,000 cubic meters of water from #1 pond to elevation 92.9 meters.
- Collected daily water samples during release.
- Began lowering dams surrounding #1 tailings pond and spreading along exposed tailings beach.
- Collect five samples of waste rock for acid producing potential.
- Collected samples of tailings for leach tests.

AUGUST - Completed lowering of approximately 95% of the dams surrounding #1 tailings pond. Side slopes were flattened to increase dam stability and excess fill material was trucked or pushed onto the tailings beach.
- Moved 2800 bags of hydrated lime from the crusher building onto the B-zone tailings beach and covered it with fill material.
- Constructed a spillway at 93.5 meter elevation in East dam of #1 tailings pond.
- Completed placement of the mill rejects along the B-zone tailings beach.
- Installed four thermistors in the tailings area.
- Removed the pump house from the Kognak River and dismantled the fresh water line.

SEPTEMBER- Stored all equipment, secured buildings and left the site by September 8th.

NOVEMBER - Submitted report on 1991 decommissioning activity

2.0 SUMMARY

Following the submission of the Abandonment and Restoration Plan for Cullaton Lake to the Northwest Territories Water Board in May 1991 work began on implementation of the plan in June 1991. Efforts in 1991 concentrated on decommissioning of the tailings storage area. Restoration work in this area involves lowering of the water level in tailings pond #1 to 92.9 meters with the release of 175,000 cubic meters of water to the environment. Discharge of the water was accomplished by using six syphons placed across the east side of #1 dam. The syphons consisted of six (6) inch plastic pipes.

Water was released for one week in June and one week at the end of July. During this release of water, daily water sampling was conducted at the stations designated in the Surveillance Network Program and analyzed for the elements required. Results of all water samples collected at the various locations are attached along with graphs for station 940-3 showing water quality at the #2 pond discharge from April, 1986 to July, 1991. These graphs demonstrate the continuous improvement in water quality at #2 pond discharge over the past five years with results in 1990 and 1991 being stabilized at very low contaminant concentrations with the quality far exceeding the discharge limit requirements for all elements.

Work at the site consisted of two periods from June 14th to 22nd and from July 23rd to September 8th.

During the June visit emphasis was directed at mobilizing an equipment fleet to conduct the earthmoving operations which would take place in July and August. Accommodations were set up in the camp and several pieces of underground and surface earth moving equipment made operational.

Other work involved setting up syphons in #1 pond and the release of 80,000 cubic meters of water from #1 pond. A start was made on moving the mill reject material and spreading it along the B-zone tailings beach and the collection of tailings which had been spilled outside the #1 pond area during operations.

The work crew returned to the site on July 23rd and began earth moving operations. The work comprised of moving the remaining mill reject pile onto the tailings beach and spreading it to 0.5 meters thickness and the lowering of #1 tailings dams. Lowering of the dams was accomplished using the D8 bulldozer with the material being pushed into the pond to cover the exposed tailings beach and downstream slopes being flattened to improve the long term stability of these structures.

Excess material generated from the lowering of the #1 dams was trucked to the remaining tailings beach and spread in these areas. Approximately 95% of the dams surrounding #1 tailings pond were lowered in 1991 and about 45% of the exposed tailings covered. Although a cover of approximately 0.5 meters was achieved, much fill still needs to be added to the B-zone tailings area to achieve the desired 1400 mm thickness.

Along with placing the fill material on the tailings beach other activities being undertaken included:

The placement and covering of 2800 bags of hydrated lime along the B-zone beach.

The installation of 4 thermistors in the tailing area. Two in the Shear Lake tailings and two in the B-zone tailings.

Discharging an additional 95,000 cubic meters from tailings pond #1 to level 92.9 meters. Total discharge for 1991 was approximately 175,000 cubic meters.

The collection of 5 samples of waste rock and a sample of mill rejects for acid generation testing. Testwork was conducted at Canmet in Elliott Lake, Ontario. Overall results indicated that the waste rock was not acid generating.

The construction of a spillway in the East dam of #1 pond area. Currently the invert is at elevation 93.8 meters and will need to be lowered to the desired 93.5 meter elevation in 1992.

Removal of the pump house and equipment from the Koqnak River and dismantling of the fresh water supply line.

The collection of four sediment samples from tailings pond #2 for analysis.

A detailed report of 1991 site activity was submitted to the Water Resources division in November, 1991. Results of all sampling are repeated in this report in appendix I along with results of the acid generating tests conducted on samples of waste rock.

Analyses of water and sediment samples were conducted by Saskatchewan Research Council in Saskatoon. An outline of their Quality Assurance Program is included in appendix II.

To ensure that field samples were not contaminated these samples were collected by either myself or Rodney McKay, who had been trained in proper sample collection and preservation techniques. Only new bottles were used for sample collection, each bottle was rinsed at the sample collection station prior to collecting the sample for analysis. All bottles were properly labelled prior to sample collection. Immediately following collection the samples were preserved and shipped at the earliest possible date to the lab for analysis.

Since the operation remained closed throughout 1991 no water was used for industrial purposes and no water was pumped from the mine.

Modifications made to the waste management facilities in 1991 are outlined above and illustrated in the drawings and photographs included in appendix III.

The tailings area decommissioning efforts initiated in 1991 will be continued in 1992. An outline of the work proposed for 1992 was submitted to the Water Resources Division for approval in January 1992.

Revisions to the Spill Contingency Plan for the Cullaton site have been completed and the revised plan will be submitted for your review in the near future.

There were no unauthorized discharges at the site during 1991.

The tailings dams surrounding #1 pond received major modifications in 1991 with the lowering of these dams and flattening of the side slopes to increase the long term stability of these structures. With the lowering of the water level in #1 pond the hydraulic pressure being exerted across #1 pond dams has been drastically reduced.

The condition of the dams surrounding tailings pond #2 remained unchanged from 1990. Some cracking and sloughing of the upstream face is evident, as previously reported, but the overall structure remains sound. Water level in this pond is controlled by the breach in the East side resulting in very low head being exerted along the remainder of this structure. As decommissioning activity progresses these dams will also be lowered and the fill placed as cover on the exposed tailings beach in #1 pond.

3.0. SAMPLING RESULTS

940-1 : KOGNAK RIVER AT PUMP HOUSE

Water quality excellent.

940-2 : TAILINGS POND #1 AT DISCHARGE

Water quality stable and very good. Contaminant levels much lower than maximum acceptable levels.

940-3 : TAILINGS POND #2 AT DISCHARGE

Water quality remained very good during effluent discharge. Contaminants remained much lower than maximum acceptable levels. During discharge minor increases were noticed in sulphate and cyanide levels.

940-5 : TAILINGS POND #2 AT NORTH WEST CORNER

High cyanide readings were detected at this location during the July sampling. The highest cyanide level was at 2.4 mg/L on July 29th and all samples exceeded 1 mg/L from July 24 to 30th. These results were received from Saskatchewan Research Council and all samples have been forwarded to Manitoba Research council for confirmation of these results. Results of the check analyses are not yet available.

Metal levels remained stable at low levels during this period.

The reason for high cyanide levels at this location is unknown. Everything appeared normal during sampling and this result was unexpected. The water entering this area from pond #1 contained very low cyanide levels as did both of the other two sampling locations in pond #2 where the highest cyanide reading recorded was 0.065 mg/L.

Additional sampling will be needed at this location in 1992. Additional sampling was not possible this year since the crew had left site prior to results being received from Saskatchewan Research Council.

940-6 : TAILINGS POND #2 NEAR CENTER

Water quality remained very good during discharge. Cyanide levels increased slightly to a high of 0.065 mg/L and sulphate levels increased to 199 mg/L. Metal levels remained low.

940-7 : DIVERSION DITCH

Water quality at this location was excellent.

940-9 : DRAINAGE CREEK AT KOGNAK RIVER

Water quality at this location remained very good. The only noticeable change during effluent discharge was an increase in sulphate level to a high of 142 mg/L and a very slight increase in cyanide level to 0.007 mg/L. Metal values remained stable at very low levels.

POND #2 SEDIMENT SAMPLES

Sediment samples were collected at four locations within #2 tailings pond. Samples collected were black, fibrous organics. Metal concentrations found in these samples agree closely with samples collected in 1990.

OTHER SAMPLING

Three sets of readings were taken from the four thermistors installed in the tailings area in August.

Waste rock samples were collected to determine acid generating potential. These tests were conducted at CANMET in Elliott Lake, Ontario. Results of these tests indicate that overall the waste rock at Cullaton is not acid generating. Only the sample of mill reject material showed a minor potential for acid generation based on the acid-base accounting results. The B-zone waste rock has a higher net neutralization potential than the Shear zone waste rock.

Detailed results for all samples collected during 1991 are included in appendix I.

4.0 1992 CULLATON WORK PROGRAM

JULY 20 TO AUGUST 24, 1992

1. Lower spillway invert in #1 dam to 93.5 meter level and contour rock fill.

2. Complete lowering of #1 dam and flattening of side slopes.

3. Haul excess fill from #1 dam to the tailings beach and spread.

4. If needed, begin removal of till from #2 dam, reduce side slopes and truck excess material to the tailings beach in #1 pond and spread.

5. Prepare Lead Nitrate and ship to Nickel Plate mine for disposal.

6. Approximately 600 drums of used carbon remain on site. Recommend disposing of this carbon along the B-Zone tailings beach and covering with fill.

7. Collect water samples, as per the Surveillance Network Program requirements, and collect two sets of readings from the Thermistors (July 21 & August 23).

8. Secure all buildings and equipment prior to departure.

The crew for this phase will consist of 1 supervisor, 1 cook 1 mechanic and 5 equipment operators.

APPENDIX I
SAMPLING RESULTS

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-1 : KOGNAK RIVER AT PUMPHOUSE

DATE: Day/Month/Year	190691	250690
PHYSICAL PROPERTIES		
pH	6.44	7.92
Suspended Solids-mg/L	1	<5
MAJOR CONSTITUENTS		
SO4 - mg/L	10	1
TRACE CONSTITUENTS		
Total Cyanide - mg/L	0.024	<0.005
TRACE METALS		
As - mg/L	<0.0005	<0.005
Cu - mg/L	0.002	<0.01
Ni - mg/L	0.001	<0.05
Pb - mg/L	0.006	<0.05
Zn - mg/L	<0.005	<0.01

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-2 : POND #1 AT DISCHARGE

DATE: Day/Month/Year	300791	290791	280791	260791	250791	240791	220691	210691	200691	200691 940/2A	190691	AVERAGE 1990
PHYSICAL PROPERTIES												
pH	8.15	8.10	8.02	8.15	7.62	7.64	7.91	7.81	7.88	N.D.	7.74	7.71
Suspended Solids-mg/L	5	14	9	8	<1	<1	11	44	57	N.D.	8	7.7
MAJOR CONSTITUENTS												
SO4 - mg/L	258	250	253	254	246	247	247	233	239	N.D.	238	234
TRACE CONSTITUENTS												
Total Cyanide - mg/L	0.028	0.028	0.028	0.028	0.028	0.027	0.025	0.026	0.023	N.D.	0.023	0.018
TRACE METALS												
As - mg/L	0.006	0.007	0.005	0.005	0.005	0.008	0.012	0.014	0.018	0.014	0.016	0.008
Cu - mg/L	0.004	0.005	0.004	0.004	0.003	0.009	0.003	0.004	0.004	0.005	0.005	<0.01
Ni - mg/L	0.004	0.006	0.009	0.007	0.003	0.016	0.007	0.009	0.01	0.008	0.004	<0.05
Pb - mg/L	0.014	0.007	0.008	0.008	<0.005	0.010	0.006	0.009	0.007	<0.005	0.012	<0.05
Zn - mg/L	0.010	0.006	0.010	0.012	0.018	<0.005	<0.005	0.15	<0.005	<0.005	<0.005	<0.01

Sample 940/2A is a check sample for 940-2 taken at the same time.

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-3 : TAILINGS POND #2 AT DISCHARGE

DATE: Day/Month/Year	300791	290791	280791	260791	250791	240791	220691	220691 CHECK	210691	200691	190691	AVERAGE 1990
PHYSICAL PROPERTIES												
pH	8.06	7.86	7.89	7.92	7.16	7.17	7.13	6.97	7.02	6.95	6.80	7.79
Suspended solids-mg/L	1	2	2	3	2	3	4	3	2	2	<1	3
MAJOR CONSTITUENTS												
SO4 - mg/L	237	209	196	202	140	150	84	81	51	45	43	63
TRACE CONSTITUENTS												
Total Cyanide - mg/L	0.018	0.027	0.011	0.018	0.013	0.011	0.006	0.008	0.003	0.002	0.003	<0.005
TRACE METALS												
As - mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.005
Cu - mg/L	0.008	0.010	0.010	0.010	0.008	0.009	0.008	0.009	0.008	0.008	0.009	0.01
Ni - mg/L	0.009	0.008	0.009	0.005	0.009	0.009	0.006	---	0.004	0.004	0.009	<0.05
Pb - mg/L	0.008	<0.005	<0.005	0.011	<0.005	0.016	0.014	<0.005	0.014	<0.005	0.008	<0.05
Zn - mg/L	0.006	0.016	0.043	0.008	0.006	0.018	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01

CHECK SAMPLE LABELLED "SPECIAL" TAKEN AT 940-3 LOCATION AT SAME TIME AS REGULAR SAMPLE.

Mercury should be analysed too

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-5 : TAILINGS POND #2 AT NORTHWEST CORNER

DATE: Day/Month/Year	300791	290791	280791	260791	250791	240791	220691	210691	200691	190691	AVERAGE 1990
PHYSICAL PROPERTIES											
pH	8.07	8.12	7.99	7.98	8.03	7.38	7.59	7.64	7.47	6.91	8.84
Suspended Solids-mg/L	1	1	1	2	1	1	3	4	17	3	11
MAJOR CONSTITUENTS											
SO4 - mg/L	269	262	261	259	267	285	241	252	227	61	68
TRACE CONSTITUENTS											
Total Cyanide - mg/L	1.7	2.4	1.9	1.4	1.1	1.4	0.25	0.18	0.15	0.01	<0.005
TRACE METALS											
As - mg/L	0.004	0.004	0.005	0.005	0.005	0.004	0.006	0.006	0.007	0.004	<0.005
Cu - mg/L	0.003	0.004	0.004	0.004	0.006	0.006	0.004	0.005	0.004	0.009	0.01
Ni - mg/L	0.007	0.009	0.007	0.006	0.010	0.006	0.002	0.004	<0.001	0.005	<0.05
Pb - mg/L	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	0.040	0.008	<0.05
Zn - mg/L	0.007	0.021	0.021	<0.005	0.010	0.007	<0.005	<0.005	0.006	<0.005	<0.01

There is no obvious reason for the high cyanide readings at this location in July. These high cyanides levels are not present in the water being released from pond #1 or at the center and discharge samples from pond #2. These samples have been forwarded to Manitoba Research Council for check analysis. Results from them have been delayed due to the shortage of a critical chemical for analysis.

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-6 : TAILINGS POND #2 NEAR CENTER

DATE: Day/Month/Year	300791	290791	280791	260691	250791	240791	220691	210691	200691	190691	AVERAGE 1990
PHYSICAL PROPERTIES											
pH	7.92	7.94	7.94	7.89	7.92	7.46	7.22	7.08	6.96	6.80	8.03
Suspended Solids-mg/L	1	1	1	1	2	<1	15	3	1	2	11
MAJOR CONSTITUENTS											
SO4 - mg/L	199	198	198	176	156	159	74	68	45	43	345
TRACE CONSTITUENTS											
Total Cyanide - mg/L	0.030	0.065	0.060	0.050	0.011	0.030	0.008	0.007	0.003	0.003	0.027
TRACE METALS											
As - mg/L	0.005	0.004	0.004	0.004	0.005	0.003	0.003	0.003	0.002	0.002	0.007
Cu - mg/L	0.011	0.010	0.008	0.008	0.009	0.007	0.09	0.008	0.009	0.008	0.01
Ni - mg/L	0.009	0.007	0.004	0.006	0.008	0.006	0.007	0.006	0.003	0.004	<0.05
Pb - mg/L	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.05
Zn - mg/L	0.024	0.010	0.008	0.007	0.013	<0.005	0.011	<0.005	<0.005	<0.005	<0.01

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-7 : DIVERSION DITCH AT NORTHWEST CORNER OF POND #2

DATE: Day/Month/Year	220691	190691
PHYSICAL PROPERTIES		
pH	7.09	7.07
Suspended Solids-mg/L	<1	<1
MAJOR CONSTITUENTS		
SO4 - mg/L	22	22
TRACE CONSTITUENTS		
Total Cyanide - mg/L	0.002	0.002
TRACE METALS		
As - mg/L	0.002	0.002
Cu - mg/L	0.002	0.004
Ni - mg/L	0.008	0.006
Pb - mg/L	<0.005	<0.005
Zn - mg/L	0.009	<0.005

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

STATION - 940-9 : DRAINAGE CREEK AT KOGNAK RIVER

DATE: Day/Month/Year	300791	290791	280791	260791	250791	240791	210691	200691	190691	AVERAGE 1990
PHYSICAL PROPERTIES										
pH	8.11	8.18	8.11	8.14	6.41	6.44	7.05	7.10	7.09	7.33
Suspended Solids-mg/L	1	1	1	3	<1	<1	<1	<1	<1	<5
MAJOR CONSTITUENTS										
SO4 - mg/L	142	139	107	54	0.6	0.6	8	7	7	14
TRACE CONSTITUENTS										
Total Cyanide - mg/L	0.007	0.007	0.005	0.003	<0.001	<0.001	<0.001	<0.001	0.001	<0.005
TRACE METALS										
As - mg/L	0.0007	0.0007	0.0007	<0.0005	<0.0005	<0.0005	0.0006	0.0006	0.0008	<0.005
Cu - mg/L	0.003	0.005	0.005	0.003	0.002	0.003	0.004	0.005	0.005	<0.01
Ni - mg/L	0.002	0.006	0.005	0.005	0.003	0.004	0.006	0.002	<0.001	0.05
Pb - mg/L	0.006	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.05
Zn - mg/L	<0.005	0.010	0.057	0.008	0.010	0.009	0.013	0.006	<0.005	<0.01

INTERNATIONAL CORONA CORPORATION
CULLATON LAKE MINE
WATER SAMPLING RESULTS

POND #2 SEDIMENT SAMPLES TAKEN AT 4 LOCATIONS

DATE: JUNE 20, 1991

SAMPLE NUMBER	200601	200602	200603	200604	AVERAGE 1990
TRACE METALS					
As - ppm	25	25	33	21	35
Cu - ppm	140	340	290	110	234
Ni - ppm	82	97	74	59	79
Pb - ppm	12	10	<4	<4	4
Zn - ppm	81	56	34	35	36

RESULTS ARE REPORTED ON A DRY BASIS.
MATERIAL COLLECTED WAS BLACK AND FIBROUS ORGANICS.

RESULTS FOR CULLATON WASTEROCK ACID-BASE ACCOUNTING

Sample No.	%* S	Total Acid Production Kg CaCO3 Per tonne	Total Alkalinity Kg CaCO3 Per tonne	Net Neutralization Potential Kg CaCO3 Per tonne
#1 S-Zone	0.11	3.44	7.12	+3.68
#2 S-Zone	0.11	3.44	3.42	-0.02
#3 B-Zone	0.04	1.25	70.59	+69.34
#4 B-Zone	0.01	0.31	127.38	+127.07
#5 B-Zone	1.08	33.75	123.74	+89.99
#6 Mill Reject	0.12	3.75	0.98	-2.77
AVG.	0.25	7.66	55.54	+47.88

* Lecco Surface Analysis

SAMPLE LOCATIONS:

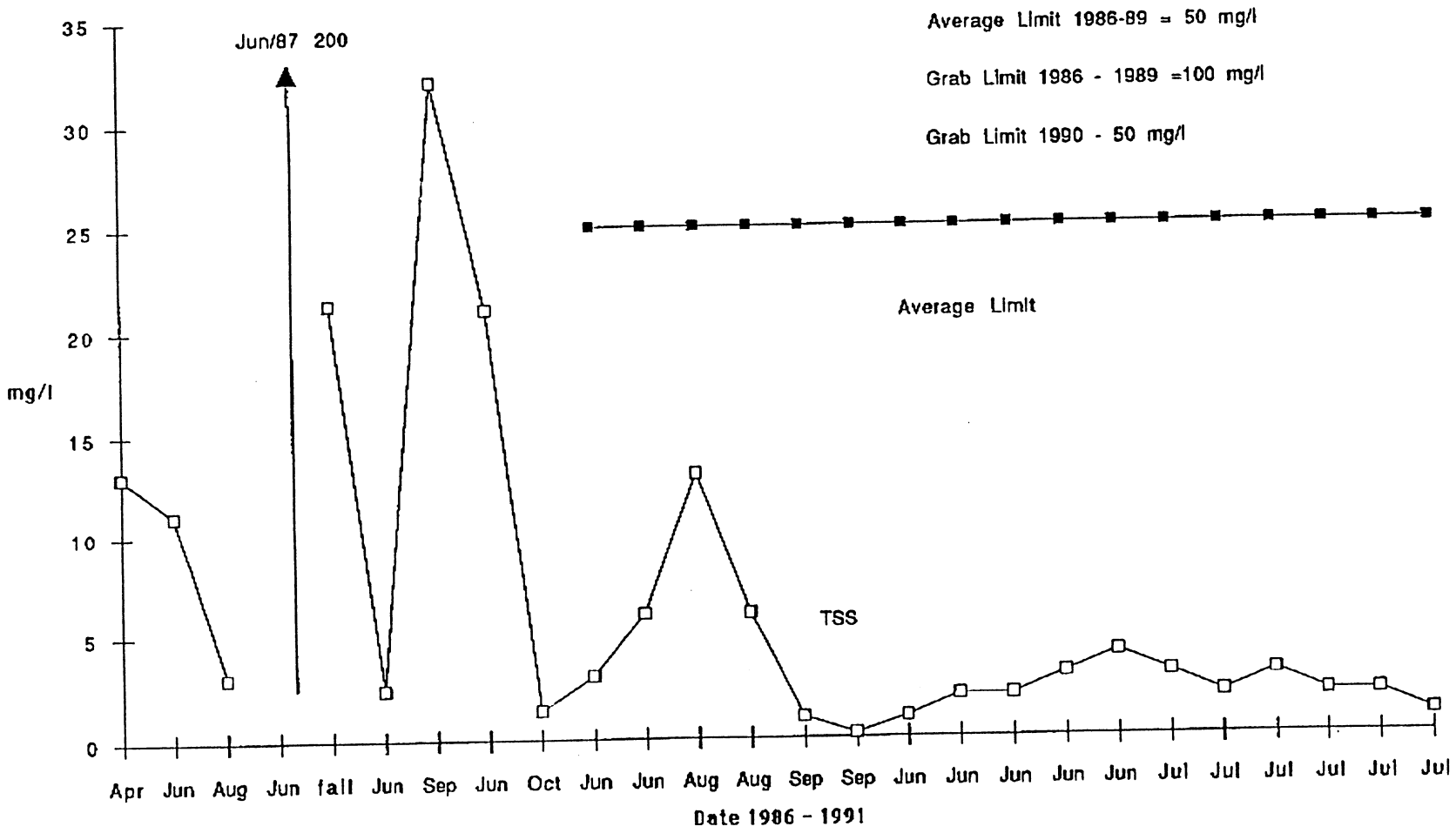
#1 - Shear Lake waste storage area.
#2 - Top of #1 tailings dam - East side at syphons.
#3 - Access road to #1 dam West side. Behind fuel storage tanks.
#4 - South side of crusher approach ramp.
#5 - B-Zone waste storage area.
#6 - Mill reject pile beside crusher building.

S-Zone = Shear Lake.

INTERNATIONAL CORONA CORPORATION - CULLATON LAKE

Sample Station 940-3
#2 Tailings Pond Discharge

Total Suspended Solids



FIGU

INTERNATIONAL CORONA CORPORATION

Sample Station 940-3
#2 Tailings Pond Discharge

Total Arsenic

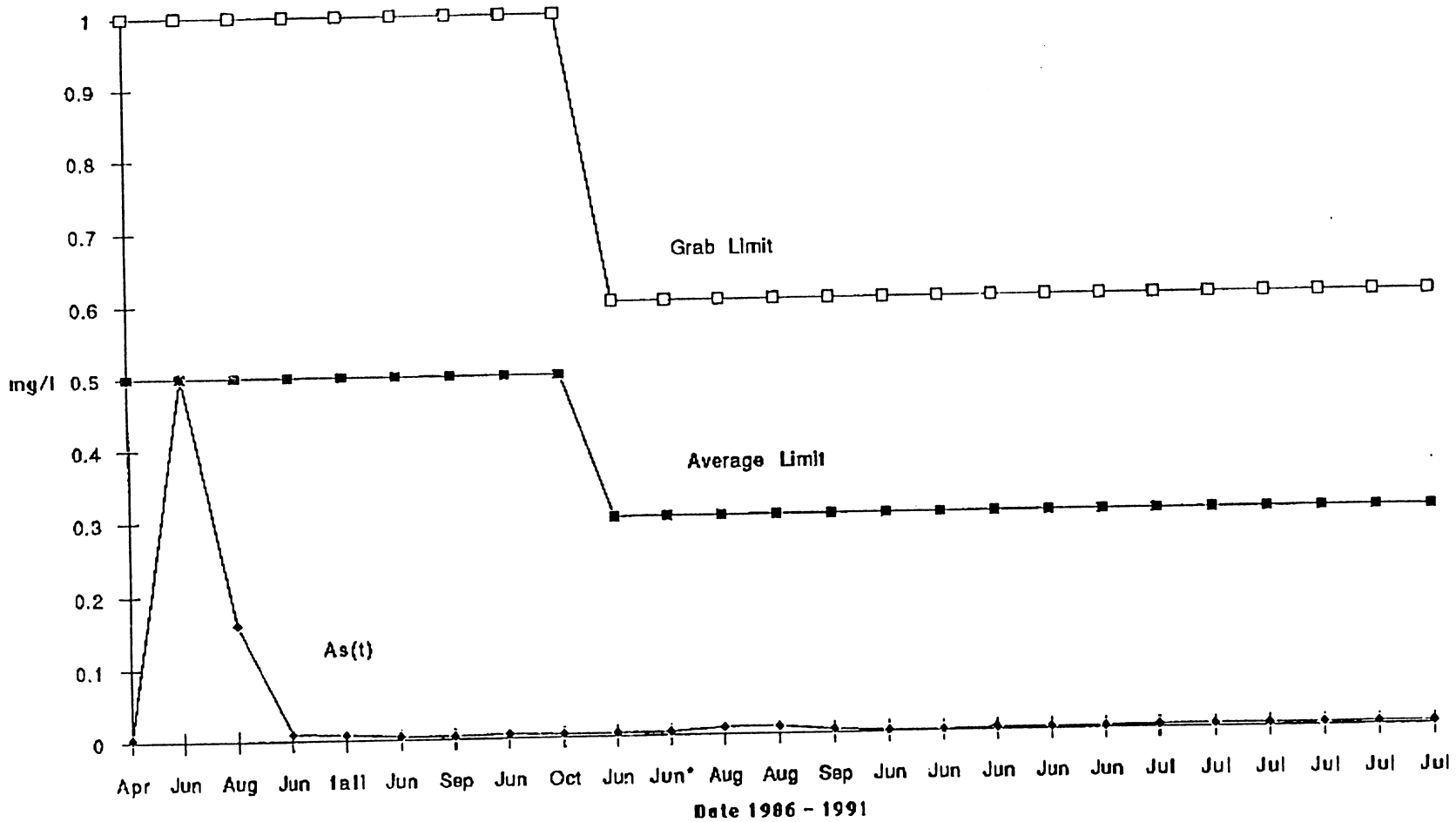
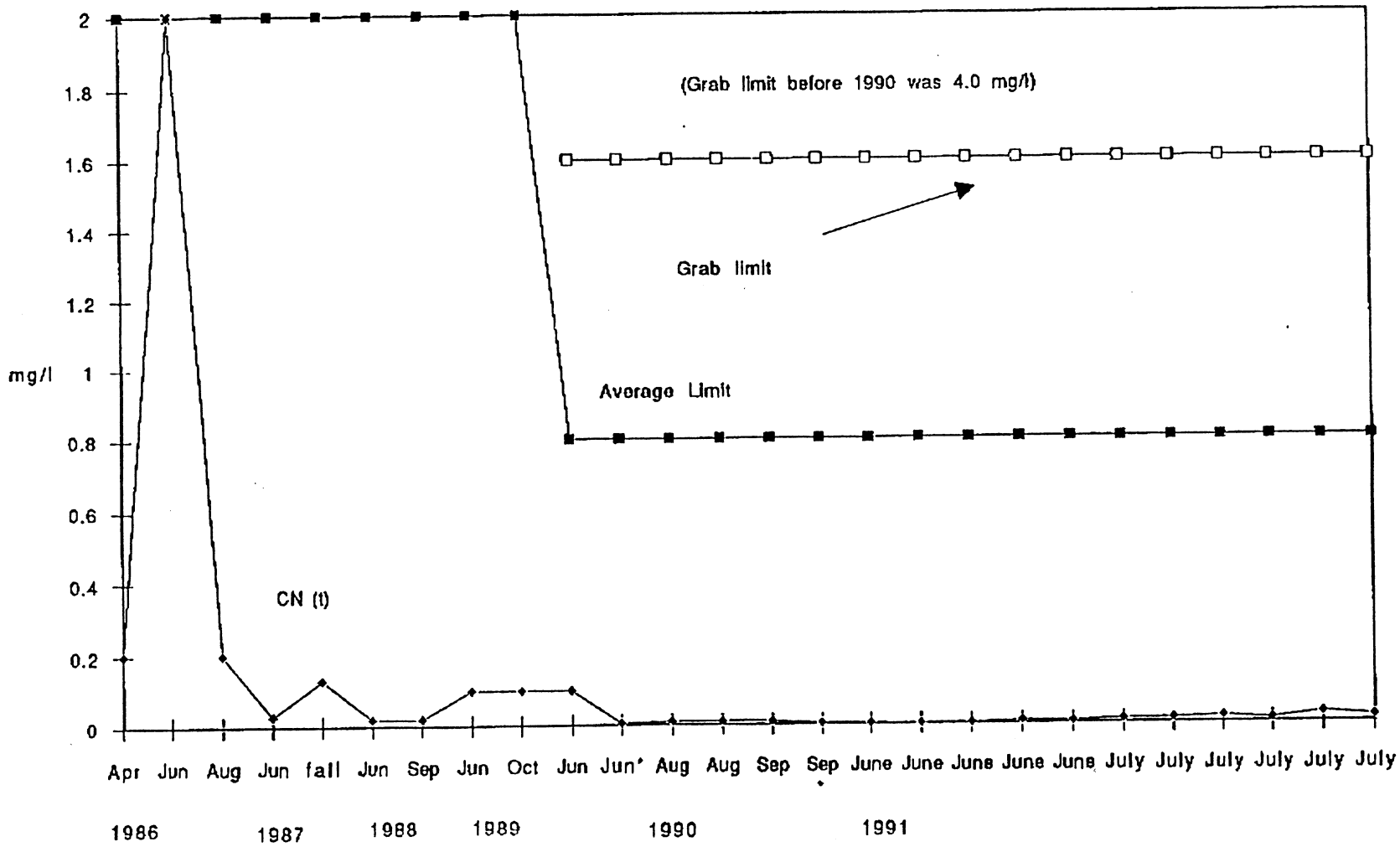


FIGURE 2

INTERNATIONAL CORONA CORPORATION - CULLATON LAKE

Sample Station 940-3
#2 Tailings Pond Discharge

Total Cyanide



FIG[illegible]3

INTERNATIONAL CORONA CORPORATION

Sample Station 940-3
#2 Tailings Pond Discharge

TOTAL COPPER

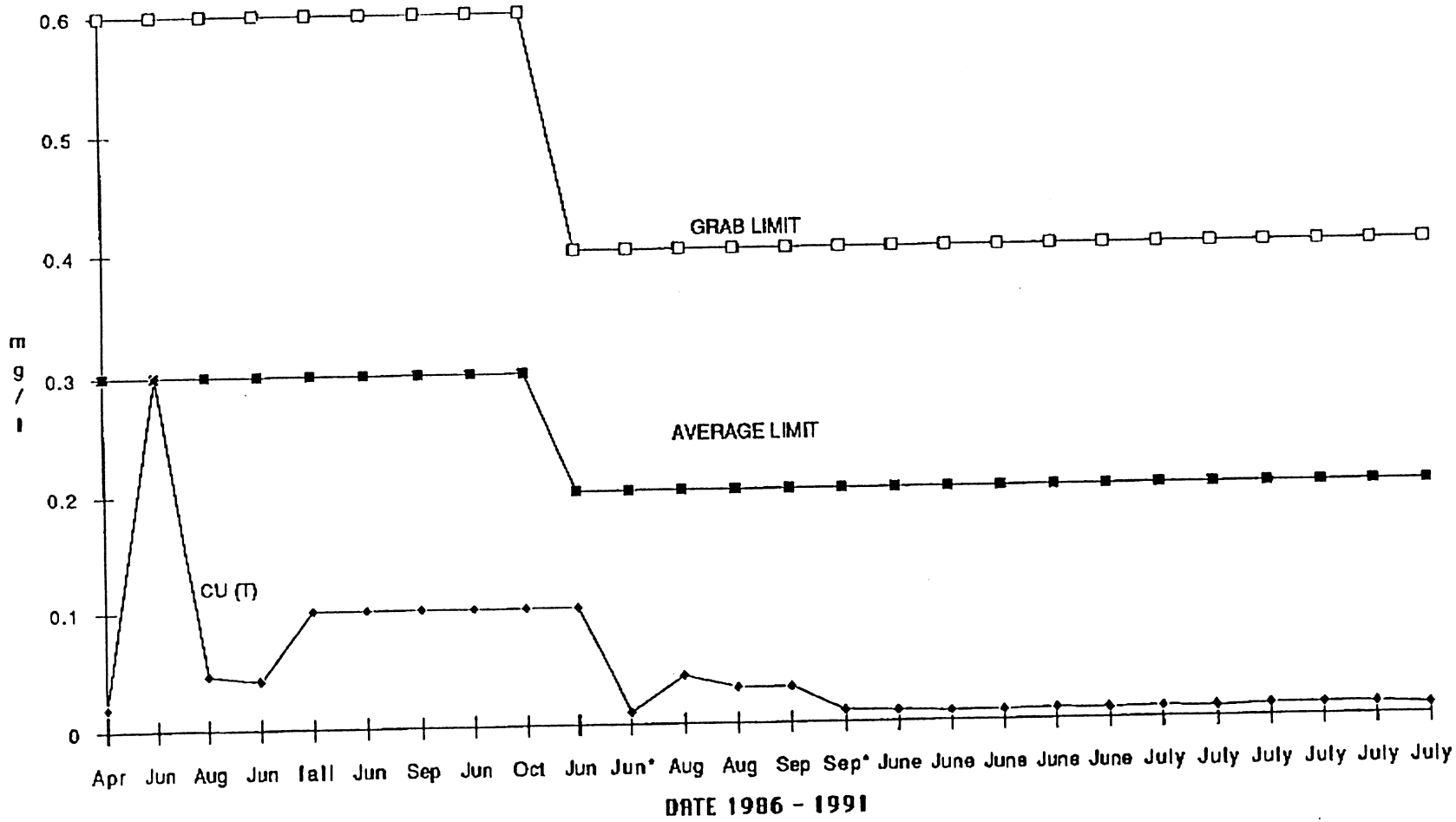


FIGURE 4

Sample Station 940-3
#2 Tailings Pond Discharge

Total Nickel

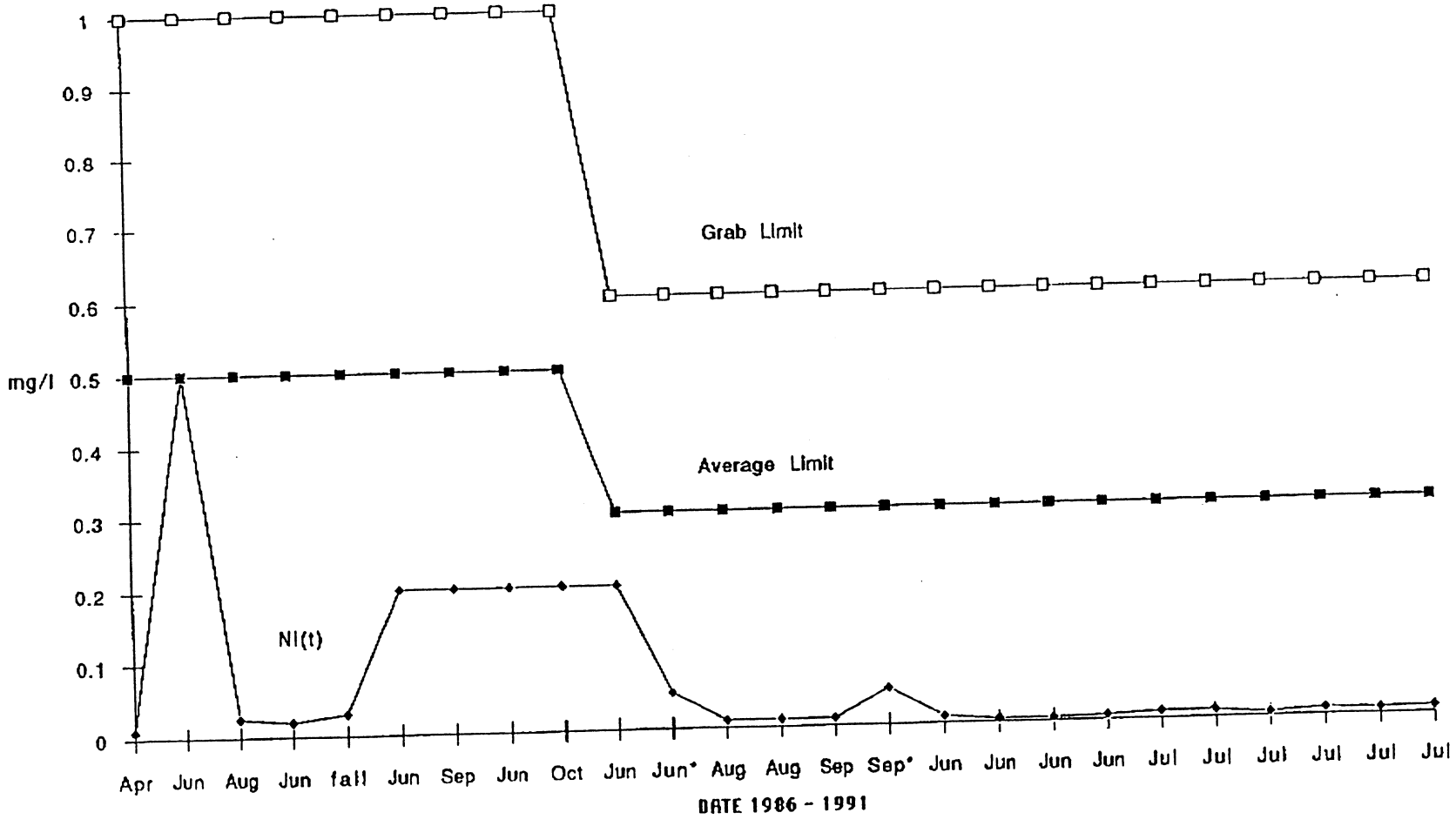


FIGURE 5

INTERNATIONAL CORONA CORPORATION - CULLATON LAKE

Sample Station 940-3
#2 Tailings Pond Discharge

Total Zinc

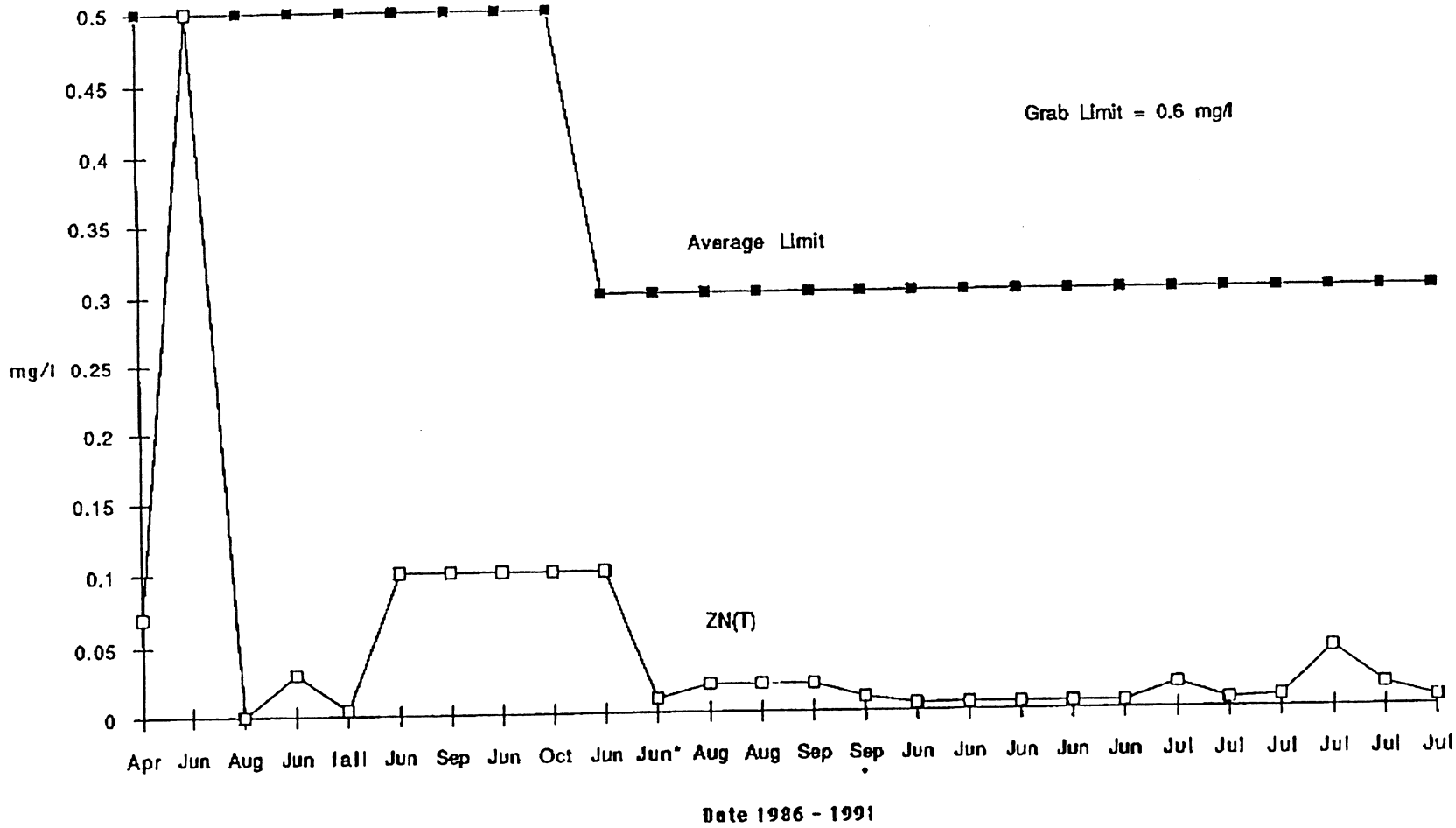


FIGURE 6

INTERNATIONAL CORONA CORPORATION - CULLATION LAKE

Sample Station 940-3
#2 Tailings Pond Discharge

Total Lead

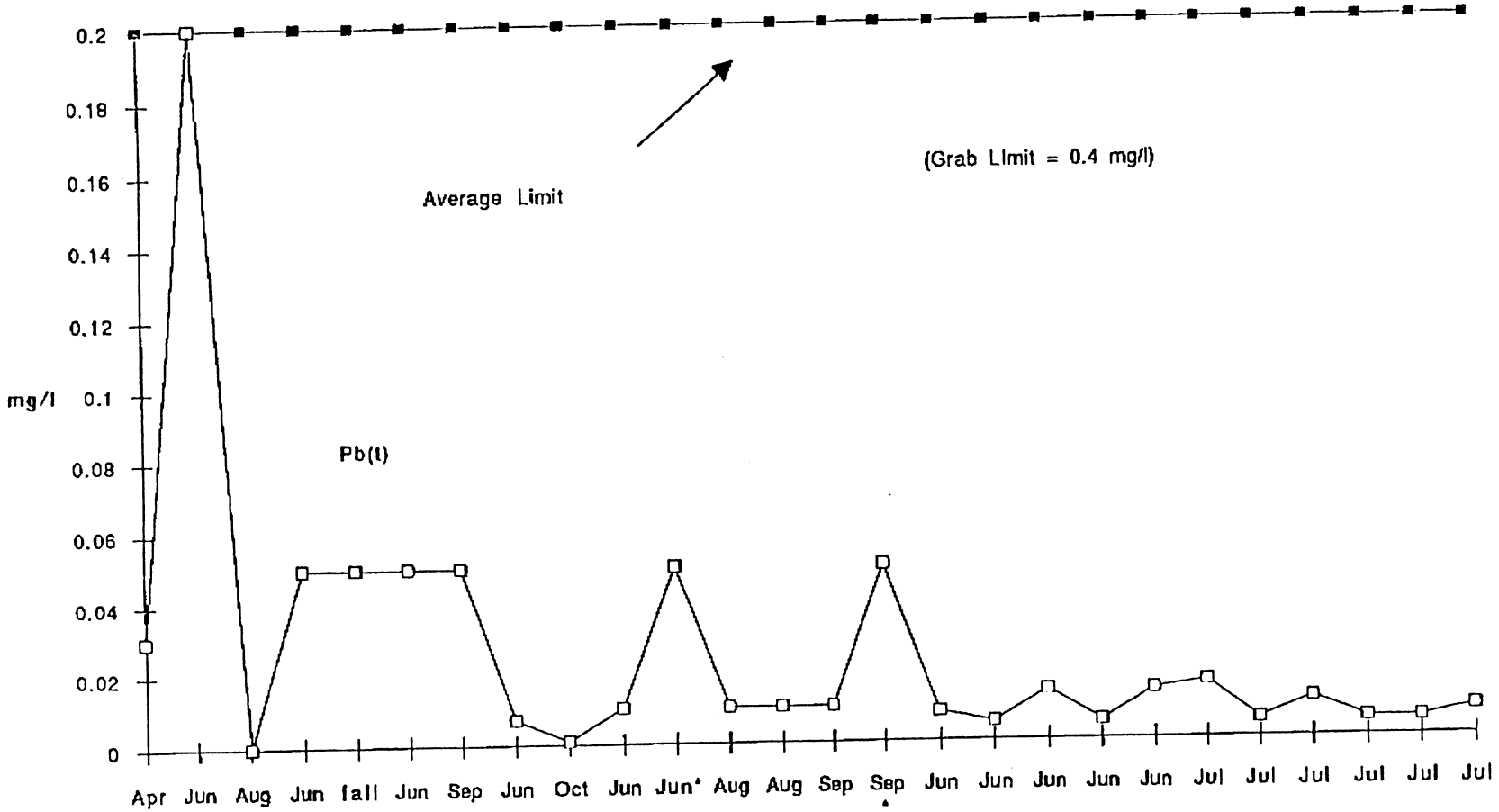


FIGURE 7

INTERNATIONAL CORONA CORPORATION - CULLATON LAKE

Sample Station 940-3
#2 Tailings Pond Discharge

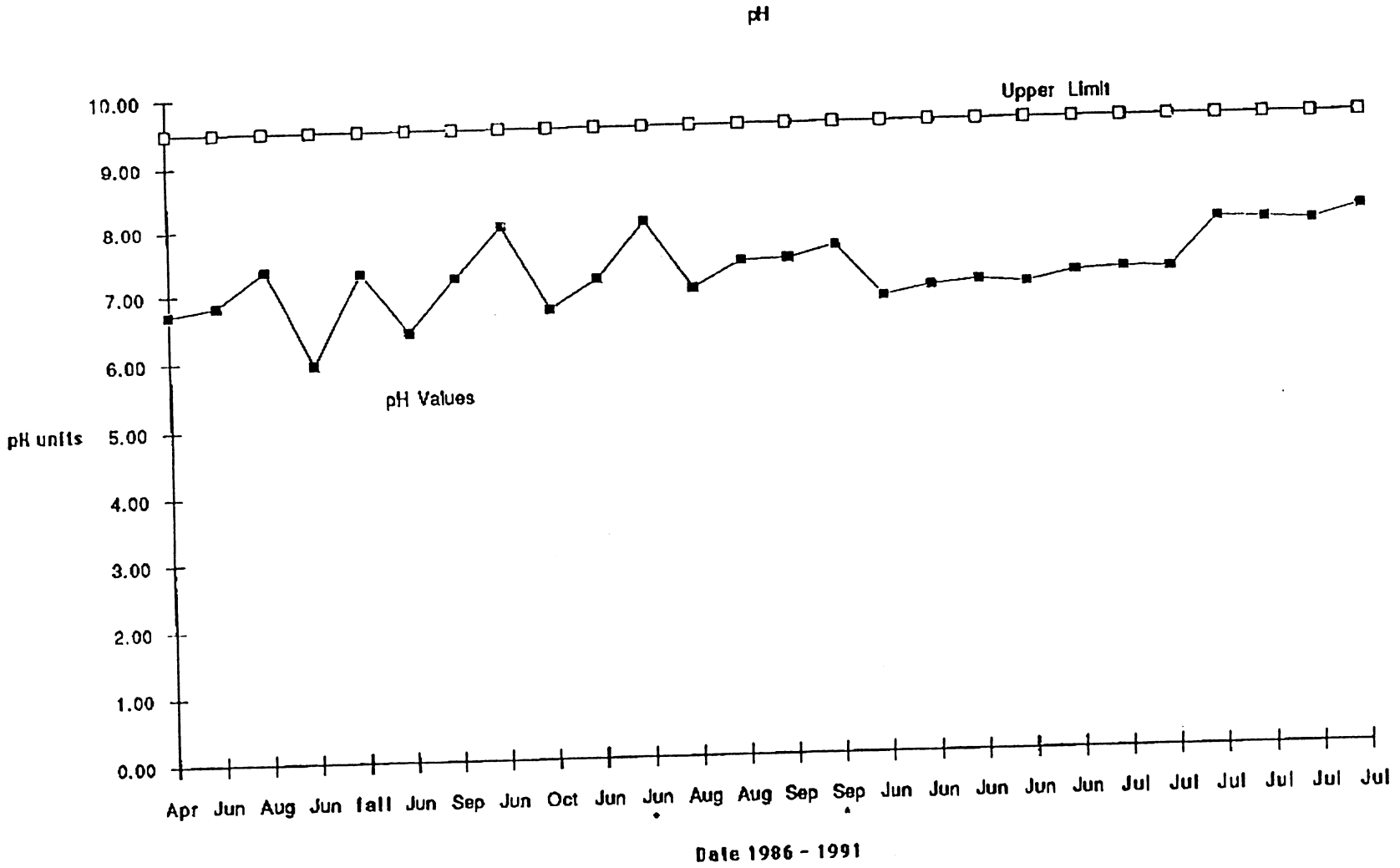


FIGURE 8

THERMISTOR CABLE READINGS

Thermistor Cable No. 1

Location No. 1 - Cullaton Lake Tailings (Shear Lake)

Depth (m)	Date: Aug 24 / 1991 K-OHMS	Aug 24 / 1991 TEMP - DEG C	Aug 26,1991 K-OHMS	Aug 26, 1991 TEMP - DEG C	Sep 03, 1991 K-OHMS	Sep 03, 1991 TEMP - DEG C
0.3	8.56	+ 13.20	7.82	+ 15.10	9.38	+ 11.14
0.8	8.71	+ 12.81	7.89	+ 14.90	9.32	+ 11.38
1.3	9.69	+ 10.56	8.33	+ 13.75	10.66	+ 8.58
1.8	10.43	+ 9.03	11.10	+ 7.74	12.38	+ 5.50
2.3	12.56	+ 5.22	13.25	+ 4.15	14.03	+ 3.05
2.8	15.98	+ 0.43	16.08	+ 0.28	16.07	+ 0.28

Depth (m)	Date:					
0.3						
0.8						
1.3						
1.8						
2.3						
2.8						

THERMISTOR CABLE READINGS

Thermistor Cable No. 2

Location No. 2 - Cullaton Lake Tailings (Shear Lake)

Date: Aug 24,1991	Aug 24, 1991		Aug 26, 1991		Aug 26, 1991	Sep 03, 1991	Sep 03, 1991
Depth (m)	K-OHMS	TEMP - DEG C	K-OHMS	TEMP - DEG C	K - OHMS	TEMP - DEG C	
0.3	8.72	+ 12.78	7.87	+14.96	9.68	+10.52	
0.8	8.68	+ 12.88	7.82	+ 15.15	9.55	+ 10.86	
1.3	8.58	+ 13.12	7.77	+ 15.23	10.03	+ 9.88	
1.8	9.89	+ 10.13	10.88	+ 8.14	12.51	+ 5.32	
2.3	12.02	+ 6.12	13.06	+ 4.45	13.89	+ 3.19	
2.8	16.00	+ 0.41	16.20	+ 0.16	16.24	+ 0.11	

Date:						
Depth (m)						
0.3						
0.8						
1.3						
1.8						
2.3						
2.8						

THERMISTOR CABLE READINGS

Thermistor Cable No. 3

Location No. 3 - Cullaton Lake Tailings (B-Zone)

Depth (m)	Date: Aug 24, 1991 K-OHMS	Aug 24, 1991 TEMP - DEG C	Aug 26, 1991 K-OHMS	Aug 26, 1991 TEMP - DEG C	Sept 03, 1991 K-OHMS	Sept 03, 1991 TEMP - DEG C
0.3	8.65	+ 12.95	7.65	+ 15.56	10.07	+ 9.75
0.8	8.54	+ 13.22	7.56	+ 15.83	10.22	+ 9.45
1.3	8.68	+ 12.88	7.88	+ 14.85	10.67	+ 8.55
1.8	9.63	+ 10.69	10.72	+ 8.46	12.17	+ 5.87
2.3	11.95	+ 6.24	12.97	+ 4.58	13.94	+ 3.10
2.8	15.98	+ 0.43	16.09	+ 0.29	16.09	+ 0.29

Depth (m)	Date:					
0.3						
0.8						
1.3						
1.8						
2.3						
2.8						

THERMISTOR CABLE READINGS

Thermistor Cable No. 4

Location No. 4 - Cullaton Lake Tailings (B-Zone)

Date:	Aug 24, 1991	Aug 24, 1991	Aug 26, 1991	Aug 26, 1991	Sept 03, 1991	Sept 03, 1991
Depth (m)	K-OHMS	TEMP - DEG C	K-OHMS	TEMP - DEG C	K-OHMS	TEMP - DEG C
0.3	7.83	+ 15.06	7.87	+ 14.96	9.43	+ 11.12
0.8	8.14	+ 14.25	7.89	+ 14.90	9.19	+ 11.67
1.3	7.21	+ 16.85	7.99	+ 14.63	9.53	+ 10.90
1.8	9.00	+ 12.11	10.08	+ 9.73	11.75	+ 6.58
2.3	11.39	+ 7.22	12.11	+ 5.96	13.43	+ 3.87
2.8	15.86	+ 0.58	15.87	+ 0.56	15.79	+ 0.66

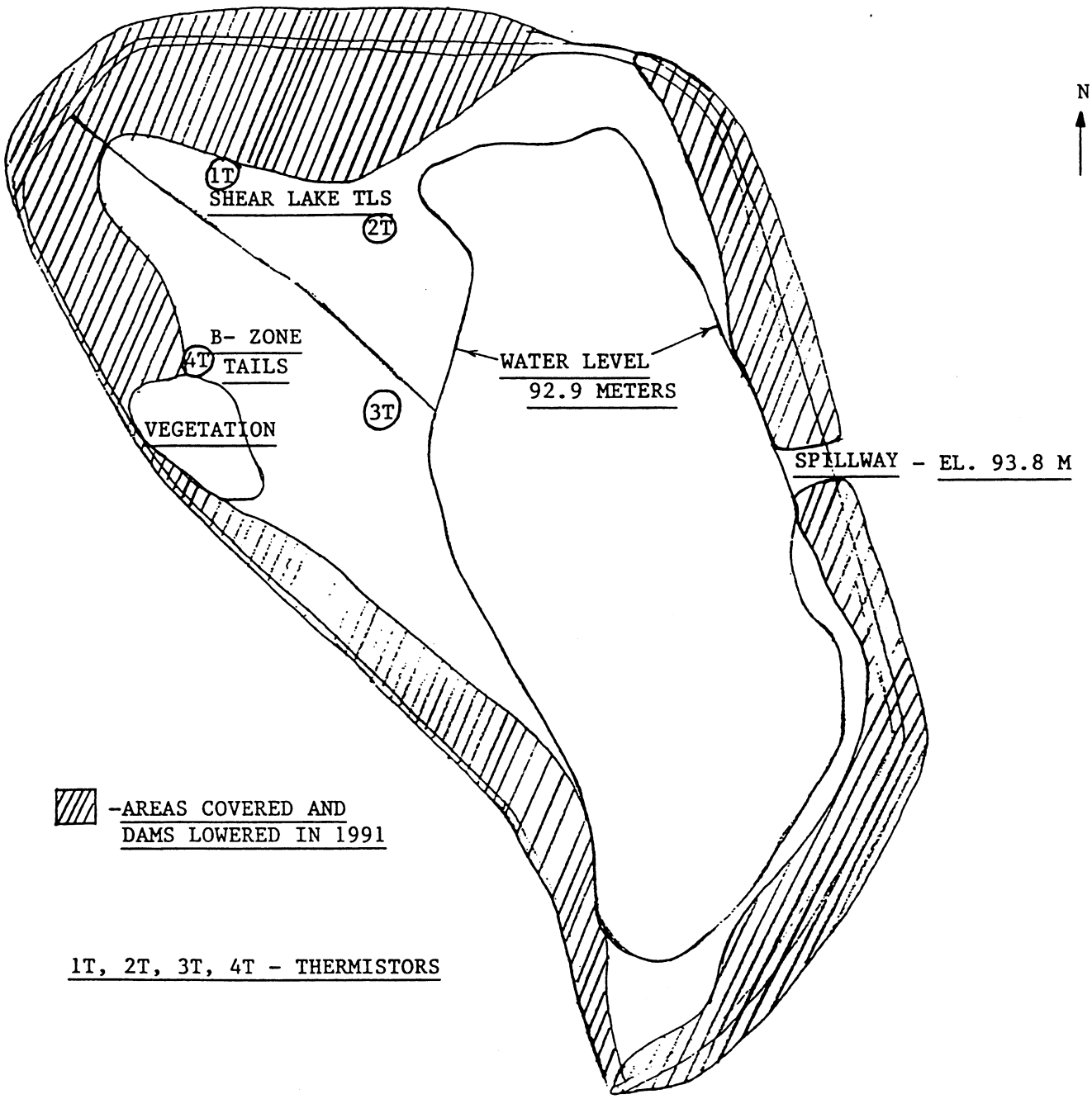
Date:						
Depth (m)						
0.3						
0.8						
1.3						
1.8						
2.3						
2.8						

APPENDIX III

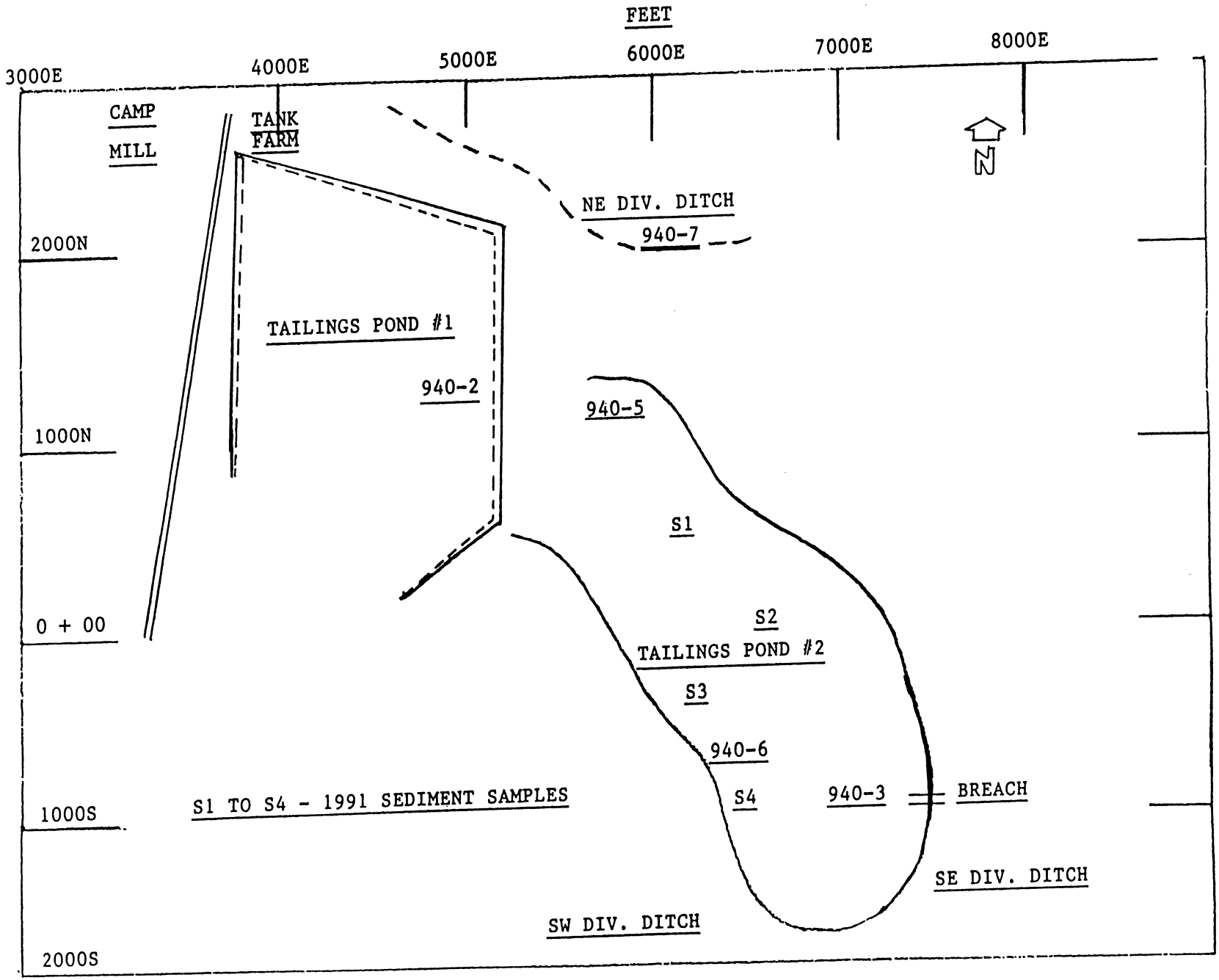
DRAWINGS

PHOTOGRAPHS

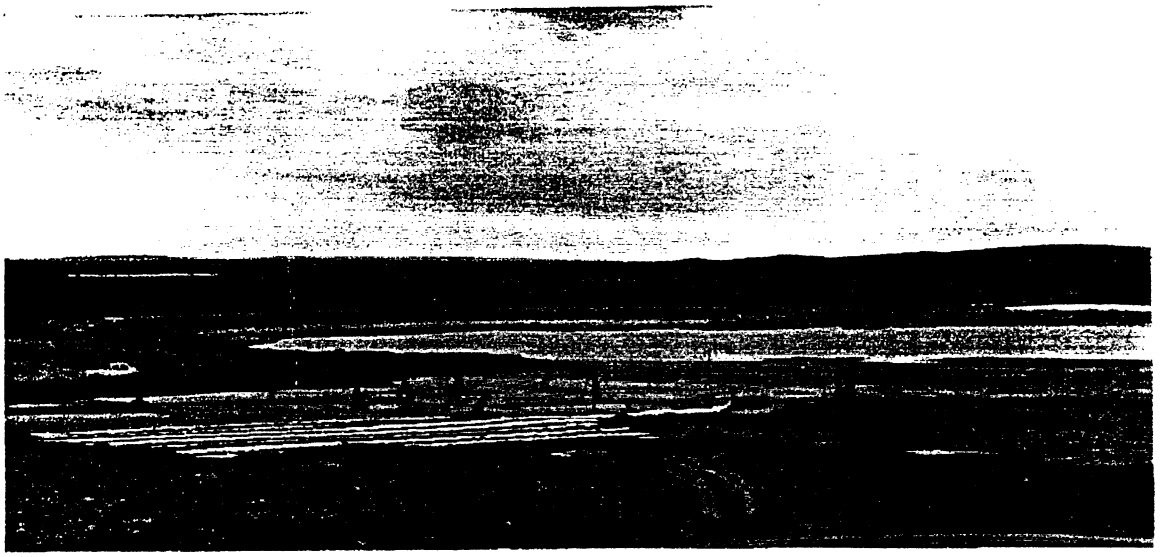
CULLATON LAKE - TAILINGS POND #1



WORK COMPLETED - 1991

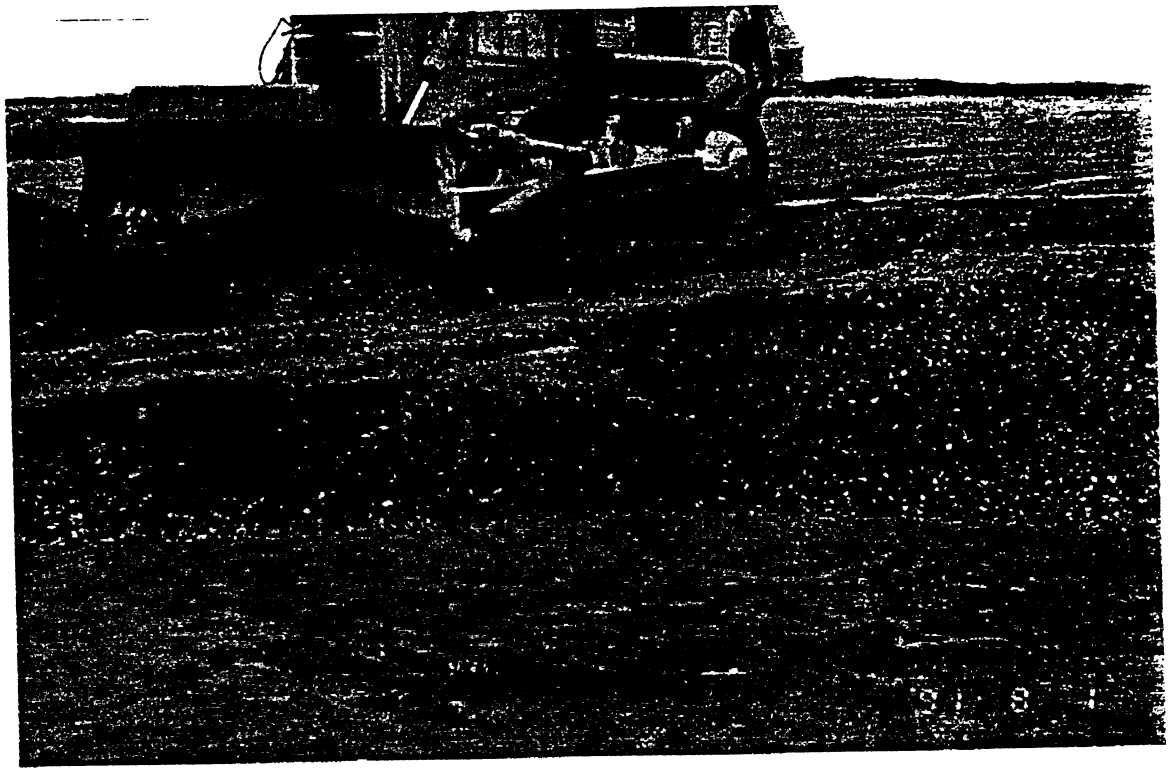


CULLATON LAKE TAILINGS AREA SAMPLE LOCATIONS

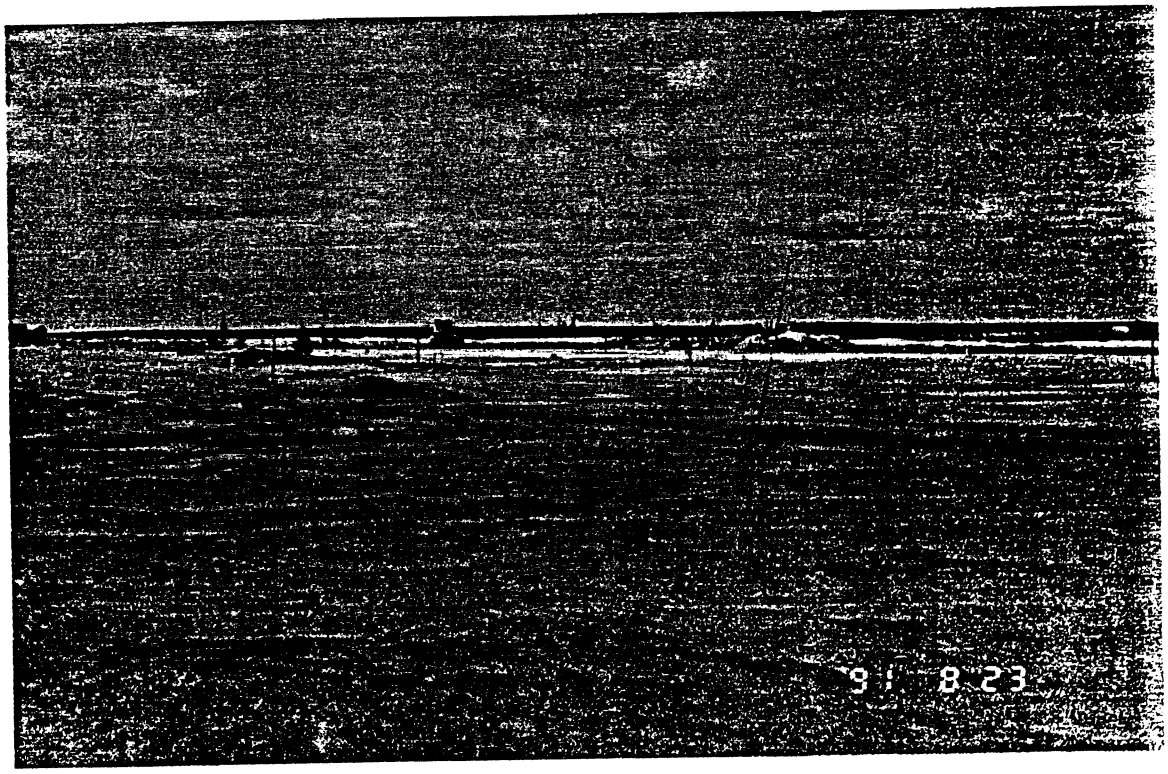




TAILINGS AREA COVERED - 1991



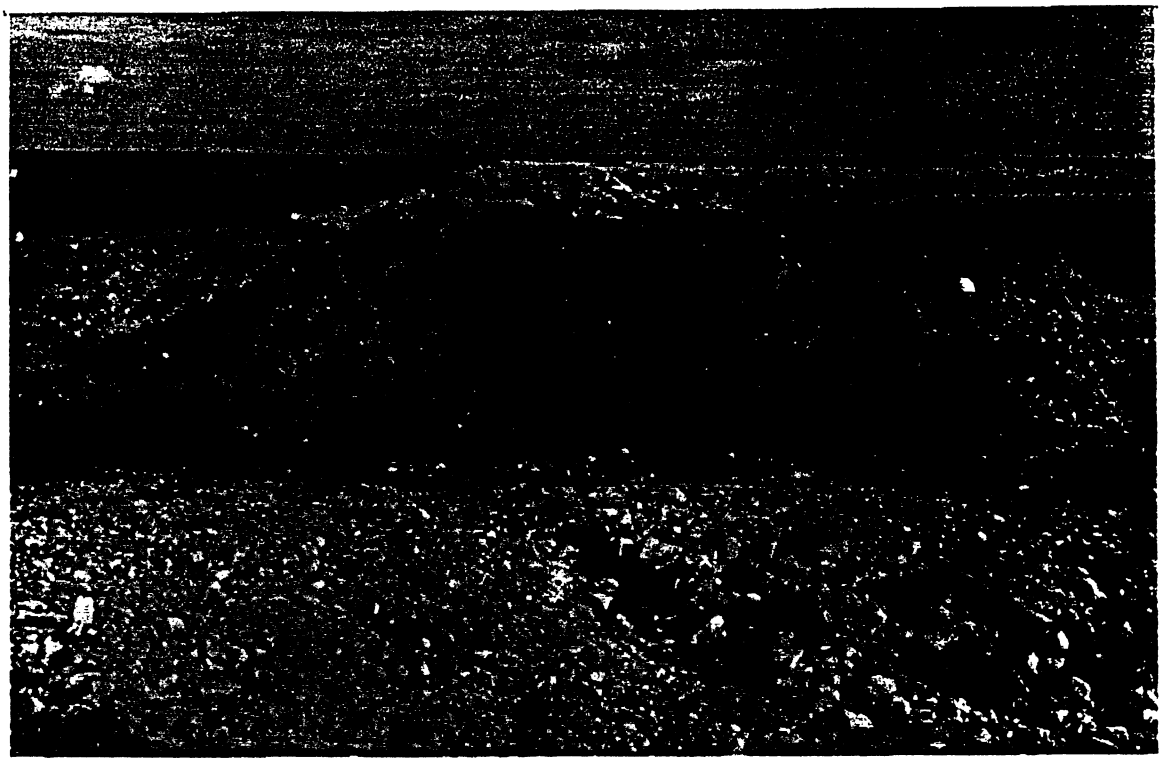
MILL REJECTS - BEING SPREAD ON B-ZONE



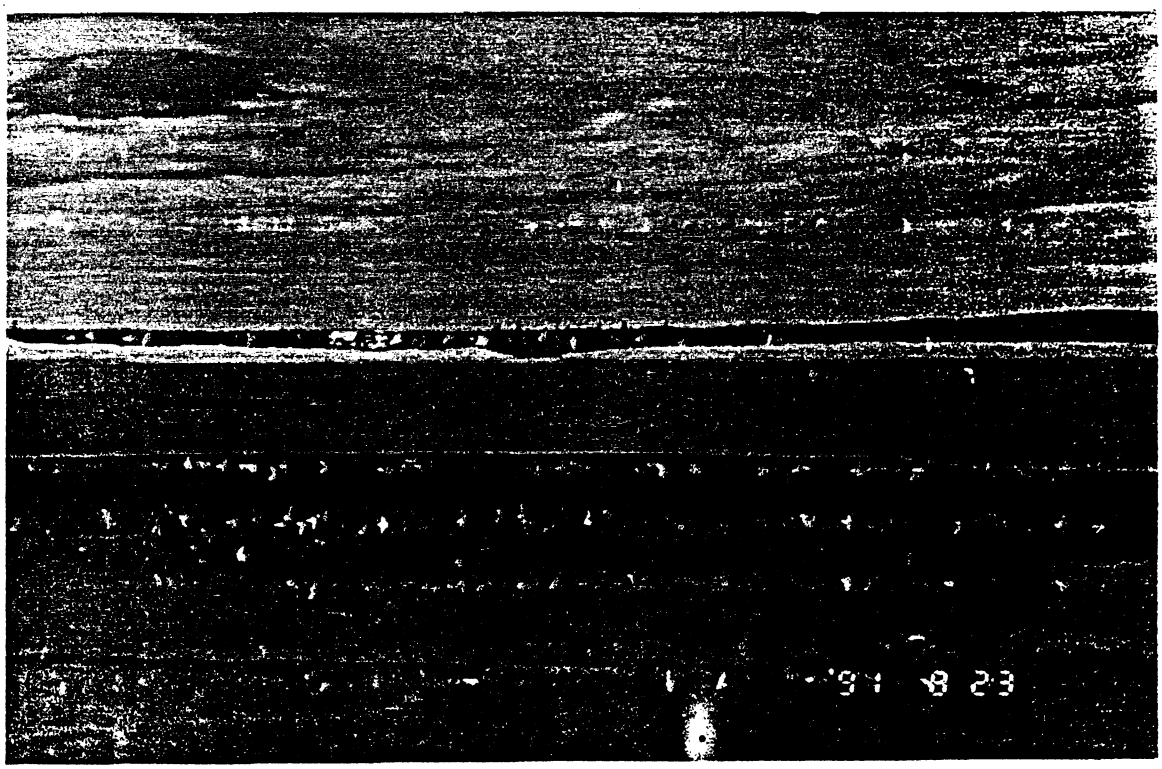
FILL BEING PLACED - LOOKING NORTH



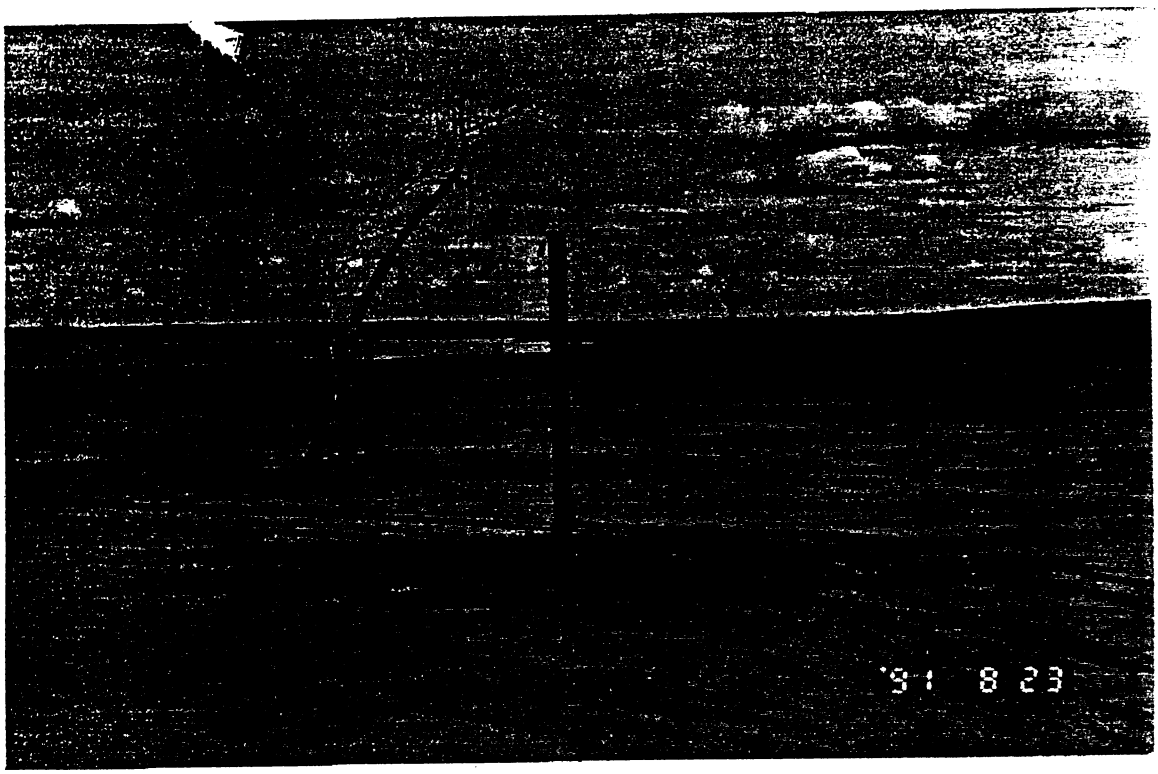
SHEAR LAKE TAILINGS - 500 MM FILL



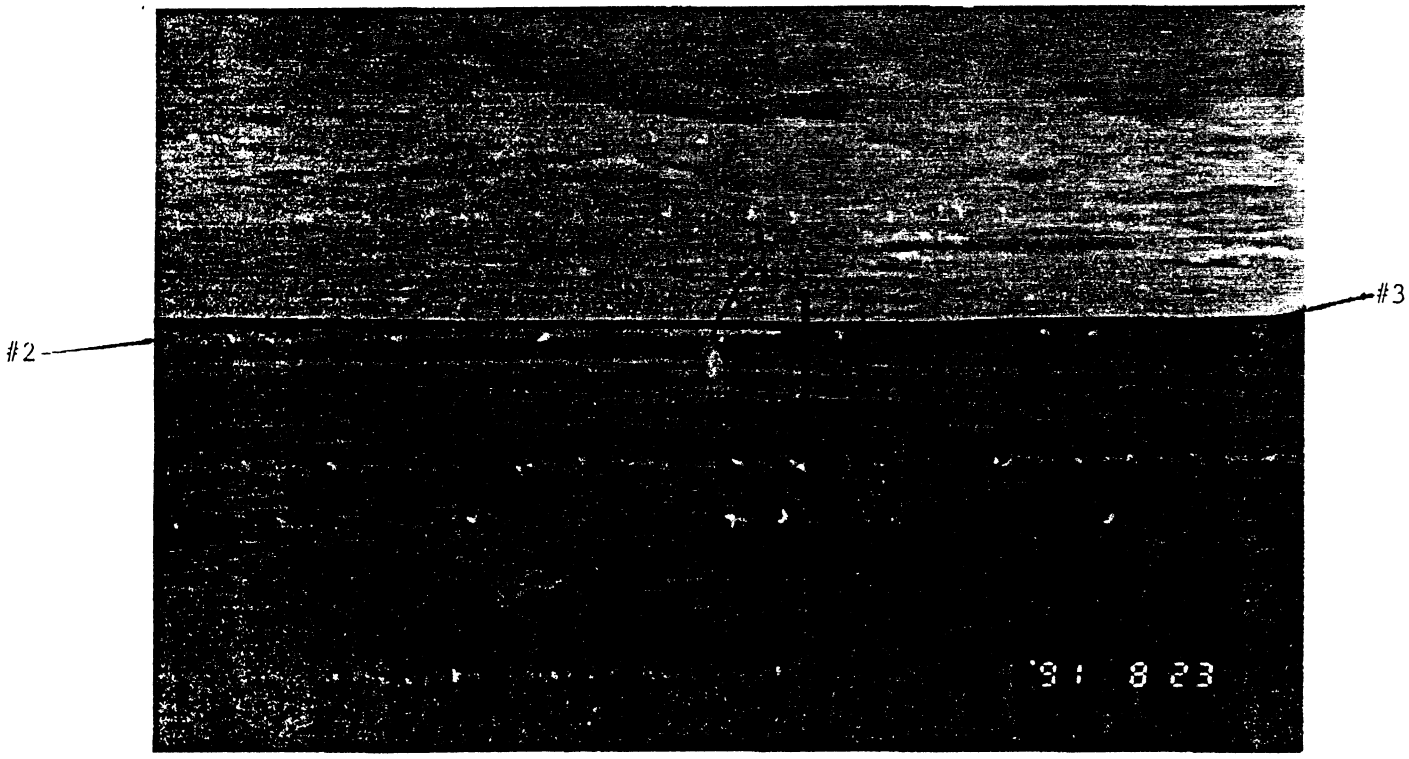
SPILLWAY BEING EXCAVATED - #1 EAST DAM



SPILLWAY IN #1 DAM - LOOKING EAST



#1 THERMISTOR INSTALLATION



THERMISTOR INSTALLATIONS

Scanned

Energy Mines and Resources Canada
Energie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

0940
IN
WB
Keewatin
DISTRICT.

COLUMN LEACHING CHARACTERISTICS OF CULLATON LAKE B AND SHEAR ZONE TAILINGS PHASE 1 - ROOM TEMPERATURE LEACHING

N.K. DAVE

ELLIOT LAKE LABORATORY

SEPTEMBER 1991

- 1992
WATER RESOURCES
DIVISION — YELLOWKNIFE
N.W.T.

MINING RESEARCH LABORATORY
DIVISION REPORT MSL 91- (CF)

COLUMN LEACHING CHARACTERISTICS OF CULLATON LAKE B AND SHEAR ZONE TAILINGS PHASE 1 - ROOM TEMPERATURE LEACHING

N.K. Dave*

EXECUTIVE SUMMARY

Column leaching tests were conducted for the Cullaton Lake B and Shear Zone (S Zone) tailings to evaluate kinetically the oxidation potential and leaching characteristics at room temperature. Duplicate columns, filled with well mixed tailings from each zone, were inoculated with Thiobacilli ferro-oxidans and subjected to batch trickle leach and rest cycles. For leaching purposes, well aerated natural lake water was used and the effluent, collected weekly, was analyzed for pH, Eh, Ec, total acidity, alkalinity, SO^{-2}_4, CN^-, Fe, Cu, Ni, Zn, Pb, Hg, Sb and As. Tailings head samples were also analyzed for physical and chemical characteristics. The Cullaton Lake waste rock samples were analyzed for acid/base accounting.

The results showed that although the sulphide contents of both B and S Zone tailings were low, they readily oxidized at the favourable conditions of room temperature which represented a worst case scenario. The effects were more pronounced for the B Zone compared to the S Zone in relation to their geology of iron sulphide formation and trace metal mineralogy.

Both zones, however, also exhibited high water retention capacity and poor drainage characteristics, which controlled the oxidation rate. These conditions permitted a shallow and limited unsaturated zone near the top surface of the column which was subjected to periodic oxidation and leaching. The acidic front, however, migrated to the entire column depth.

The total loading of sulphate, acidity and iron was higher for the B Zone, but because of its low sulphur, iron and other heavy metals, the loading in terms of per cent removal was higher for the S Zone.

A high net average Neutralization Potential (NP) of 48 kg $CaCO_3$/tonne was observed for the Cullaton waste rock combined. Based on the kinetic test data for the tailings, the waste rock will be classified as non-acid generating.

Key words: Acid mine drainage; Leaching; Sulphide tailings.

*Environmental Research Scientist, Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario.

CONTENTS

	Page
EXECUTIVE SUMMARY	i
RESUME	ii
INTRODUCTION	1
GEOLOGY AND MINERALOGY	2
B Zone	3
Shear Zone	5
KINETIC LEACHING TESTS	6
RESULTS AND DISCUSSION	8
WASTE ROCK ACID/BASE ACCOUNTING	13
CONCLUSION AND RECOMMENDATIONS	13
REFERENCES	14
APPENDIX A	A-81

TABLES

No.		
1.	Physical characteristics of B and S Zone tailings	16
2.	Chemical characteristics of B and S Zone tailings	17
3.	Leachate water quality parameters for the B Zone	18
4.	Leachate water quality parameters for the S Zone	23
5.	Total loadings and mass balance of various parameters for B and S Zone tailings	28
6.	Sulphate production and loadings for the B Zone	29
7.	Sulphate production and loadings for the S Zone	30
8.	Moisture distribution and paste pH for B Zone columns as a function of column depth at the termination of the experiment	31
9.	Moisture distribution of paste pH for S Zone columns as a function of column depth at the termination of the experiment	32
10.	Results for Cullaton waste rock acid/base accounting	33

FIGURES

1.	Location of Cullaton Lake Mines, Northwest Territories	34
2.	Location of B and Shear Zones at the Cullaton Lake Mine property	35
3.	Leaching column experimental set up	36
4.	Leaching columns experimental arrangement for B and Shear zone tailings	37
5.	Weekly leachate flow volumes for B Zone columns	38
6.	Total accumulated volume (average) per column for B Zone	39

7. Effluent temperature for B Zone columns 40
8. Effluent pH for B Zone columns 41
9. Effluent electrical conductance 'Ec' for B Zone columns 42
10. Effluent redox potential 'Eh' (absolute) for B Zone columns 43
11. Effluent acidity for B Zone columns 44
12. Effluent alkalinity for B Zone columns 45
13. Effluent total sulphate (SO_4^{-2}) concentration for B Zone columns .. 46
14. Effluent total iron (Fe) concentration for B Zone columns 47
15. Effluent total antimony (Sb) concentration for B Zone columns 48
16. Effluent total arsenic (As) concentration for B Zone columns 49
17. Effluent total copper (Cu) concentration for B Zone columns 50
18. Effluent total cyanide (CN^-) concentration for B Zone columns 51
19. Effluent total lead (Pb) concentration for B Zone columns 52
20. Effluent total mercury (Hg) concentration for B Zone columns 53
21. Effluent total nickel (Ni) concentration for B Zone columns 54
22. Effluent total zinc (Zn) concentration for B Zone columns 55
23. Weekly leachate flow volume for S Zone column 56
24. Total accumulated volume (average) per column for S Zone 57
25. Effluent temperature for S Zone columns 58
26. Effluent pH for S Zone columns 59
27. Effluent electrical conductance 'Ec' for S Zone columns 60
28. Effluent redox potential 'Eh' (absolute) for S Zone columns 61
29. Effluent acidity for S Zone columns 62
30. Effluent alkalinity for S Zone columns 63
31. Effluent total sulphate (SO_4^{-2}) concentration for S Zone columns .. 64
32. Effluent total iron (Fe) concentration for S Zone columns 65
33. Effluent total antimony (Sb) concentration for S Zone columns 66
34. Effluent total arsenic (As) concentration for S Zone columns 67
35. Effluent total copper (Cu) concentration for S Zone columns 68
36. Effluent total cyanide (CN^-) concentration for S Zone columns 69
37. Effluent total lead (Pb) concentration for S Zone columns 70
38. Effluent total mercury (Hg) concentration for S Zone columns 71
39. Effluent total nickel (Ni) concentration for S Zone columns 72
40. Effluent total zinc (Zn) concentration for S Zone columns 73
41. Grain size distribution of B Zone tailings 74
42. Grain size distribution of S Zone tailings 75
43. Total loading for acidity, alkalinity, iron, sulphate, copper, nickel, zinc and lead for B and S Zone tailings 76

44. Rate of sulphate production per kg of tailings (dry weight) for B Zone tailings 77

45. Cumulative rate of sulphur consumption (percent) for B Zone tailings 78

46. Rate of sulphate production per kg of tailings (dry weight) for S Zone tailings 79

47. Cumulative rate of sulphur consumption (percent) for S Zone tailings 80

INTRODUCTION

The Cullaton Lake Gold Mines Ltd., owned by the International Corona Corporation of Vancouver (acquired in 1985), is located in the District of Keewatin, Northwest Territories at 61° 16′ North latitude and 98° 30′ west longitude. The property is located 416 km northwest of Churchill, Manitoba, and 620 km north of Thompson, Manitoba (Figure 1). The site is at the tree line and in the zone of discontinuous permafrost.

The Company (Cullaton Lake Gold Mines Ltd.) operated a 300 tonnes per day gold mill at the site from October 1981 to August 1985 and produced about 100,000 ounces of gold. The site has been on care and maintenance since September 1985. International Corona Corporation is now planning to decommission the mine and tailings sites.

The ore milled at the site came from two distinct orebodies, namely B and Shear (S) Zones. A total of 373,000 tonnes of ore was processed at the mill, of which 150,000 tonnes came from the B Zone, and the balance of 223,000 tonnes from the Shear Zone. The B Zone is located at the mill site, and the Shear Zone is located approximately 5 km to the north (Figure 2).

The Cullaton Lake B Zone deposit is a gold-bearing iron formation in a turbiditic sedimentary basin which forms part of the Rankin Inlet - Ennadi Archean greenstone belt in the Keewatin district of the Northwest Territories. The belt consists of clastic sediments (turbidites), pillow lavas and iron formations. This assemblage is indicative of an eugeosynclinal environment.

The B Zone iron formation consists of four distinct facies, namely, carbonate, silicate, oxide and sulphide. The gold mineralization is confined in a strata bound nature to the sulphide facies iron formation. Pyrrhotite and pyrite are the dominant sulphides with lesser amounts of arsenopyrite and chalcopyrite. Gold occurs free in the non-metalliferous gangue and shows no preference for any one sulphide [Page 1983; Trow, 1991].

The Shear Zone is located in a discontinuous ridge outcrop of

orthoquartzite. Gold occurs in the fractured and sheared orthoquartzite at the Shear Zone deposit. Mineralization is found in altered shears, breccia zones, pyritic shears, and pyritic sericitic impure quartzite [Chataway, 1983; Trow, 1991].

Because of pyrite, pyrrhotite and other reactive sulphide mineralization of the orebodies, the acid mine drainage issue from tailings and waste rock needs to be addressed in preparation for a final decommissioning plan for the site. International Corona Corporation contracted Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario, to conduct detailed kinetic leaching tests on Cullaton Lake B and S Zone tailings (see Appendix A). Results of the column leaching tests performed at room temperature and under conditions of batch leaching and rest cycles are presented here.

These tests represented a worst case scenario of favourable oxidation and leaching conditions at room temperature (25°C). In reality, for most of the year at the northern site, ambient temperatures are quite low where both chemical and biological oxidation processes proceed slowly [Knapp, 1987]. It is further proposed that similar tests be undertaken at cold temperatures to evaluate differences in leaching characteristics, if any.

GEOLOGY AND MINERALOGY

Page [1983], and Chataway and Hanson [1983] have studied the geology and mineralogy of the Cullaton Lake area in detail. A brief summary is provided here for background.

The mine property lies within the Churchill Structural Province of the Canadian Shield in what is termed the Kaminak Subprovince, a Precambrian greenstone belt which extends from the Saskatchewan border to the Rankin Inlet.

The oldest units are intercalated volcanic and sedimentary rocks of Archean Age called the Henik Group. This group consists of heterogeneous

volcanic rocks, predominantly andesite and basalt, intercalated with clastic sediments of greywacke and argillite composition.

The Archean Henik Group is separated from the Lower Proterozoic Montgomery Lake Group by a series of plutonic and associated metamorphic rocks. This sequence is comprised of various bodies of granodiorite and monzonite which have transformed the Henik Group rocks into a variety of gneisses and schists.

The lower Proterozoic Montgomery Lake Group lies unconformably above the Henik Group and the intrusive metamorphosed sequence. This group is comprised of a thick series of boulder-conglomerate, greywacke, quartzite and siltstone.

The Hurwitz Group, Aphebian in age, lies unconformably above the Montgomery Lake Group. It is comprised of a broad assemblage of clastic sedimentary rocks, including conglomerate, orthoquartzite, slate, shale, dolomite, greywacke and arkose.

A sequence of middle Proterozoic intrusive rocks consisting of granite, quartz monzonite, granodiorite, gabbro and diabase dykes intrude the rocks of the above-described groups.

B ZONE

Gold mineralization in the B Zone is confined to sulphide iron formations in the sedimentary sequence of the Henik group.

Based on dominant mineralogy, the B Zone iron formation consists of four distinct facies, namely, carbonate, oxide, silicate, and sulphide. The gold mineralization is confined in a strata bound nature to the sulphide facies iron formation. The carbonate iron formation consists of layered chert and ankerite; the oxide iron formation consists of chert, magnetite, and siderite with minor iron sulphides and chlorites, the silicate iron formation consists of chert, chlorite and minor amounts of stilpnomelane, minnesotaite and siderite, and the sulphide iron formation consists of chert, pyrrhotite,

pyrite, arsenopyrite, magnetite, siderite, minor chalcopyrite and chlorite. The sulphide facies is found within, or bordering the oxide facies and ranges in thickness from 0.6 to 17.5 m.

The gold occurs free in the non-metalliferous gangue and shows no preference to any one sulphide or arsenide mineral.

The trace element content of the B Zone iron formation is comparable to that of the Algoman type iron formation with the exception of increased amounts of Au and Ag. Au and Ag are enriched in the iron formation in all lithologies, and display a positive correlation with As and S. Sr, Y, Rb, Ce, Ba, Ni and Zn form a group of elements which show a strong positive correlation within the group, and negative correlation with Au, Ag, S and As. Zn, Co, Cu and Sb as in most Algoman type deposits occur in very low abundances, and their distribution does not correlate with that of any other element. It is assumed that the local concentrations of these elements control their abundances.

The veins of the deposit contain low quantities of gold compared to lithologies that they transect.

Approximately twelve iron formations in the Cullaton Lake district occur along a strike length of 30 km and through a stratigraphic thickness of up to .5 km. The lithological control of gold in the B Zone orebody may also be found 1.8 km down strike from the deposit in the same iron formation. The same relationship was also found in an iron formation (the A Zone iron formation) 0.6 km west of the B Zone. The other iron formations of the district were sampled in outcrop and boulders, and it was demonstrated that the high gold content of sulphide lithology persists throughout the district.

The association of economic quantities of gold with sulphide iron formation suggests a sedimentary origin for the gold. The wide geographical and stratigraphic distribution of the high-gold sulphide lithology suggests that gold was introduced into the turbiditic basin in hydrothermal solution

for the entire history of the basin. The localization of gold with a discrete lithology suggests that the precipitation of gold was controlled by local chemical-sedimentary conditions within the basin, rather than proximity to a discharge site. It is suggested that gold, arsenic and antimony remained in solution as thio complexes. Precipitation of these elements was prompted by the reduction of reduced sulphur species as a consequence of the local precipitation of iron sulphides.

SHEAR ZONE

The Shear Zone area is underlain by orthoquartzite and slate, shale and siltstone. The former occurs as a discontinuous ridge of outcrop extending almost the length of the property in a north-south direction.

The orthoquartzite is white with variations of pink to red, fine-grained to glassy, and varies from thin bedded to thick bedded or massive. Typically, the orthoquartzite is composed of 97% or more quartz, with only scattered sericite, feldspar and magnetite. Less pure quartzites occurring in the lower part of the unit are commonly sheared and contain sericite and pyrite.

A greywacke underlies the orthoquartzites with a conformable contact indicating the greywacke is a part of the Hurwitz Group and not the Henik volcanic. The thinly bedded shale, slate and siltstone unit occurs stratigraphically above the orthoquartzite and the contact area is an interbedded transition zone of siltstone and quartzites with strong hematitic staining.

Gold occurs in the fractured and sheared orthoquartzite in the Shear Zone orebody. Mineralization is found in: a) altered shears; b) breccia zones; c) pyritic shears; and d) pyritic sericitic impure quartzite.

The altered Shear Zones are extensive and related to the regional structural patterns. Alteration products common to most zones are saponite, limonite, and hematite with occasional chlorite, epidote and sericite. Quartz

and tourmaline are present in some zones. Gold occurs as free gold visibly as sheared flecks or as fine nuggets and as a residue after the transformation of auriferous pyrite to limonite.

A vuggy quartz pyritic quartzite breccia containing gold appears within an altered Shear Zone having pyrite with milky white quartz matrix.

Unaltered Shear Zones consisting of closely spaced pyrite-filled fractures are also gold bearing. The pyrite occurs as loosely packed filling in the fractures. Generally, these zones are narrow and appear discontinuous.

A different type of gold mineralization was observed in the impure sheared sericitic quartzite consisting of 5 to 15% pyrite (8% average), disseminated to semi-massive in places. The alteration products of the Shear Zones are not present, but strong sericite and/or epidote is present in the sheared rock, possibly having been introduced post-deformation.

A characteristic feature of the auriferous zones is a pyritic halo extending from 0.5 to 6 m. The pyrite content averages 2 to 3%, but can be as much as 15%. Generally, the pyritic halo has a low gold content.

KINETIC LEACHING TESTS

METHOD

Column lysimeter leaching tests were conducted for both B and Shear Zone tailings at room temperature (25^{o}), to determine kinetically the leaching characteristics at favourable weathering conditions (worst case scenario).

A total of four columns were set-up for these tests, two for each of the B and S Zone. Initially, it was considered to conduct such tests in triplicates, but the quantity of the material at hand permitted tests in duplicates only. Each leaching column consisted of a clear plexiglass tube, 80 cm in height and 12.5 cm in diameter, the bottom of which contained 7.5 cm thick layers of clean gravel and sand for bed support and filter purposes (Figure 3).

Cullaton Lake tailings for B and S Zones were separately homogenized, as received, using a clean cement mixer and were charged into respective columns. Each B and S zone column contained 12.5 and 9.7 kg of tailings, respectively.

For physical and chemical characterization of tailings prior to leaching, appropriate amounts of head samples were collected, homogenized and analyzed for each zone, for moisture content, dry bulk and grain densities, particle size distribution, paste pH, total sulphur, net neutralization potential, and total cyanide, Kjedhal nitrogen, phosphorus and total metals: Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Sr, Th, Ti, U, V, Zn.

The leaching procedure consisted of the introduction of water at the column top and collection of the effluent from the bottom of the sand-gravel filter bed. The drainage tube was fitted with a water trap to prevent the entry of air from the bottom and its height was adjusted so that the water table in the column was at the sand-tailings interface. The complete experimental set-up is shown in Figure 4.

At the start of the experiment all the columns were inoculated with 250 mL of underground leaching solution containing various strains of thiobacilli ferro-oxidans, obtained from one of the Elliot Lake area mines employing in situ leaching of pyritic uranium ore. The columns were first allowed to settle and acclimatize for a week to allow the leaching solution to disperse throughout the tailings mass.

The columns were then batch leached by adding 500 mL of fresh water once every week for 34 weeks. For leaching purpose, the water used was collected from one of the area lakes, Gravelpit Lake, on a weekly basis and kept at room temperature and well aerated.

The water percolated freely through the column transporting dissolved oxidation reaction products and other soluble salts, and was collected as an

effluent in a narrow neck sample bottle. Progressively with time, the tailings were observed to have increased water retention and poor drainage, causing ponding of water on the tailings surface. This prevented adequate air exposure and establishment of unsaturated conditions within tailings for proper oxidation and leaching. Larger leaching volumes (1 L per week as desired) were thus excluded.

A weekly composite effluent sample was collected, its volume and temperature measured, and analyzed on a weekly basis for 34 weeks. The measured parameters were pH, electrical conductance Ec, redox potential Eh, total acidity and alkalinity, total dissolved cyanide CN^-, and SO_4^{-2}, and total dissolved metals: Fe, Cu, Ni, Pb, Zn, As, Hg, and Sb.

Near the termination of the experiment, it was observed that the columns were retaining (in large amounts) and plugging up with sludge material which caused much reduced drainage. This phenomenon was more pronounced for B Zone than S Zone tailings. All four columns (both B and S Zones) were then flushed with an additional 500 mL of water and drained completely using a vacuum suction. The columns were then leached again for an additional two week period. At the completion of tests, solid core samples were taken from each column and analyzed for moisture content and paste pH.

RESULTS AND DISCUSSION

Tables 1 and 2 show the physical, chemical and acid-base accounts for the two tailings types. The leaching characteristics in terms of the effluent quantity, quality and chemical composition are shown respectively for B and S Zones in Tables 3 and 4. Figures 5 through 22 and 23 through 40, illustrate the leaching profiles with time for the two zones for weekly effluent volume collected, total accumulated volume, effluent temperature, pH, Ec, Eh, total acidity, total alkalinity, sulphate, total dissolved Fe, Sb, As, Cu, CN_{tot}, Pb, Hg, Ni and Zn, respectively.

The oxidation and mobilization of reaction products are clearly evident for both zones, although markedly different. The B Zone tailings, which were characterized by a dark greenish grey colour, finer particle size (d_{50} = 65 μm, Figure 41), higher iron and sulphur contents and a negative net neutralization potential of -31.6 kg $CaCO_3$/tonne, showed rapid oxidation with pH dropping from 8 to 3 within 20 days. Acidity increased within 15 days from zero to a maximum of 8000 mg/L at 50 days, alkalinity decreased from 140 mg/L to zero within a week with a corresponding increase in parameters such as Ec, Eh, SO_4^{-2}, Fe and trace amounts of Sb. Unlike the continuous oxidation process of the iron sulphide formation, the B Zone leaching trends showed a characteristic peak at approximately 25 to 50 days, depending on the parameter and which gradually decreased to its initial or below initial value. For example, both Ec and SO_4^{-2} peaked at approximately 25 days and dropped below initial values after 100 days.

The pH, however, remained depressed throughout the experiment, except at the termination of the test when unplugging of the columns by suction altered the pH to 7.8 in one of the columns, B-2. This also increased the alkalinity and other trace metal concentrations, for example Cu, Ni and Zn, which were less than 0.1 mg/L throughout the experiment. Pb was present in measurable amounts, around 0.2 mg/L, up to 50 days, decreasing to less than 0.1 mg/L onwards. Trace amounts of As, 0.1 to 0.2 mg/L, were also detected initially, decreasing to below detection (<0.01 mg/L) after acidification. Because of the decreased pH, total CN was absent in the effluent except in occasional trace amounts of <0.05 mg/L. No mercury was detected except in some isolated instances which are attributed to instrumental undercorrection with the varying sample matrix. All these results correlate well with the iron sulphide matrix containing trace heavy metals associated with the gold mineralization of the B Zone. The short term oxidation and a rapid peaking of the parameter concentrations is an anomaly not found in other leaching

experiments of low sulphide tailings of Elliot Lake deposits or massive sulphides of base metal mines. For the B Zone, a total of 7.8% S, 0.6% Fe, 0.3% Cu, 0.02% Ni, 0.06% Zn and 0.02% Pb was removed during the leaching period (Table 5).

For the S Zone, with its characteristic brownish-orange tailings, coarser particle size (d_{50} = 100 μm, Figure 42), low iron and sulphur contents and less negative net neutralization potential of -14.29 kg $CaCO_3$/tonne, the oxidation started slowly at around the 100 day mark with decreasing pH, increasing acidity and dissolved metal concentrations. Data for the S Zone also showed a peaking trend but with broad and less distinct peaks compared to those observed for the B Zone. The oxidation was marginal with Fe and SO_4^{-2} increasing from 0 to 300 and 2000 to 3200 mg/L, respectively. Cu, Ni and Zn also showed increased concentrations with decreasing pH. A slight increase in Pb concentration was also observed, but not distinctly. No changes in parameters such as CN, As, Sb, Hg were observed which were already near detection limits. The observed buffering capacity, and hence, the total residual alkalinity of the S Zone was higher than that of the B Zone. For the S Zone a total of 20.2% S, 0.3% Fe, 1.1% Cu, 3.1% Ni, 0.5% Zn and 0.9% Pb was removed during the same leaching period (Table 5).

Common to both the zones were the variations between column duplicates, which were more pronounced for the S Zone. This may be attributable to coarser particle size of S Zone tailings and channelling.

The data clearly showed that although the sulphide contents of both B and S Zones tailings were very low (2.34 and 0.51%, respectively), both tailings oxidized easily under favourable laboratory conditions. The kinetic tests thus confirmed the reactivity of tailings as determined by their net negative neutralization potentials obtained during static acid-base accounting.

The kinetic rate of oxidation, total acidity generated and loadings for

iron and sulphate were higher for the B Zone than those for the S Zone tailings. Total loading and percent removal for Cu, Ni, Zn, and Pb, on the other hand, were higher for the S Zone as shown in Table 5 and Figure 43. The rate of sulphate production per kg of waste per week and cumulative percent sulphur consumed are shown in Tables 6 and 7, and in Figures 44 and 47 for B and S Zones, respectively. Although sulphur oxidation rates were lower for the S Zone, the total sulphur consumption was 2.5 times greater than that for the B Zone.

A buffering trend in both systems was observed around pH 3, probably because of their silicate matrix. Carbonate alkalinity was not readily evident from either static or kinetic tests.

Data for moisture and paste pH profiles as a function of depth, for various columns (Tables 8 and 9) at the termination of the experiment, suggested that both B and S Zone tailings in the column tests were in a high degree of moisture saturation near the top and throughout the column depths. Moisture retention and saturation for the S Zone tailings were higher (close to 100%) than those for the B Zone tailings. These conditions were readily evidenced during solid core sampling where the tailings exhibited 'slime-like' characteristics of poor consolidation and rapid liquefaction. The S Zone solid core samples were fluid-like for the entire column depths compared to B Zone tailings where the bottom half samples were partially consolidated. These observations were consistent with the measured moisture profiles (Tables 8 and 9). Calculated pore moisture saturations in excess of 100% are attributed to excess moisture retention by hydrolysis of oxidation reaction products such as Fe^{+3}, metal hydroxide sludge formation and adsorption on tailings solids. Hydrated ferric-oxyhydroxide and other metal hydroxide precipitates are known for their excess water retention capabilities (80-95% by weight).

These conditions of high water retention in the column tests permitted

a shallow and limited unsaturated zone close to the tailings surface which was subjected to periodic oxidation and leaching. The rate of oxidation thus may be controlled by the degree of moisture saturation of the pore space, the latter being high for the S Zone, and hence slow oxidation.

It is interesting to note that even with these saturation conditions coupled with a low sulphide content, approximately 20% of the total sulphur was oxidized and removed from the S Zone tailings. The observed characteristic leaching peaks are attributed to the limited capacity of the available influence zone amenable to oxidation.

Saturation conditions prevailing below the exposed and unsaturated zone may be providing the rate determining factor in controlling further oxidation. The transport of oxidation reaction products depended, however, on the buffering capacity of the media.

Sedimentation, adsorption and sludge coating of the type similar to metal hydroxides were visually observable in the sand and gravel filter beds and in the drainage tubes. Because of anaerobic conditions, dark coloured mold and/or fungi was also growing in the clear plastic drainage tubes. These sediments were disturbed when suction was applied to improve drainage of the columns near the completion of the tests which is the most probable cause of increased metal concentrations near the end.

Although the columns were charged weekly with 500 mL of water, the effluent volume collected per week averaged around 350 mL. The balance of 150 mL/week represented loss to evaporation.

The influent volume represented a net precipitation of approximately 39.5 mm per week or 1343 mm for the entire 34 week period. In terms of accelerated leaching, the total volume applied corresponded to 3.36 years of total precipitation at the rate of 400 mm per year for the Collaton Lake site, based on its meteorological data. Assuming a net infiltration rate of 10%, the total accumulated volume of approximately 12 L represented in actuality,

precipitation and recharge events of 23.7 years. Based on the measured physical parameters, the total accumulated flow represented pore volume exchanges of 5.2 and 6.74 times respectively for B and S Zones.

WASTE ROCK ACID/BASE ACCOUNTING

A total of six waste rock samples from the Cullaton Lake site were also analyzed for their total sulphide content, total acid production potential, total alkalinity and the net neutralization potential. Results are shown in Table 10.

Although the sulphur contents (ranging from 0.01 to 1.08 as S) of the waste rock from B and S Zones were comparable to those for the tailings, much higher net neutralization potential values, ranging from 69 to 127 kg $CaCO_3$/tonne, were obtained for the B Zone waste rock because of its carbonate content. Assuming an equal mix of waste rock from B and S Zones, other Cullaton Lake rejects and overburden, a net neutralization potential of approximately 48 kg $CaCO_3$/tonne was obtained for the combined wasterock.

Because of the observed high alkalinity and net neutralization potential of the B Zone waste rock, and the fact that there are no waste rock piles as such at the site, except in the tailings impoundment where the waste rock is disposed of with overburden and other reject fragments, kinetic leaching tests for waste rock are not necessary or advised.

CONCLUSION AND RECOMMENDATIONS

1. Although characterized by very low sulphide contents, both B and S Zones tailings had negative net neutralization potential (NP) and were amenable to oxidation and thus acid mine drainage under favourable laboratory conditions. The effects were more pronounced for the B Zone than the S Zone tailings.

2. Because of their high water retention capacity and poor drainage characteristics, the oxidation rate may have been controlled by the degree of moisture saturation of the pore space. These conditions permitted a shallow and limited unsaturated zone near the immediate top surface which was subjected to periodic oxidation and leaching. The acidic front, however, migrated to the entire column depth.
3. Although total sulphate and metal loadings in the effluent were higher for the B Zone, the total percentage of sulphur and heavy metals removed, was higher for the S Zone.
4. The tailings were significantly reactive and oxidized readily. Decommissioning and acid mine drainage control measures should include oxygen and/or moisture retention barriers. Disposal options incorporating permanent saturation under a water cover or permafrost throughout the entire depth of tailings are believed to be suitable and should be further evaluated for their economic feasibility.
5. Because of the northern location of the site, the ambient temperatures may be too low to support bacterial oxidation of metal sulphides. It is, therefore, recommended that similar kinetic tests be undertaken at lower temperatures (average for the site) to evaluate temperature effects if any.
6. For the Cullaton Lake waste rock, a high net average neutralization potential (NP) of 48 kg $CaCO_3$/tonne was obtained for all the waste rock combined. Kinetic leaching tests similar to those for the tailings are, therefore, not necessary.

REFERENCES

1. Chataway, R.T. and Hanson, W., 1983, "Cullaton Lake Gold Mines Ltd. and Royex Sturgex Mining, Shear Lake property, Cullaton Lake, N.W.T."; Summary Report, Cullaton Lake, December 1983.

2. Knapp, R.A., 1987, "The biogeochemistry of acid generation in sulphide tailings and waste rock"; Proc. Acid Mine Drainage Seminar/Workshop, Halifax, Nova Scotia, March 1987, pp. 47-65.

3. Page, Charles E., 1983, "The geology of the Cullaton Lake B-zone gold deposit, Northwest Territories"; M.Sc. Thesis, University of Waterloo, Ontario, 1983.

4. Trow Consulting Engineers Ltd., 1991, "Abandonment and restoration plan, Cullaton Lake Gold Mines Ltd.", Trow Consulting Engineers, Thunder Bay, Ontario, April 1991.

Table 1 - Physical characteristics of B and S Zone tailings

Parameter	B-Zone	S-Zone
Dry bulk density (kg)	1.85	1.67
Grain density (kg)	2.99	2.53
Moisture content wt.(%)	10.23	10.69
Porosity (%)	38.05	34.02
Wet mass of tailings in column (kg)	12.5	9.7
Total bulk vol. dry tailings (L)	6.07	5.19
Total pore vol. dry tailings (L)	2.31	1.77
% pore vol. moisture saturation	55	59
d_{10} μm	25	28
d_{50} μm	65	100
Colour	Greenish grey	Brownish orange

Table 2 - Chemical characteristics of B and S Zone tailings all units are μg/g (ppm).

Parameter	B-Zone	S-Zone
Total 'S' %	2.34	0.51
Total acid generation potential $CaCO_3$ kg/tonne	73.125	15.94
Total alkalinity, $CaCO_3$ kg/tonne	41.47	1.65
Net neutralization potential $CaCO_3$ kg/tonne	-31.655	-14.29
Ag	<30	<30
Al	20,000	4,000
As	1,600	<100
Ba	100	540
Be	<4	<4
Ca	25,000	1,300
Cd	70	<30
CN	11.1	<2
Co	<40	<40
Cr	<20	<20
Cu	60	20
Fe	190,000	29,000
Hg ppb	<2	<2
K	4,100	1,200
Mg	11,000	600
Mn	1,000	190
Mo	<10	<10
TKN as N	110	<100
Na	1,800	800
Ni	<80	<80
P	600	100
Pb	70	<40
Sr	110	<10
Th	<12	<12
Ti	800	110
U	19	<10
V	40	20
Zn	<80	<80
Zr	50	40

Table 3 - Leachate water quality parameters for the B Zone.

DATE SAMPLED	TIME (d) FROM START	COLUMN B#1 VOLUME (mL)	COLUMN B#2 VOLUME (mL)	COLUMN AVERAGE VOLUME (mL)	COLUMN AVERAGE VOL_ACC (mL)	COLUMN B#1 PH	COLUMN B#2 PH	COLUMN AVERAGE PH	COLUMN B#1 EH (mV)	COLUMN B#2 EH (mV)	COLUMN AVERAGE EH (mV)	COLUMN B#1 EH(NHE) (mV)
CULLATON LAKE	LEACHING TEST: B-ZONE #1 AND #2											
08-Nov-90	0				0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	7	428.0	391.8	409.9	409.9	8.230	7.520	7.875	140.3	145.3	142.8	384.3
22-Nov-90	14	419.7	376.4	398.1	808.0	4.349	5.848	5.099	163.3	54.7	109.0	407.3
29-Nov-90	21	352.8	321.7	337.3	1145.2	3.343	4.004	3.674	265.0	161.3	213.2	509.0
06-Dec-90	28	339.0	368.1	353.6	1498.7	3.314	3.673	3.494	276.0	227.0	251.5	520.0
13-Dec-90	35	407.8	402.0	404.9	1903.6	3.218	3.383	3.301	276.0	254.0	265.0	520.0
20-Dec-90	42	387.6	390.8	389.2	2292.8	3.133	3.216	3.175	281.0	270.0	275.5	525.0
27-Dec-90	49	332.1	354.7	343.4	2636.2	3.069	3.182	3.126	291.0	274.0	282.5	535.0
03-Jan-91	56	345.3	440.8	393.1	3029.3	2.976	3.210	3.093	298.0	261.0	279.5	542.0
10-Jan-91	63	361.0	343.1	352.1	3381.4	2.895	3.176	3.036	315.0	277.0	296.0	559.0
17-Jan-91	70	358.3	355.0	356.7	3738.0	2.899	3.396	3.148	327.0	247.0	287.0	571.0
24-Jan-91	77	341.4	360.6	351.0	4089.0	2.780	2.658	2.719	342.0	289.0	315.5	586.0
31-Jan-91	84	373.6	337.8	355.7	4444.7	2.857	3.537	3.197	350.0	237.0	293.5	594.0
07-Feb-91	91	366.7	374.0	370.4	4815.1	2.479	3.555	3.017	360.0	246.0	303.0	604.0
14-Feb-91	98	362.1	364.1	363.1	5178.2	2.860	3.670	3.265	358.0	225.0	291.5	602.0
21-Feb-91	105	366.4	348.5	357.5	5535.6	2.881	3.637	3.259	359.0	239.0	299.0	603.0
28-Feb-91	112	335.7	363.3	349.5	5885.1	2.891	3.842	3.367	373.0	221.0	297.0	617.0
07-Mar-91	119	362.8	357.5	360.2	6245.3	2.853	3.813	3.333	379.0	220.0	299.5	623.0
14-Mar-91	126	347.1	355.2	351.2	6596.4	2.907	3.861	3.384	380.0	223.0	301.5	624.0
21-Mar-91	133	353.8	332.7	343.3	6939.7	2.938	3.931	3.435	405.0	220.0	312.5	649.0
04-Apr-91	147	342.7	217.9	280.3	7220.0	2.808	3.798	3.303	424.0	211.0	317.5	668.0
11-Apr-91	154	220.7	308.7	264.7	7484.7	2.788	3.779	3.284	452.0	227.0	339.5	696.0
18-Apr-91	161	365.7	343.8	354.8	7839.4	2.878	3.916	3.397	441.0	224.0	332.5	685.0
25-Apr-91	168	360.1	351.2	355.7	8195.1	2.853	4.001	3.427	436.0	220.0	328.0	680.0
02-May-91	175	360.0	357.6	358.8	8553.9	2.822	3.908	3.365	486.0	234.0	360.0	730.0
09-May-91	182	376.6	354.7	365.7	8919.5	2.921	4.017	3.469	490.0	224.0	357.0	734.0
16-May-91	189	372.3	357.5	364.9	9284.4	2.903	3.802	3.353	507.0	257.0	382.0	751.0
23-May-91	196	386.2	391.6	388.9	9673.3	2.937	3.951	3.444	499.0	233.0	366.0	743.0
30-May-91	203	407.2	391.1	399.2	10072.4	2.962	3.944	3.453	501.0	256.0	378.5	745.0
06-Jun-91	210	355.5	297.2	326.4	10398.8	2.929	3.937	3.433	498.0	250.0	374.0	742.0
13-Jun-91	217	398.5	267.0	332.8	10731.5	3.009	4.007	3.508	512.0	246.0	379.0	756.0
20-Jun-91	224	387.5	310.0	348.8	11080.3	2.864	3.115	2.990	542.0	422.0	482.0	786.0
27-Jun-91	231	430.8	420.7	425.8	11506.0	3.203	4.766	3.985	504.0	258.0	381.0	748.0
04-Jul-91	238	458.5	416.8	437.7	11943.7	3.136	7.828	5.482	523.0	247.0	385.0	767.0

Cont.

Table 3 - cont.

DATE SAMPLED	COLUMN B#2 EH (NHE) (mV)	COLUMN AVERAGE EH (NHE) (mV)	COLUMN B#1 EC (US)	COLUMN B#2 EC (US)	COLUMN AVERAGE EC (US)	COLUMN B#1 TEMP (DEG.C)	COLUMN B#2 TEMP (DEG.C)	COLUMN AVERAGE TEMP (DEG.C)	COLUMN B#1 ACIDITY (mg/L)	COLUMN B#2 ACIDITY (mg/L)	COLUMN AVERAGE ACIDITY (mg/L)	COLUMN B#1 ALKALINITY (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	389.3	386.8	7390	7330	7360	25.0	25.0	25.0	0.00	0.00	0.00	140.07
22-Nov-90	298.7	353.0	9260	8570	8915	23.0	23.0	23.0	579.30	256.01	417.66	0.00
29-Nov-90	405.3	457.2	12070	10500	11285	22.0	22.0	22.0	3164.98	1605.86	2385.42	0.00
06-Dec-90	471.0	495.5	20850	18250	19550	23.0	22.0	22.5	4983.46	3455.87	4219.67	0.00
13-Dec-90	498.0	509.0	15470	14520	14995	22.0	22.0	22.0	6686.35	6035.24	6360.80	0.00
20-Dec-90	514.0	519.5	14390	14390	14390	21.0	20.5	20.8	7637.96	7788.22	7713.09	0.00
27-Dec-90	518.0	526.5	13400	13790	13595	24.0	24.0	24.0	7995.68	8414.28	8204.98	0.00
03-Jan-91	505.0	523.5	10960	11290	11125	21.0	21.0	21.0	7462.67	7988.56	7725.62	0.00
10-Jan-91	521.0	540.0	8560	8640	8600	21.0	20.5	20.8	5884.99	6460.97	6172.98	0.00
17-Jan-91	491.0	531.0	7350	7340	7345	23.0	22.5	22.8	4507.65	4883.29	4695.47	0.00
24-Jan-91	533.0	559.5	4930	5680	5305	19.0	19.0	19.0	3556.04	3856.55	3706.30	0.00
31-Jan-91	481.0	537.5	4520	4380	4450	21.0	20.5	20.8	2764.69	2995.08	2879.89	0.00
07-Feb-91	490.0	547.0	4540	4090	4315	22.0	22.0	22.0	2123.60	2394.06	2258.83	0.00
14-Feb-91	469.0	535.5	3850	3740	3795	21.5	21.5	21.5	1943.30	2143.64	2043.47	0.00
21-Feb-91	483.0	543.0	4330	4200	4265	21.5	22.0	21.8	3606.12	1804.32	2705.22	0.00
28-Feb-91	465.0	541.0	4010	3840	3925	21.5	21.0	21.3	1327.25	1464.99	1396.12	0.00
07-Mar-91	464.0	543.5	3800	3610	3705	20.5	20.5	20.5	1126.91	1264.65	1195.78	0.00
14-Mar-91	467.0	545.5	3650	3450	3550	21.0	20.5	20.8	941.25	1029.10	985.18	0.00
21-Mar-91	464.0	556.5	3520	3330	3425	21.5	22.0	21.8	1079.30	898.58	988.94	0.00
04-Apr-91	455.0	561.5	3860	3540	3700	21.0	21.0	21.0	627.50	753.00	690.25	0.00
11-Apr-91	471.0	583.5	3690	3450	3570	20.5	20.5	20.5	426.70	715.35	571.03	0.00
18-Apr-91	468.0	576.5	3270	3060	3165	21.0	21.0	21.0	451.17	671.74	561.46	0.00
25-Apr-91	464.0	572.0	2980	2740	2860	22.0	22.0	22.0	473.73	584.01	528.87	0.00
02-May-91	478.0	604.0	3530	3180	3355	21.5	21.5	21.5	481.25	511.33	496.29	0.00
09-May-91	468.0	601.0	3500	3210	3355	22.0	22.0	22.0	360.94	466.21	413.58	0.00
16-May-91	501.0	626.0	3600	3300	3450	24.5	24.0	24.3	322.14	421.06	371.60	0.00
23-May-91	477.0	610.0	3250	2980	3115	24.0	24.0	24.0	220.68	375.40	298.04	0.00
30-May-91	500.0	622.5	2990	2740	2865	22.5	22.5	22.5	246.04	339.89	292.97	0.00
06-Jun-91	494.0	618.0	3240	2950	3095	21.5	21.5	21.5	225.75	294.23	259.99	0.00
13-Jun-91	490.0	623.0	3360	2890	3125	22.0	22.0	22.0	152.19	291.70	221.95	0.00
20-Jun-91	666.0	726.0	3470	3290	3380	22.5	22.5	22.5	182.63	169.95	176.29	0.00
27-Jun-91	502.0	625.0	3330	3160	3245	25.0	24.5	24.8	121.75	58.34	90.05	0.00
04-Jul-91	491.0	629.0	3660	3440	3550	23.5	23.5	23.5	111.61	0.00	55.81	0.00

Cont.

Table 3 - cont.

DATE SAMPLED	COLUMN B#2 ALKALINITY (mg/L)	COLUMN AVERAGE ALKALINITY (mg/L)	COLUMN B#1 Cu (mg/L)	COLUMN B#2 Cu (mg/L)	COLUMN AVERAGE Cu (mg/L)	COLUMN B#1 Fe TOTAL (mg/L)	COLUMN B#2 Fe TOTAL (mg/L)	COLUMN AVERAGE Fe TOTAL (mg/L)	COLUMN B#1 Ni (mg/L)	COLUMN B#2 Ni (mg/L)	COLUMN AVERAGE Ni (mg/L)	COLUMN B#1 Pb (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	132.97	136.52	0.017	0.007	0.012	0	0	0.08	0.097	0.077	0.087	0.293
22-Nov-90	8.12	4.06	0.020	0.008	0.014	254	80	166.95	0.054	0.083	0.069	0.203
29-Nov-90	0.00	0.00	0.064	0.016	0.040	1480	767	1123.50	<0.002	<0.002	0.000	0.320
06-Dec-90	0.00	0.00	0.000	0.000	0.000	2772	1862	2317.00	0.000	0.000	0.000	0.177
13-Dec-90	0.00	0.00	0.000	0.000	0.000	3676	3249	3462.50	0.000	0.000	0.000	0.247
20-Dec-90	0.00	0.00	0.000	0.000	0.000	4143	4001	4072.00	0.000	0.000	0.000	0.256
27-Dec-90	0.00	0.00	0.000	0.000	0.000	3346	3590	3468.00	0.000	0.000	0.000	0.197
03-Jan-91	0.00	0.00	0.000	0.000	0.000	4029	4199	4114.00	0.000	0.000	0.000	0.240
10-Jan-91	0.00	0.00	0.000	0.000	0.000	3416	3609	3512.50	0.000	0.000	0.000	0.311
17-Jan-91	0.00	0.00	0.000	0.000	0.000	2346	2622	2484.00	0.000	0.000	0.000	0.128
24-Jan-91	0.00	0.00	0.000	0.000	0.000	1678	1998	1838.00	0.000	0.000	0.000	0.133
31-Jan-91	0.00	0.00	0.000	0.000	0.000	1401	1638	1519.50	0.000	0.000	0.000	0.053
07-Feb-91	0.00	0.00	0.000	0.000	0.000	1030	1406	1218.00	0.000	0.000	0.000	0.152
14-Feb-91	0.00	0.00	0.000	0.000	0.000	983.2	1164.0	1073.60	0.000	0.000	0.000	0.078
21-Feb-91	0.00	0.00	0.000	0.000	0.000	789.6	949.0	869.30	0.000	0.000	0.000	0.044
28-Feb-91	0.00	0.00	0.000	0.000	0.000	584.6	777.5	681.05	0.001	0.000	0.000	0.040
07-Mar-91	0.00	0.00	0.000	0.000	0.000	497.6	701.7	599.65	0.000	0.000	0.000	0.062
14-Mar-91	0.00	0.00	0.000	0.000	0.000	418.8	585.8	502.30	0.000	0.000	0.000	0.030
21-Mar-91	0.00	0.00	0.000	0.000	0.000	299.8	473.6	386.70	0.000	0.000	0.000	0.031
04-Apr-91	0.00	0.00	0.003	0.000	0.001	193.700	412.700	303.20	0.012	0.000	0.006	0.035
11-Apr-91	0.00	0.00	0.013	0.000	0.006	89.570	94.690	92.13	0.040	0.000	0.020	0.000
18-Apr-91	0.00	0.00	0.000	0.000	0.000	108.400	343.900	226.15	0.014	0.000	0.007	0.055
25-Apr-91	0.00	0.00	0.000	0.000	0.000	124.500	289.200	206.85	0.002	0.000	0.001	0.046
02-May-91	0.00	0.00	0.000	0.000	0.000	76.660	246.900	161.78	0.000	0.000	0.000	0.000
09-May-91	0.00	0.00	0.000	0.000	0.000	70.660	211.300	140.98	0.000	0.000	0.000	0.000
16-May-91	0.00	0.00	0.022	0.000	0.011	42.320	170.000	106.16	0.015	0.000	0.008	0.015
23-May-91	0.00	0.00	0.001	0.000	0.001	35.190	159.000	97.10	0.002	0.000	0.001	0.000
30-May-91	0.00	0.00	0.003	0.000	0.001	35.130	150.400	92.77	0.002	0.000	0.001	0.000
06-Jun-91	0.00	0.00	0.016	0.000	0.008	30.490	127.600	79.05	0.000	0.000	0.000	0.170
13-Jun-91	0.00	0.00	0.030	0.010	0.020	3.997	118.700	61.35	0.056	0.006	0.031	0.000
20-Jun-91	0.00	0.00	0.640	0.071	0.356	6.093	22.490	14.29	0.325	0.044	0.184	0.045
27-Jun-91	2.54	1.27	0.060	0.113	0.087	1.482	1.553	1.52	0.054	0.029	0.041	0.015
04-Jul-91	66.99	33.50	0.007	0.046	0.026	2.352	0.000	1.18	0.000	0.020	0.010	0.000

Cont.

Table 3 - cont.

DATE SAMPLED	COLUMN B#2 Pb (mg/L)	COLUMN AVERAGE Pb (mg/L)	COLUMN B#1 Zn (mg/L)	COLUMN B#2 Zn (mg/L)	COLUMN AVERAGE Zn (mg/L)	COLUMN B#1 SULPHATE (mg/L)	COLUMN B#2 SULPHATE (mg/L)	COLUMN AVERAGE SULPHATE (mg/L)	COLUMN B#1 As (mg/L)	COLUMN B#2 As (mg/L)	COLUMN AVERAGE As (mg/L)	COLUMN B#1 Hg (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	0.165	0.229	0.020	0.021	0.021	5836.60	5631.69	5734.15	0.183	0.080	0.132	0.020
22-Nov-90	0.188	0.196	0.055	0.012	0.034	7597.07	7818.85	7707.96	0.161	0.080	0.121	0.020
29-Nov-90	0.213	0.267	0.101	0.020	0.061	11040.62	9447.14	10243.88	0.080	0.080	0.080	0.078
06-Dec-90	0.136	0.157	0.072	0.021	0.046	24608.14	11706.84	18157.49	0.000	0.000	0.000	0.000
13-Dec-90	0.223	0.235	0.095	0.036	0.066	14989.35	14349.22	14669.29	0.000	0.000	0.000	0.000
20-Dec-90	0.242	0.249	0.095	0.056	0.076	15477.82	15088.86	15283.34	0.000	0.000	0.000	0.000
27-Dec-90	0.213	0.205	0.071	0.046	0.058	10295.96	11547.55	10921.76	0.000	0.000	0.000	0.000
03-Jan-91	0.249	0.245	0.101	0.058	0.080	11168.01	11005.63	11086.82	0.000	0.000	0.000	0.000
10-Jan-91	0.252	0.281	0.098	0.062	0.080	8635.49	8671.16	8653.33	0.000	0.000	0.000	0.000
17-Jan-91	0.186	0.157	0.067	0.043	0.055	6642.79	6543.58	6593.19	0.000	0.000	0.000	0.000
24-Jan-91	0.172	0.153	0.063	0.047	0.055	5105.38	5433.02	5269.20	0.000	0.000	0.000	0.000
31-Jan-91	0.104	0.078	0.046	0.049	0.048	4451.55	4607.31	4529.43	0.000	0.000	0.000	0.000
07-Feb-91	0.144	0.148	0.151	0.153	0.152	3684.79	3986.71	3835.75	0.000	0.000	0.000	0.000
14-Feb-91	0.135	0.106	0.142	0.135	0.138	3503.37	3371.41	3437.39	0.000	0.000	0.000	0.000
21-Feb-91	0.073	0.058	0.114	0.112	0.113	3123.84	3192.51	3158.18	0.000	0.000	0.000	0.000
28-Feb-91	0.060	0.050	0.112	0.100	0.106	2962.71	2905.38	2934.05	0.000	0.000	0.000	0.000
07-Mar-91	0.087	0.075	0.095	0.097	0.096	2728.02	2717.16	2722.59	0.000	0.000	0.000	0.000
14-Mar-91	0.045	0.037	0.081	0.104	0.092	2507.35	2548.28	2527.82	0.000	0.000	0.000	0.000
21-Mar-91	0.076	0.053	0.061	0.086	0.073	2350.89	2322.40	2336.65	0.000	0.000	0.000	0.000
04-Apr-91	0.047	0.041	0.031	0.062	0.047	2202.52	2147.07	2174.80	0.000	0.000	0.000	0.000
11-Apr-91	0.050	0.025	0.013	0.070	0.041	2029.01	2092.84	2060.93	0.000	0.000	0.000	0.000
18-Apr-91	0.012	0.033	0.015	0.051	0.033	2116.50	2171.58	2144.04	0.000	0.000	0.000	0.000
25-Apr-91	0.048	0.047	0.005	0.069	0.037	2197.93	2143.64	2170.79	0.000	0.000	0.000	0.000
02-May-91	0.045	0.023	0.022	0.047	0.035	1951.07	2024.49	1987.78	0.000	0.000	0.000	0.000
09-May-91	0.040	0.020	0.026	0.049	0.037	1867.49	1974.11	1920.80	0.000	0.000	0.000	0.000
16-May-91	0.016	0.016	0.030	0.060	0.045	1706.53	1683.06	1694.80	0.000	0.000	0.000	0.000
23-May-91	0.016	0.008	0.036	0.025	0.031	1654.89	1667.03	1660.96	0.000	0.000	0.000	0.000
30-May-91	0.203	0.102	0.019	0.032	0.026	1758.97	1751.51	1755.24	0.000	0.000	0.000	0.000
06-Jun-91	0.127	0.148	0.015	0.020	0.018	1600.02	1586.30	1593.16	0.000	0.000	0.000	0.000
13-Jun-91	0.023	0.012	0.028	0.052	0.040	1693.81	1606.35	1650.08	0.000	0.000	0.000	0.000
20-Jun-91	0.000	0.022	0.127	0.144	0.135	1752.11	1612.55	1682.33	0.000	0.000	0.000	0.000
27-Jun-91	0.016	0.015	0.019	0.041	0.030	1676.46	1582.48	1629.47	0.000	0.000	0.000	0.000
04-Jul-91	0.008	0.004	0.003	0.008	0.006	1609.06	1683.45	1646.26	0.000	0.000	0.000	0.000

Cont.

Table 3 - cont.

DATE SAMPLED	COLUMN B#2 Hg (mg/L)	COLUMN AVERAGE Hg (mg/L)	COLUMN B#1 Sb (mg/L)	COLUMN B#2 Sb (mg/L)	COLUMN AVERAGE Sb (mg/L)	COLUMN B#1 CN (mg/L)	COLUMN B#2 CN (mg/L)	COLUMN AVERAGE CN (mg/L)
CULLATON LAKE								
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	0.020	0.020	0.097	0.076	0.087	0.000	0.000	0.000
22-Nov-90	0.020	0.020	<0.05	<0.05	0.000	0.000	0.000	0.000
29-Nov-90	0.020	0.049	0.367	0.126	0.247	0.050	0.039	0.045
06-Dec-90	0.000	0.000	0.000	0.464	0.232	0.031	0.011	0.021
13-Dec-90	0.000	0.000	0.396	0.523	0.459	0.048	0.010	0.029
20-Dec-90	0.000	0.000	0.323	0.374	0.348	0.010	0.011	0.011
27-Dec-90	0.000	0.000	0.259	0.229	0.244	0.010	0.010	0.010
03-Jan-91	0.000	0.000	0.325	0.272	0.298	0.010	0.010	0.010
10-Jan-91	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.010
17-Jan-91	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.010
24-Jan-91	0.000	0.000	0.000	0.000	0.000	0.010	0.005	0.008
31-Jan-91	0.000	0.000	0.000	0.000	0.000	0.005	0.008	0.007
07-Feb-91	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.005
14-Feb-91	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.005
21-Feb-91	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.005
28-Feb-91	0.000	0.000	0.000	0.000	0.000	0.040	0.010	0.025
07-Mar-91	0.000	0.000	0.000	0.000	0.000	0.040	0.011	0.026
14-Mar-91	0.000	0.000	0.000	0.000	0.000	0.040	0.090	0.065
21-Mar-91	0.000	0.000	0.000	0.000	0.000	0.040	0.015	0.028
04-Apr-91	0.000	0.000	0.000	0.000	0.000	0.040	0.013	0.027
11-Apr-91	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.007
18-Apr-91	0.000	0.000	0.000	0.000	0.000	0.005	0.011	0.008
25-Apr-91	0.000	0.000	0.000	0.000	0.000	0.006	0.010	0.008
02-May-91	0.000	0.000	0.000	0.000	0.000	0.005	0.007	0.006
09-May-91	0.000	0.000	0.000	0.000	0.000	0.005	0.008	0.007
16-May-91	0.000	0.000	0.000	0.000	0.000	0.006	0.004	0.005
23-May-91	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.006
30-May-91	0.000	0.000	0.000	0.000	0.000	0.005	0.007	0.006
06-Jun-91	0.000	0.000	0.000	0.000	0.000	0.005	0.006	0.006
13-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.005
20-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
27-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
04-Jul-91	0.000	0.000	0.000	0.000	0.000			ERR

Table 4 - Leachate water quality parameters for the S Zone.

DATE SAMPLED	TIME (d) FROM START	COLUMN S#1 VOLUME (mL)	COLUMN S#2 VOLUME (mL)	COLUMN AVERAGE VOLUME (mL)	COLUMN AVERAGE VOL_ACC (mL)	COLUMN S#1 PH	COLUMN S#2 PH	COLUMN AVERAGE PH	COLUMN S#1 EH (mV)	COLUMN S#2 EH (mV)	COLUMN AVERAGE EH (mV)	COLUMN S#1 EH (NHE) (mV)
CULLATON LAKE	LEACHING TEST: S-ZONE #1 AND #2											
08-Nov-90	0				0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	7	427.6	428.4	428.0	428.0	5.930	5.430	5.680	216.0	239.0	227.5	460.0
22-Nov-90	14	464.1	391.6	427.9	855.9	7.229	6.805	7.017	113.5	136.7	125.1	357.5
29-Nov-90	21	382.8	364.4	373.6	1229.5	7.338	3.334	5.336	123.7	459.0	291.4	367.7
06-Dec-90	28	355.8	391.3	373.6	1603.0	3.342	3.737	3.540	372.0	462.0	417.0	616.0
13-Dec-90	35	379.8	439.0	409.4	2012.4	7.537	7.201	7.369	141.7	166.3	154.0	385.7
20-Dec-90	42	356.9	368.4	362.7	2375.1	7.466	7.360	7.413	109.5	132.5	121.0	353.5
27-Dec-90	49	340.3	377.9	359.1	2734.2	7.419	7.414	7.417	146.0	164.3	155.2	390.0
03-Jan-91	56	373.7	348.8	361.3	3095.4	7.341	7.294	7.318	117.7	146.3	132.0	361.7
10-Jan-91	63	331.6	334.4	333.0	3428.4	7.274	4.328	5.801	135.0	390.0	262.5	379.0
17-Jan-91	70	373.7	375.5	374.6	3803.0	7.198	3.267	5.233	128.5	482.0	305.3	372.5
24-Jan-91	77	375.0	334.7	354.9	4157.9	7.358	4.869	6.114	131.5	325.0	228.3	375.5
31-Jan-91	84	345.9	381.2	363.6	4521.4	7.337	4.054	5.696	197.3	435.0	316.2	441.3
07-Feb-91	91	357.4	354.0	355.7	4877.1	7.349	3.634	5.492	165.7	458.0	311.9	409.7
14-Feb-91	98	362.1	360.3	361.2	5238.3	7.273	3.321	5.297	187.7	405.0	296.4	431.7
21-Feb-91	105	388.2	364.9	376.6	5614.9	7.247	3.095	5.171	176.5	403.0	289.8	420.5
28-Feb-91	112	378.9	359.0	369.0	5983.8	7.070	2.936	5.003	233.0	435.0	334.0	477.0
07-Mar-91	119	360.2	345.5	352.9	6336.7	4.452	2.769	3.611	356.0	541.0	448.5	600.0
14-Mar-91	126	357.0	365.2	361.1	6697.8	3.680	2.687	3.184	430.0	574.0	502.0	674.0
21-Mar-91	133	331.8	336.0	333.9	7031.7	3.492	2.698	3.095	412.0	581.0	496.5	656.0
04-Apr-91	147	361.1	340.0	350.6	7382.2	3.166	2.594	2.880	525.0	595.0	560.0	769.0
11-Apr-91	154	201.1	198.3	199.7	7581.9	3.099	2.629	2.864	429.0	589.0	509.0	673.0
18-Apr-91	161	354.8	358.3	356.6	7938.5	3.086	2.671	2.879	441.0	602.0	521.5	685.0
25-Apr-91	168	347.6	356.8	352.2	8290.7	2.977	2.630	2.804	446.0	610.0	528.0	690.0
02-May-91	175	364.1	349.6	356.9	8647.5	2.873	2.596	2.735	477.0	607.0	542.0	721.0
09-May-91	182	380.9	358.9	369.9	9017.4	2.825	2.626	2.726	582.0	609.0	595.5	826.0
16-May-91	189	357.0	354.5	355.8	9373.2	2.805	2.587	2.696	589.0	611.0	600.0	833.0
23-May-91	196	397.3	394.3	395.8	9769.0	2.773	2.562	2.668	602.0	618.0	610.0	846.0
30-May-91	203	376.9	384.0	380.5	10149.4	2.770	2.529	2.650	593.0	612.0	602.5	837.0
06-Jun-91	210	403.1	388.0	395.6	10545.0	2.722	2.584	2.653	585.0	603.0	594.0	829.0
13-Jun-91	217	382.8	421.3	402.1	10947.0	2.759	2.579	2.669	583.0	603.0	593.0	827.0
20-Jun-91	224	199.3	196.8	198.1	11145.1	2.472	2.393	2.433	591.0	610.0	600.5	835.0
27-Jun-91	231	431.6	396.8	414.2	11559.3	2.766	2.447	2.607	603.0	623.0	613.0	847.0
04-Jul-91	238	389.9	403.4	396.7	11955.9	2.740	2.447	2.594	478.0	616.0	547.0	722.0

Cont.

Table 4 - cont.

DATE SAMPLED	COLUMN S#2 EH (NHE) (mV)	COLUMN AVERAGE EH (NHE) (mV)	COLUMN S#1 EC (US)	COLUMN S#2 EC (US)	COLUMN AVERAGE EC (US)	COLUMN S#1 TEMP (DEG.C)	COLUMN S#2 TEMP (DEG.C)	COLUMN AVERAGE TEMP (DEG.C)	COLUMN S#1 ACIDITY (mg/L)	COLUMN S#2 ACIDITY (mg/L)	COLUMN AVERAGE ACIDITY (mg/L)	COLUMN S#1 ALKALINITY (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	483.0	471.5	3450	3280	3365	25.0	25.0	25.0	82.34	89.82	86.08	15.23
22-Nov-90	380.7	369.1	4650	4330	4490	23.0	23.0	23.0	118.24	113.19	115.72	21.32
29-Nov-90	703.0	535.4	5200	5130	5165	22.0	22.0	22.0	203.09	174.85	188.97	30.45
06-Dec-90	706.0	661.0	5320	5390	5355	22.5	22.5	22.5	300.51	225.38	262.95	0.00
13-Dec-90	410.3	398.0	4700	5260	4980	22.0	22.5	22.3	134.82	109.24	122.03	45.68
20-Dec-90	376.5	365.0	4270	4750	4510	20.5	20.0	20.3	107.52	122.10	114.81	44.66
27-Dec-90	408.3	399.2	4150	4500	4325	24.0	24.0	24.0	90.67	111.65	101.16	49.74
03-Jan-91	390.3	376.0	3780	3840	3810	21.0	21.0	21.0	108.91	146.00	127.46	27.41
10-Jan-91	634.0	506.5	3370	3320	3345	20.5	20.0	20.3	95.81	166.95	131.38	25.37
17-Jan-91	726.0	549.3	3300	3470	3385	22.5	23.0	22.8	110.19	247.33	178.76	21.32
24-Jan-91	569.0	472.3	2430	2460	2445	19.0	19.0	19.0	81.72	176.90	129.31	26.39
31-Jan-91	679.0	560.2	2420	2560	2490	22.0	22.0	22.0	120.50	269.98	195.24	26.39
07-Feb-91	702.0	555.9	2270	2540	2405	22.0	22.0	22.0	125.83	250.43	188.13	43.65
14-Feb-91	649.0	540.4	2250	2630	2440	21.5	21.5	21.5	112.07	153.58	132.83	24.36
21-Feb-91	647.0	533.8	2700	3370	3035	22.0	22.0	22.0	130.26	288.97	209.62	21.32
28-Feb-91	679.0	578.0	2670	3500	3085	21.5	21.5	21.5	171.71	487.52	329.62	14.21
07-Mar-91	785.0	692.5	2700	3680	3190	20.5	20.5	20.5	217.21	669.39	443.30	0.00
14-Mar-91	818.0	746.0	2780	3510	3145	20.5	20.5	20.5	282.94	833.66	558.30	0.00
21-Mar-91	825.0	740.5	2880	3800	3340	21.5	22.0	21.8	343.57	954.92	649.25	0.00
04-Apr-91	839.0	804.0	3290	4340	3815	21.0	21.0	21.0	389.05	1079.30	734.18	0.00
11-Apr-91	833.0	753.0	3270	4140	3705	20.0	20.0	20.0	439.25	1129.50	784.38	0.00
18-Apr-91	846.0	765.5	3010	3770	3390	21.0	21.0	21.0	446.16	1147.98	797.07	0.00
25-Apr-91	854.0	772.0	2850	3500	3175	21.5	21.5	21.5	478.74	1245.73	862.24	0.00
02-May-91	851.0	786.0	3460	4210	3835	21.5	21.5	21.5	486.26	1215.65	850.96	0.00
09-May-91	853.0	839.5	3620	4200	3910	22.0	22.0	22.0	566.47	1198.11	882.29	0.00
16-May-91	855.0	844.0	3770	4360	4065	24.0	24.0	24.0	578.32	1143.96	861.14	0.00
23-May-91	862.0	854.0	3390	3870	3630	24.0	24.0	24.0	512.37	999.38	755.88	0.00
30-May-91	856.0	846.5	3120	3570	3345	22.5	22.5	22.5	591.00	859.87	725.44	0.00
06-Jun-91	847.0	838.0	3320	3510	3415	21.5	21.5	21.5	537.74	771.10	654.42	0.00
13-Jun-91	847.0	837.0	3310	3600	3455	22.0	22.0	22.0	519.98	743.19	631.59	0.00
20-Jun-91	854.0	844.5	3890	3780	3835	22.5	22.5	22.5	446.42	662.03	554.23	0.00
27-Jun-91	867.0	857.0	3190	4040	3615	24.5	25.0	24.8	446.42	862.41	654.42	0.00
04-Jul-91	860.0	791.0	3560	4330	3945	23.5	23.5	23.5	471.79	877.63	674.71	0.00

Cont.

Table 4 - cont.

DATE SAMPLED	COLUMN S#2 ALKALINITY (mg/L)	COLUMN AVERAGE ALKALINITY (mg/L)	COLUMN S#1 Cu (mg/L)	COLUMN S#2 Cu (mg/L)	COLUMN AVERAGE Cu (mg/L)	COLUMN S#1 Fe TOTAL (mg/L)	COLUMN S#2 Fe TOTAL (mg/L)	COLUMN AVERAGE Fe TOTAL (mg/L)	COLUMN S#1 Ni (mg/L)	COLUMN S#2 Ni (mg/L)	COLUMN AVERAGE Ni (mg/L)	COLUMN S#1 Pb (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	5.08	10.16	0.000	0.016	0.008	0.000	0.077	0.039	0.563	0.806	0.685	0.000
22-Nov-90	7.11	14.22	0.018	0.004	0.011	0.062	0.000	0.031	0.923	0.586	0.755	0.150
29-Nov-90	0.00	15.23	0.014	0.000	0.007	0.085	1.529	0.807	0.927	0.550	0.739	0.168
06-Dec-90	0.00	0.00	0.029	0.030	0.030	8.000	0.989	4.495	0.821	0.846	0.834	0.193
13-Dec-90	22.33	34.01	0.013	0.009	0.011	0.064	0.040	0.052	0.748	0.716	0.732	0.148
20-Dec-90	34.51	39.59	0.016	0.012	0.014	0.075	0.155	0.115	0.769	0.836	0.803	0.135
27-Dec-90	29.44	39.59	0.027	0.015	0.021	0.093	0.079	0.086	0.684	1.040	0.862	0.195
03-Jan-91	23.35	25.38	0.027	0.015	0.021	0.070	0.101	0.086	0.733	1.000	0.867	0.177
10-Jan-91	0.00	12.69	0.037	0.000	0.018	0.000	0.000	0.000	0.493	0.700	0.596	0.010
17-Jan-91	0.00	10.66	0.019	0.046	0.032	0.000	0.000	0.000	0.462	0.814	0.638	0.000
24-Jan-91	1.02	13.71	0.092	0.030	0.061	0.168	0.152	0.160	0.647	1.270	0.959	0.165
31-Jan-91	0.00	13.20	0.051	0.095	0.073	0.052	0.199	0.126	0.668	1.770	1.219	0.162
07-Feb-91	0.00	21.83	0.079	0.134	0.107	0.516	1.880	1.198	0.752	2.400	1.576	0.163
14-Feb-91	0.00	12.18	0.039	0.225	0.132	0.079	22.900	11.490	0.827	3.110	1.969	0.177
21-Feb-91	0.00	10.66	0.013	0.132	0.072	0.000	33.770	16.885	0.707	2.976	1.841	0.000
28-Feb-91	0.00	7.11	0.013	0.223	0.118	0.000	55.350	27.675	0.881	3.788	2.334	0.000
07-Mar-91	0.00	0.00	0.025	0.212	0.119	0.000	80.690	40.345	1.164	3.697	2.431	0.016
14-Mar-91	0.00	0.00	0.014	0.234	0.124	0.000	149.400	74.700	1.424	4.267	2.846	0.000
21-Mar-91	0.00	0.00	0.060	0.287	0.174	3.290	219.900	111.595	1.839	3.925	2.882	0.021
04-Apr-91	0.00	0.00	0.100	0.346	0.223	4.690	231.800	118.245	2.271	4.379	3.325	0.069
11-Apr-91	0.00	0.00	0.074	0.459	0.267	17.400	237.200	127.300	2.520	4.274	3.397	0.000
18-Apr-91	0.00	0.00	0.062	0.437	0.249	22.970	247.000	134.985	2.604	4.190	3.397	0.154
25-Apr-91	0.00	0.00	0.000	0.654	0.327	39.180	306.100	172.640	2.714	3.895	3.305	0.152
02-May-91	0.00	0.00	0.062	0.564	0.313	46.920	224.400	135.660	2.573	3.422	2.998	0.315
09-May-91	0.00	0.00	0.050	0.439	0.028	65.970	288.900	177.435	2.757	2.899	2.828	0.318
16-May-91	0.00	0.00	0.047	0.482	0.264	70.470	239.200	154.835	2.531	2.914	2.723	0.338
23-May-91	0.00	0.00	0.044	0.328	0.186	76.530	219.600	148.065	2.319	2.752	2.536	0.336
30-May-91	0.00	0.00	0.030	0.230	0.130	94.600	173.800	134.200	2.253	2.046	2.150	0.355
06-Jun-91	0.00	0.00	0.020	0.182	0.101	84.500	175.100	129.800	1.929	1.547	1.738	0.321
13-Jun-91	0.00	0.00	0.057	0.273	0.165	90.860	149.300	120.080	1.862	1.639	1.751	0.328
20-Jun-91	0.00	0.00	0.382	0.763	0.572	38.590	61.750	50.170	2.141	1.362	1.752	0.484
27-Jun-91	0.00	0.00	0.514	0.803	0.659	50.190	119.100	84.645	2.302	1.646	1.974	0.637
04-Jul-91	0.00	0.00	0.301	0.653	0.477	64.110			2.086	1.603	1.845	0.776

Cont.

Table 4 - cont.

DATE SAMPLED	COLUMN S#2 Pb (mg/L)	COLUMN AVERAGE Pb (mg/L)	COLUMN S#1 Zn (mg/L)	COLUMN S#2 Zn (mg/L)	COLUMN AVERAGE Zn (mg/L)	COLUMN S#1 SULPHATE (mg/L)	COLUMN S#2 SULPHATE (mg/L)	COLUMN AVERAGE SULPHATE (mg/L)	COLUMN S#1 As (mg/L)	COLUMN S#2 As (mg/L)	COLUMN AVERAGE As (mg/L)	COLUMN S#1 Hg (mg/L)
CULLATON LAKE												
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	0.140	0.070	0.167	0.487	0.327	2062.28	1946.83	2004.56	0.000	<0.08	0.000	0.000
22-Nov-90	0.000	0.075	0.133	0.288	0.211	2943.06	2684.81	2813.94	<0.08	0.000	0.000	<0.02
29-Nov-90	0.000	0.084	0.087	0.136	0.112	3421.10	3173.16	3297.13	<0.08	0.000	0.000	<0.02
06-Dec-90	0.204	0.199	0.073	0.157	0.115	3302.49	3446.49	3374.49	<0.08	<0.08	0.000	<0.02
13-Dec-90	0.152	0.150	0.050	0.088	0.069	2978.81	3298.99	3138.90	<0.08	<0.08	0.000	<0.02
20-Dec-90	0.143	0.139	0.054	0.062	0.058	2870.18	3257.95	3064.07	<0.08	<0.08	0.000	<0.02
27-Dec-90	0.171	0.183	0.056	0.119	0.088	2424.01	3022.40	2723.21	<0.08	<0.08	0.000	<0.02
03-Jan-91	0.182	0.180	0.070	0.101	0.086	2322.60	2603.55	2463.08	<0.08	<0.08	0.000	<0.02
10-Jan-91	0.000	0.005	0.035	0.061	0.048	2457.33	2442.03	2449.68	0.000	0.000	0.000	0.000
17-Jan-91	0.008	0.004	0.030	0.073	0.052	2161.82	2163.55	2162.69	0.000	0.000	0.000	0.000
24-Jan-91	0.232	0.199	0.064	0.132	0.098	2064.50	2103.18	2083.84	<0.08	<0.08	0.000	<0.02
31-Jan-91	0.211	0.187	0.066	0.169	0.118	1730.21	2039.41	1884.81	<0.08	<0.08	0.000	<0.02
07-Feb-91	0.318	0.241	0.080	0.236	0.158	1746.23	2120.21	1933.22	<0.08	<0.08	0.000	0.079
14-Feb-91	0.481	0.329	0.073	0.349	0.211	1798.25	2099.57	1948.91	<0.08	<0.08	0.000	0.097
21-Feb-91	0.083	0.042	0.043	0.360	0.201	1631.60	2169.97	1900.79	0.000	0.000	0.000	0.000
28-Feb-91	0.174	0.087	0.052	0.570	0.311	1764.48	2238.96	2001.72	0.000	0.000	0.000	0.000
07-Mar-91	0.304	0.160	0.109	0.674	0.391	1870.85	2322.27	2096.56	0.000	0.000	0.000	0.000
14-Mar-91	0.285	0.142	0.121	0.800	0.460	1854.59	2522.86	2188.73	0.000	0.000	0.000	0.000
21-Mar-91	0.424	0.222	0.144	0.780	0.462	1838.12	2616.38	2227.25	0.000	0.000	0.000	0.000
04-Apr-91	0.413	0.241	0.148	0.835	0.491	1939.76	2633.19	2286.48	0.000	0.000	0.000	0.000
11-Apr-91	0.361	0.181	0.187	0.903	0.545	1957.61	2647.7	2302.66	0.000	0.000	0.000	0.000
18-Apr-91	0.411	0.282	0.203	0.881	0.542	1795.72	2635.11	2215.42	0.000	0.000	0.000	0.000
25-Apr-91	0.377	0.264	0.229	0.934	0.581	2022.90	2863.57	2443.24	0.000	0.000	0.000	0.000
02-May-91	0.465	0.390	0.284	0.840	0.562	1965.43	2734.21	2349.82	0.000	0.000	0.000	0.000
09-May-91	0.406	0.362	0.327	0.734	0.530	2041.42	2499.76	2270.59	0.000	0.000	0.000	0.000
16-May-91	0.376	0.357	0.324	0.674	0.499	1810.48	2283.88	2047.18	0.000	0.000	0.000	0.000
23-May-91	0.388	0.362	0.311	0.636	0.474	1698.69	2009.32	1854.01	0.000	0.000	0.000	0.000
30-May-91	0.404	0.380	0.339	0.500	0.419	1844.89	1763.72	1804.31	0.000	0.000	0.000	0.000
06-Jun-91	0.422	0.371	0.318	0.400	0.359	1623.04	1703.57	1663.31	0.000	0.000	0.000	0.000
13-Jun-91	0.586	0.457	0.320	0.447	0.383	1560.65	791.18	1175.92	0.000	0.000	0.000	0.000
20-Jun-91	1.343	0.914	0.412	0.463	0.438	1444.31	1319.79	1382.05	0.000	0.000	0.000	0.000
27-Jun-91	1.269	0.953	0.537	0.543	0.540	1399.99	1628.25	1514.12	0.000	0.000	0.000	0.000
04-Jul-91	1.052	0.914	0.488	0.526	0.507	1343.60	1562.30	1452.95	0.000	0.000	0.000	0.000

Cont.

Table 4 - cont.

DATE SAMPLED	COLUMN S#2 Hg (mg/L)	COLUMN AVERAGE Hg (mg/L)	COLUMN S#1 Sb (mg/L)	COLUMN S#2 Sb (mg/L)	COLUMN AVERAGE Sb (mg/L)	COLUMN S#1 CN (mg/L)	COLUMN S#2 CN (mg/L)	COLUMN AVERAGE CN (mg/L)
CULLATON LAKE								
08-Nov-90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-Nov-90	<0.02	0.000	0.000	<0.05	0.000	0.000	0.000	0.000
22-Nov-90	0.000	0.000	0.051	0.000	0.026	0.000	0.000	0.000
29-Nov-90	0.000	0.000	0.051	0.000	0.026	0.086	0.020	0.053
06-Dec-90	<0.02	0.000	<0.05	<0.05	0.000	0.053	0.010	0.032
13-Dec-90	<0.02	0.000	<0.05	<0.05	0.000	0.050	0.010	0.030
20-Dec-90	<0.02	0.000	<0.05	<0.05	0.000	0.010	0.010	0.010
27-Dec-90	<0.02	0.000	<0.05	<0.05	0.000	0.010	0.010	0.010
03-Jan-91	<0.02	0.000	<0.05	<0.05	0.000	0.010	0.010	0.010
10-Jan-91	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.005
17-Jan-91	0.000	0.000	0.000	0.000	0.000	0.011	0.010	0.011
24-Jan-91	<0.02	0.000	<0.05	<0.05	0.000	0.018	0.007	0.013
31-Jan-91	0.045	0.023	<0.05	<0.05	0.000	0.008	0.005	0.007
07-Feb-91	0.096	0.088	<0.05	<0.05	0.000	0.006	0.004	0.005
14-Feb-91	0.195	0.146	<0.05	<0.05	0.000	0.006	0.004	0.005
21-Feb-91	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.005
28-Feb-91	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.005
07-Mar-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
14-Mar-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
21-Mar-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
04-Apr-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
11-Apr-91	0.000	0.020	0.000	0.000	0.000	0.004	0.004	0.004
18-Apr-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
25-Apr-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
02-May-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
09-May-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
16-May-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
23-May-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
30-May-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
06-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
13-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
20-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
27-Jun-91	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004
04-Jul-91	0.000	0.000	0.000	0.000	0.000			ERR

Table 5 - Total loadings and mass balance of various parameters for B and S Zone tailings.

Parameter	B Zone Total Loading (mg)	B Zone % Removal of Total	S Zone Total Loading (mg)	S Zone % Removal of Total
S	10,456.8	7.8	8,970.8	20.2
Fe	12,810.9	0.6	710.4	0.3
Cu	0.22	0.03	1.85	1.1
Ni	0.18	0.02	21.70	3.1
Zn	0.57	0.06	3.72	0.5
Pb	1.29	0.02	3.25	0.9
Acidity $CaCO_3$ equivalent	25,990.8	--	5,511.0	--
Alkalinity $CaCO_3$ equivalent	80.7	--	104.6	--

Table 6 - Sulphate production and loadings for the B Zone.

DATE SAMPLED	TIME (d) FROM START	COLUMN B#1 VOLUME (mL)	COLUMN B#2 VOLUME (mL)	COLUMN B#1 SULPHATE (mg/L)	COLUMN B#2 SULPHATE (mg/L)	COLUMN B#1 SULPHATE LOADING (g/week)	COLUMN B#2 SULPHATE LOADING (g/week)	COLUMN AVERAGE SULPHATE LOADING (g/week)	PRODCTN RATE SULPHATE (g/Kg/week)	CUMMLTV LOADING SULPHATE LOADING (g)	CUMMLTV LOADING SULPHUR CONSUMED (g)	CUMMLTV LOADING SULPHUR CONSUMED (%)
COULTON LAKE LEACHING TEST: B-ZONE #1 AND #2												
08-Nov-90	0			0 00	0 00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
15 Nov-90	7	428 0	391 8	5836 60	5631 69	2.50	2.21	2.35	0.21	2.35	0.78	0 30
22 Nov 90	14	419 7	376 4	7597 07	7818 85	3.19	2.94	3.07	0.27	5.42	1 81	0 69
29-Nov-90	21	352 8	321 7	11040 62	9447 14	3.90	3.04	3.47	0.31	8 89	2 96	1 13
06-Dec-90	28	339 0	368.1	24608.14	11706.84	8.34	4.31	6.33	0.56	15.21	5.07	1.93
13-Dec-90	35	407 8	402.0	14989.35	14349.22	6.11	5.77	5.94	0.53	21.15	7.05	2.69
20-Dec-90	42	387.6	390 8	15477.82	15088.86	6.00	5.90	5.95	0.53	27.10	9.03	3.44
27-Dec-90	49	332.1	354.7	10295.96	11547 55	3.42	4.10	3.76	0.34	30.86	10.29	3.92
03-Jan-91	56	345.3	440.8	11168.01	11005.63	3.86	4.85	4.35	0.39	35.21	11.74	4.47
10-Jan-91	63	361.0	343.1	8635.49	8671.16	3.12	2.98	3.05	0.27	38.26	12.75	4 86
17-Jan-91	70	358.3	355.0	6642.79	6543.58	2.38	2.32	2.35	0.21	40.61	13.54	5.16
24-Jan-91	77	341 4	360.6	5105.38	5433.02	1.74	1.96	1.85	0.17	42.46	14.15	5 39
31-Jan-91	84	373.6	337.8	4451.55	4607.31	1.66	1.56	1.61	0.14	44.07	14.69	5 59
07-Feb-91	91	366.7	374.0	3684.79	3986.71	1.35	1.49	1.42	0.13	45.49	15.16	5 77
14 Feb 91	98	362.1	364 1	3503.37	3371.41	1 27	1.23	1.25	0.11	46.74	15 58	5 93
21-Feb-91	105	366.4	348.5	3123.84	3192 51	1.14	1.11	1.13	0.10	47.87	15.96	6 08
28 Feb 91	112	335.7	363 3	2962 71	2905 38	0 99	1.06	1.03	0.09	48 89	16.30	6 21
07-Mar-91	119	362 8	357 5	2728 02	2717 16	0.99	0.97	0.98	0.09	49.87	16.62	6 33
14-Mar-91	126	347.1	355.2	2507.35	2548.28	0 87	0.91	0.89	0.08	50.76	16.92	6.44
21-Mar-91	133	353.8	332.7	2350.89	2322.40	0.83	0.77	0.80	0.07	51.56	17.19	6.55
04-Apr-91	147	342.7	217.9	2202.52	2147.07	0.75	0.47	0.61	0.05	52.17	17.39	6 62
11-Apr-91	154	220.7	308.7	2029.01	2092.84	0.45	0.65	0.55	0.05	52.72	17.57	6.69
18-Apr-91	161	365.7	343.8	2116.50	2171.58	0.77	0.75	0.76	0.07	53.48	17.83	6.79
25-Apr-91	168	360.1	351.2	2197.93	2143.64	0.79	0.75	0.77	0.07	54.25	18.08	6.89
02-May-91	175	360.0	357 6	1951.07	2024.49	0.70	0.72	0.71	0.06	54.97	18.32	6.98
09-May-91	182	376.6	354.7	1867.49	1974.11	0.70	0.70	0.70	0.06	55.67	18.56	7.07
16-May-91	189	372.3	357.5	1706.53	1683 06	0.64	0.60	0.62	0.06	56.29	18.76	7.15
23-May-91	196	386.2	391.6	1654.89	1667 03	0.64	0.65	0.65	0.06	56.93	18.98	7.23
30-May-91	203	407.2	391.1	1758.97	1751.51	0.72	0.69	0.70	0.06	57.63	19.21	7.32
06-Jun-91	210	355.5	297.2	1600.02	1586 30	0.57	0.47	0.52	0.05	58.15	19.38	7.38
13-Jun-91	217	398.5	267.0	1693.81	1606.35	0.67	0.43	0.55	0.05	58.71	19.57	7.45
20-Jun-91	224	387.5	310 0	1752.11	1612.55	0.68	0.50	0.59	0.05	59.29	19.76	7.53
27-Jun-91	231	430.8	420.7	1676.46	1582 48	0.72	0.67	0.69	0.06	59.99	20.00	7 62
04-Jul-91	238	458.5	416 8	1609 06	1683 45	0.74	0.70	0.72	0.06	60.71	20.24	7.71

Table 7 - Sulphate production and loadings for the S Zone.

DATE SAMPLED	TIME (d) FROM START	COLUMN S#1 VOLUME (mL)	COLUMN S#2 VOLUME (mL)	COLUMN S#1 SULPHATE (mg/L)	COLUMN S#2 SULPHATE (mg/L)	COLUMN S#1 SULPHATE LOADING (g/week)	COLUMN S#2 SULPHATE LOADING (g/week)	COLUMN AVERAGE SULPHATE LOADING (g/week)	PRODCTN RATE SULPHATE (g/Kg/week)	CUMMLTV LOADING SULPHATE LOADING (g)	CUMMLTV LOADING SULPHUR LOADING (g)	CUMMLTV LOADING SULPHUR LOADING (%)
COULTON LAKE LEACHING TEST: S-ZONE #1 AND #2												
08-Nov-90	0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Nov-90	7	427.6	428.4	2062.28	1946.83	0.88	0.83	0.86	0.10	0.86	0.29	0.65
22-Nov-90	14	464.1	391.6	2943.06	2684.81	1.37	1.05	1.21	0.14	2.07	0.69	1.56
29-Nov-90	21	382.8	364.4	3421.10	3173.16	1.31	1.16	1.23	0.14	3.30	1.10	2.49
06-Dec-90	28	355.8	391.3	3302.49	3446.49	1.18	1.35	1.26	0.15	4.56	1.52	3.44
13-Dec-90	35	379.8	439.0	2978.81	3298.99	1.13	1.45	1.29	0.15	5.85	1.95	4.41
20-Dec-90	42	356.9	368.4	2870.18	3257.95	1.02	1.20	1.11	0.13	6.96	2.32	5.25
27-Dec-90	49	340.3	377.9	2424.01	3022.40	0.82	1.14	0.98	0.11	7.95	2.65	6.00
03-Jan-91	56	373.7	348.8	2322.60	2603.55	0.87	0.91	0.89	0.10	8.83	2.94	6.67
10-Jan-91	63	331.6	334.4	2457.33	2442.03	0.81	0.82	0.82	0.09	9.65	3.22	7.28
17-Jan-91	70	373.7	375.5	2161.82	2163.55	0.81	0.81	0.81	0.09	10.46	3.49	7.89
24-Jan-91	77	375.0	334.7	2064.50	2103.18	0.77	0.70	0.74	0.09	11.20	3.73	8.45
31-Jan-91	84	345.9	381.2	1730.21	2039.41	0.60	0.78	0.69	0.08	11.89	3.96	8.97
07-Feb-91	91	357.4	354.0	1746.23	2120.21	0.62	0.75	0.69	0.08	12.58	4.19	9.49
14-Feb-91	98	362.1	360.3	1798.25	2099.57	0.65	0.76	0.70	0.08	13.28	4.43	10.02
21-Feb-91	105	388.2	364.9	1631.60	2169.97	0.63	0.79	0.71	0.08	13.99	4.66	10.56
28-Feb-91	112	378.9	359.0	1764.48	2238.96	0.67	0.80	0.74	0.09	14.73	4.91	11.11
07-Mar-91	119	360.2	345.5	1870.85	2322.27	0.67	0.80	0.74	0.09	15.47	5.16	11.67
14-Mar-91	126	357.0	365.2	1854.59	2522.86	0.66	0.92	0.79	0.09	16.26	5.42	12.27
21-Mar-91	133	331.8	336.0	1838.12	2616.38	0.61	0.88	0.74	0.09	17.00	5.67	12.83
04-Apr-91	147	361.1	340.0	1939.76	2633.19	0.70	0.90	0.80	0.09	17.80	5.93	13.43
11-Apr-91	154	201.1	198.3	1957.61	2647.70	0.39	0.53	0.46	0.05	18.26	6.09	13.78
18-Apr-91	161	354.8	358.3	1795.72	2635.11	0.64	0.94	0.79	0.09	19.05	6.35	14.37
25-Apr-91	168	347.6	356.8	2022.90	2863.57	0.70	1.02	0.86	0.10	19.91	6.64	15.02
02-May-91	175	364.1	349.6	1965.43	2734.21	0.72	0.96	0.84	0.10	20.75	6.92	15.65
09-May-91	182	380.9	358.9	2041.42	2499.76	0.78	0.90	0.84	0.10	21.59	7.20	16.29
16-May-91	189	357.0	354.5	1810.48	2283.88	0.65	0.81	0.73	0.08	22.31	7.44	16.84
23-May-91	196	397.3	394.3	1698.69	2009.32	0.67	0.79	0.73	0.08	23.05	7.68	17.39
30-May-91	203	376.9	384.0	1844.89	1763.72	0.70	0.68	0.69	0.08	23.73	7.91	17.91
06-Jun-91	210	403.1	388.0	1623.04	1703.57	0.65	0.66	0.66	0.08	24.39	8.13	18.40
13-Jun-91	217	382.8	421.3	1560.65	791.18	0.60	0.33	0.47	0.05	24.86	8.29	18.75
20-Jun-91	224	199.3	196.8	1444.31	1319.79	0.29	0.26	0.27	0.03	25.13	8.38	18.96
27-Jun-91	231	431.6	396.8	1399.99	1628.25	0.60	0.65	0.63	0.07	25.76	8.59	19.43
04-Jul-91	238	389.9	403.4	1343.60	1562.30	0.52	0.63	0.58	0.07	26.33	8.78	19.87

Table 7 - Moisture distribution and paste pH for B Zone columns as a function of column depth at the termination of the experiment.

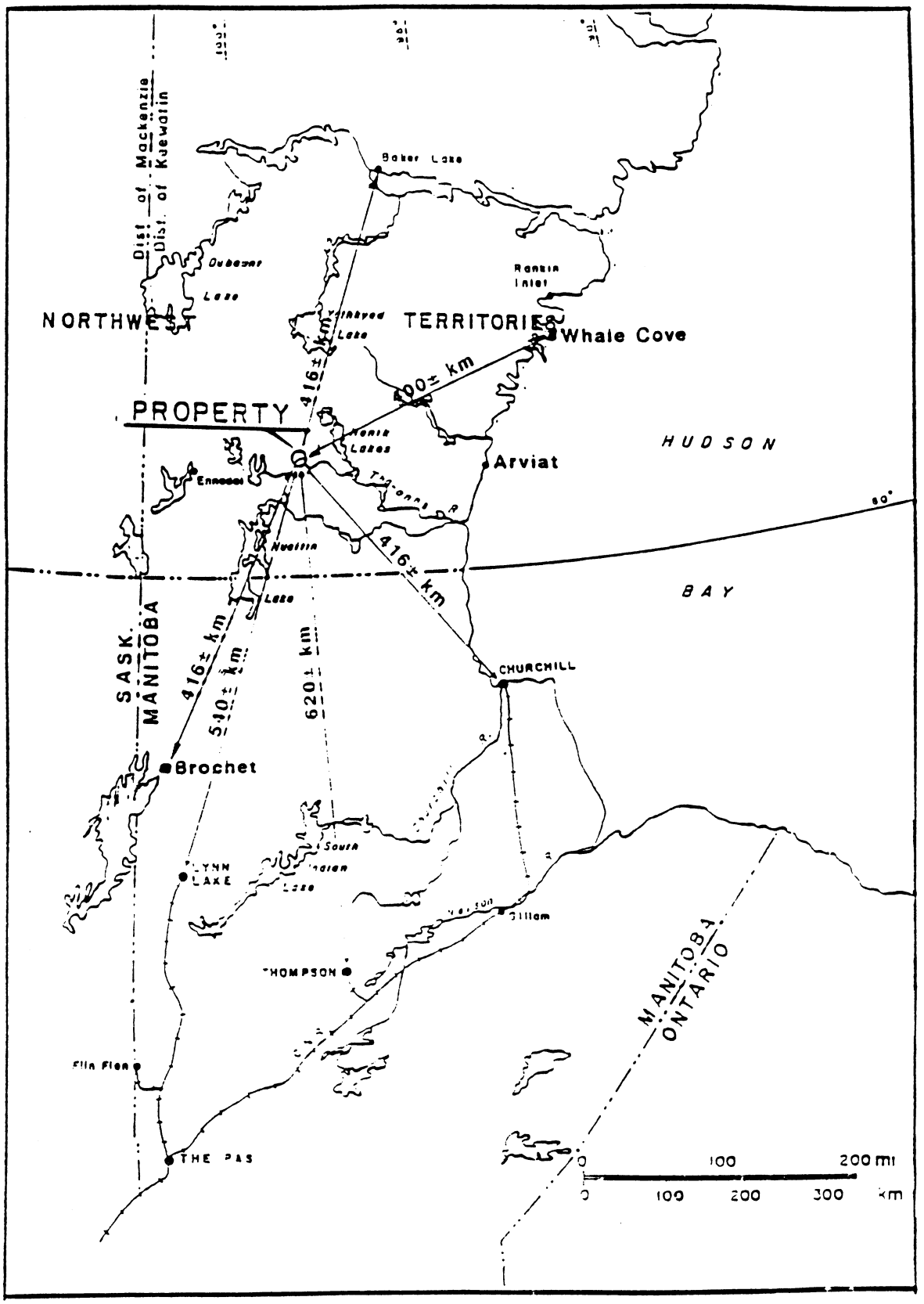
Sample No.		Depth (cm)	Wet Weight (g)	Dry Weight (g)	Weight Moisture wt (%)	Pore Vol. Moisture Saturation (%)	Paste pH
B Zone-1	1	1.25	35.37	29.06	17.84	105.4	6.420
	2	3.75	34.88	29.20	16.28	93.3	6.346
	3	6.25	35.65	30.04	15.74	90.6	6.338
	4	8.75	34.94	29.66	15.11	86.4	6.481
	5	11.25	33.28	28.21	15.23	87.2	6.162
	6	13.75	32.82	27.70	15.60	89.7	6.133
	7	16.25	33.25	27.94	15.97	92.2	6.353
	8	18.75	37.78	31.78	15.88	91.6	6.145
	9	21.25	43.24	36.34	15.96	92.1	6.423
	10	23.75	41.76	35.26	15.57	89.5	6.377
	11	26.25	34.98	29.31	16.21	94.9	6.804
	12	28.75	--	--	--	--	--
B Zone-2	1	1.25	39.02	32.40	16.97	99.2	6.878
	2	3.75	36.69	31.04	15.40	88.3	6.848
	3	6.25	38.07	32.38	14.95	85.3	6.806
	4	8.75	39.58	33.63	15.03	85.8	6.985
	5	11.25	41.35	34.98	15.41	88.4	6.902
	6	13.75	40.86	34.53	15.49	88.9	7.174
	7	16.25	44.16	37.22	15.72	90.5	7.296
	8	18.75	39.76	33.52	15.69	90.3	7.186
	9	21.25	40.34	34.01	15.69	90.3	7.093
	10	23.75	42.49	35.98	15.32	87.8	7.268
	11	26.25	36.06	30.68	14.92	85.1	7.335
	12	28.75	37.68	32.18	14.60	82.9	7.078

Table 9 - Moisture distribution of paste pH for S Zone columns as a function of column depth at the termination of the experiment.

Sample No.		Depth (cm)	Wet Weight (g)	Dry Weight (g)	Weight Moisture wt (%)	Pore Vol. Moisture Saturation (%)	Paste pH
S Zone-1	1	1.25	17.24	13.75	20.24	124.7	3.799
	2	3.75	19.21	15.76	17.96	107.5	4.216
	3	6.25	15.66	12.77	18.45	111.1	3.325
	4	8.75	19.65	16.01	18.52	111.7	3.319
	5	11.25	13.50	10.93	19.04	115.5	3.635
	6	13.75	14.45	11.70	19.03	115.5	3.954
	7	16.25	13.96	11.43	18.12	108.7	4.087
	8	18.75	16.69	13.71	17.86	106.8	4.155
	9	21.25	14.84	12.29	17.18	101.9	4.572
	10	23.75	24.62	20.63	16.21	95.1	4.481
	11	26.25	20.83	17.48	16.08	94.1	4.657
	12	28.75	13.95	11.69	16.20	95.0	4.818
S Zone-2	1	1.25	15.08	12.12	19.63	120.0	2.642
	2	3.75	13.30	10.84	18.50	111.5	2.668
	3	6.25	11.25	9.24	17.87	106.9	2.978
	4	8.75	12.46	10.11	18.86	114.2	3.042
	5	11.25	17.84	14.72	17.49	104.1	2.987
	6	13.75	19.31	15.75	18.44	111.1	2.983
	7	15.25	15.68	12.84	18.11	108.6	3.148
	8	18.75	16.98	13.84	18.49	111.4	3.092
	9	21.25	24.19	19.85	17.94	107.4	3.047
	10	23.75	24.35	20.16	17.21	102.1	3.171
	11	26.25	9.26	7.70	16.85	99.6	3.650
	12	28.75	9.17	7.69	16.14	94.6	3.722

Table 10 - Results for Cullaton waste rock/acid base accounting

Sample No.	Percent S	Total Acid Production kg $CaCO_3$/tonne	Total Alkalinity kg $CaCO_3$/tonne	Net Neutralization Potential (NP) kg $CaCO_3$/tonne
1 S Zone	0.11	3.44	7.12	+3.68
2 S Zone	0.11	3.44	3.42	-0.02
3 B Zone	0.04	1.25	70.59	+69.34
4 B Zone	0.01	0.31	127.38	127.07
5 B Zone	1.08	33.75	123.74	89.99
6 Rejects	0.12	3.75	0.98	-2.77
Average	0.25	7.66	55.54	47.88



CULLATON LAKE, DISTRICT OF KEEWATIN, N.W.T. - KEY PLAN

Fig. 1 - Location of Cullaton Lake Mines, Northwest Territories.

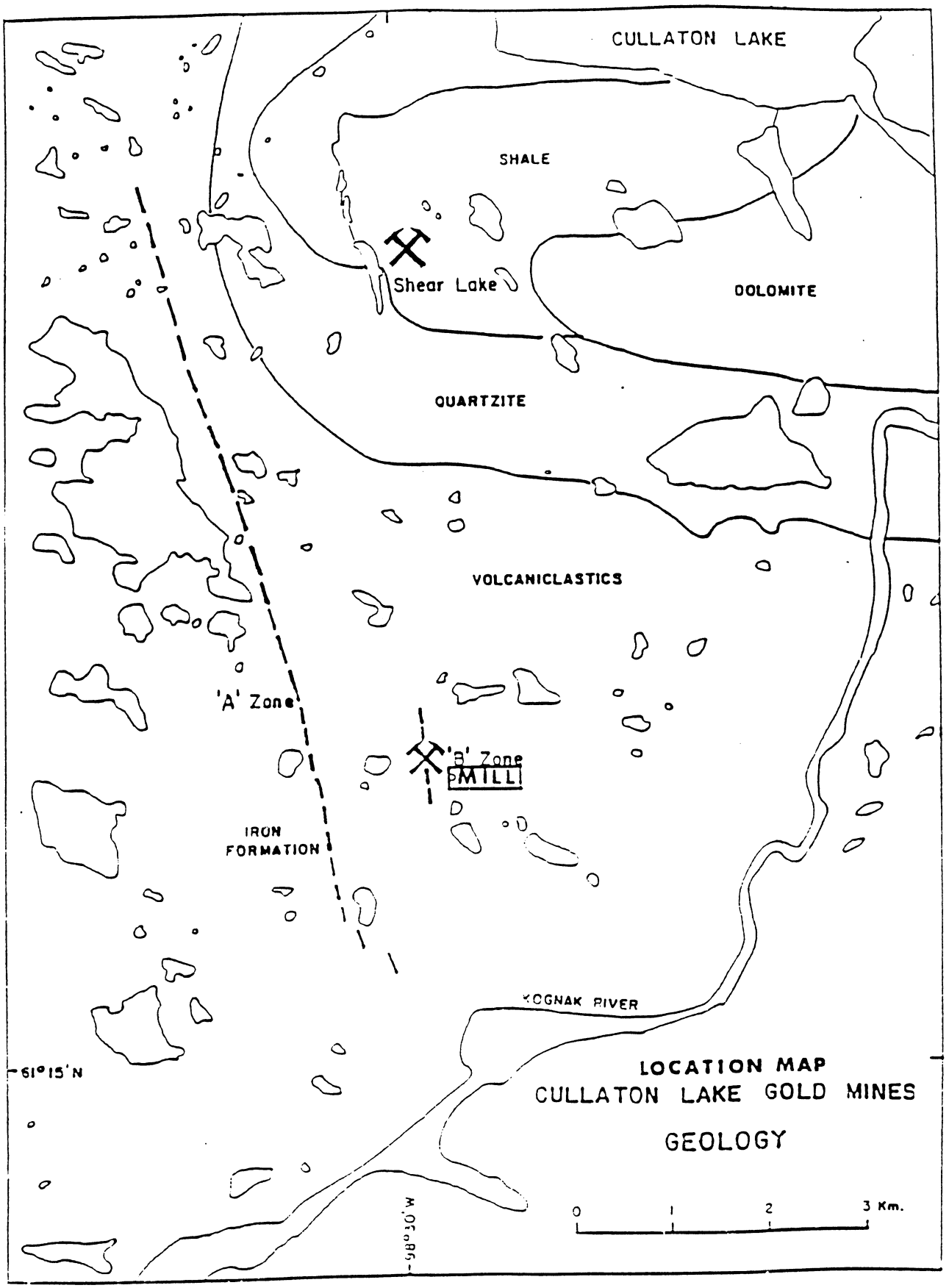


Fig. 2 - Location of B and Shear Zones at the Cullaton Lake Mine property.

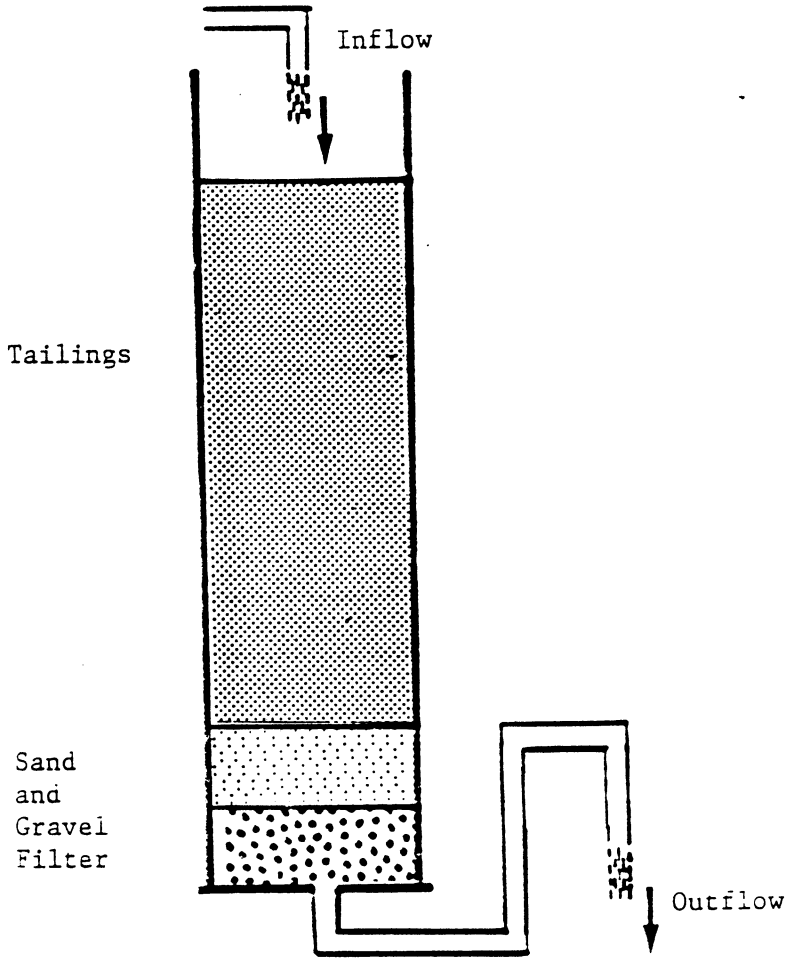


Fig. 3 - Leaching column experimental set up.

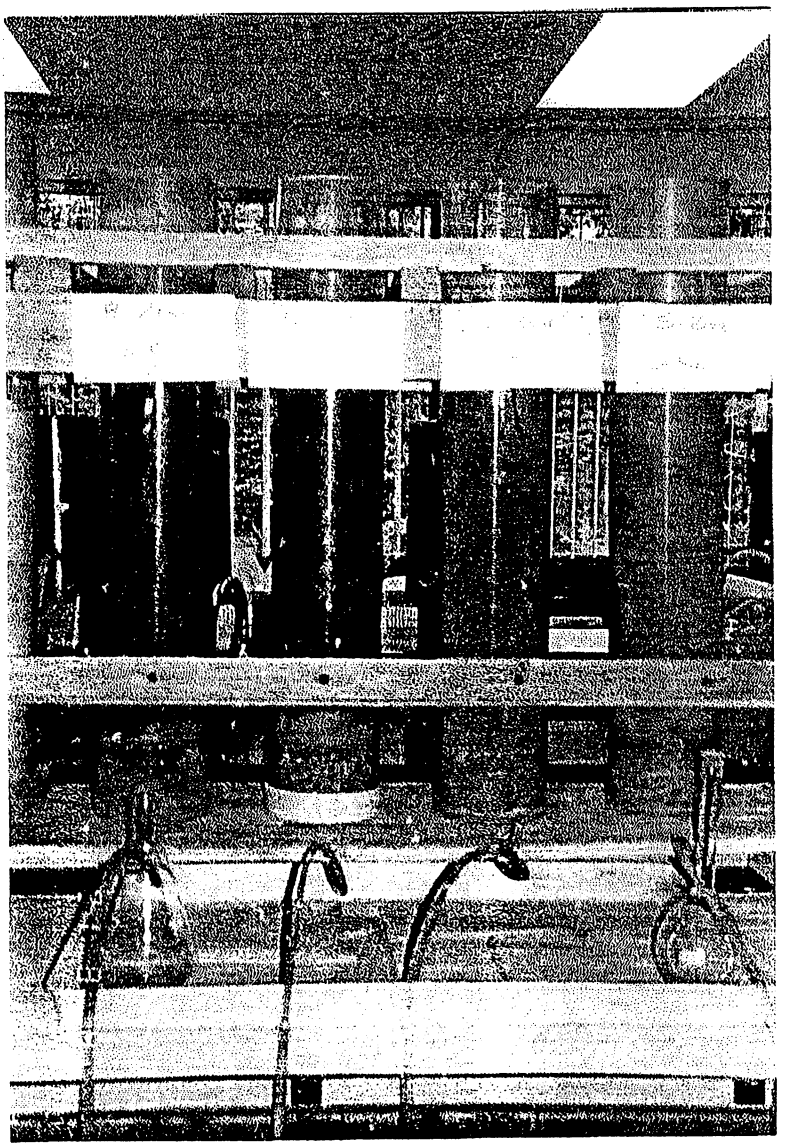


Fig. 4 - Leaching columns experimental arrangement for B and Shear Zone tailings.

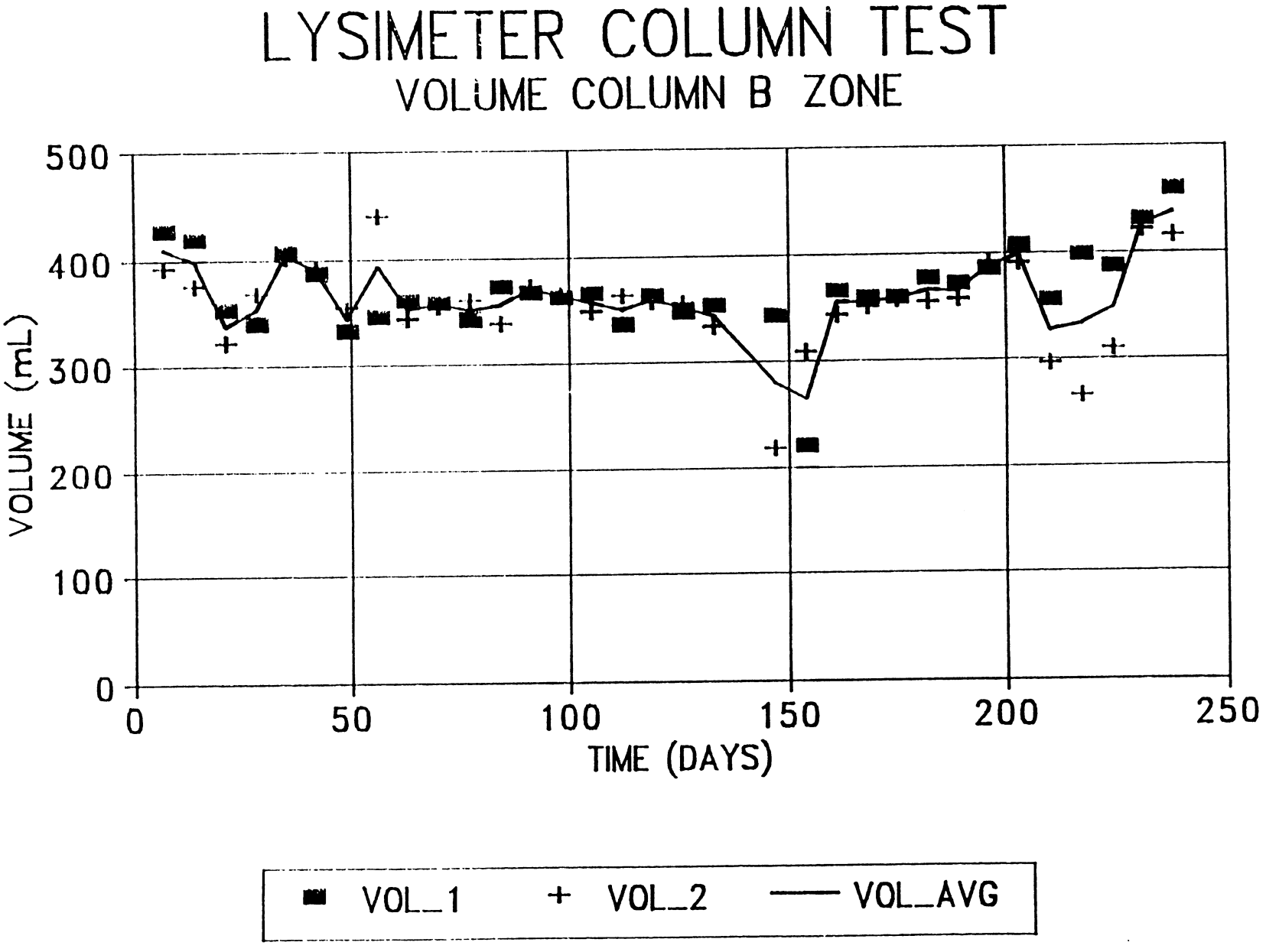


Fig. 5 - Weekly leachate flow volumes for B Zone columns.

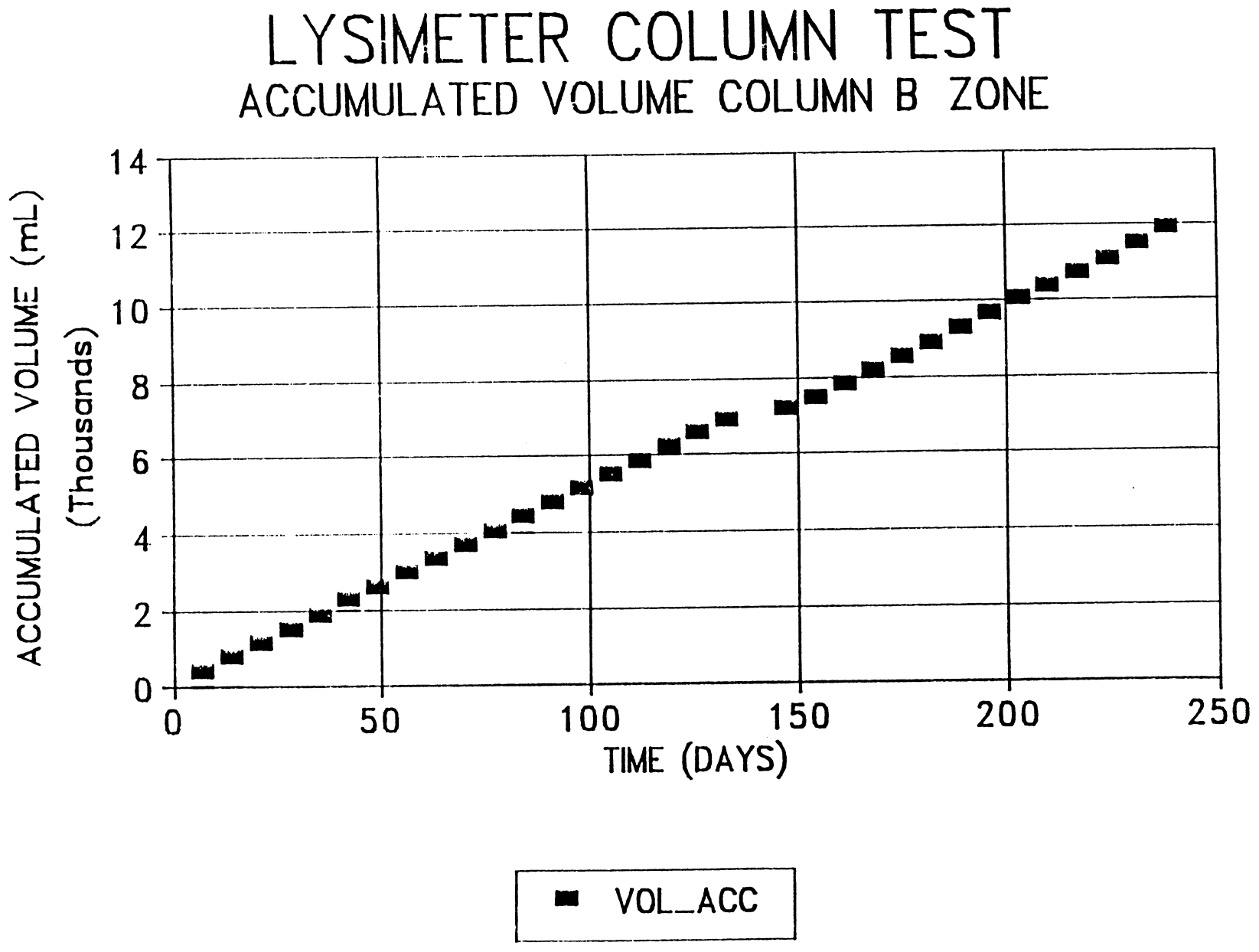


Fig. 6 - Total accumulated volume (average) per column for B Zone.

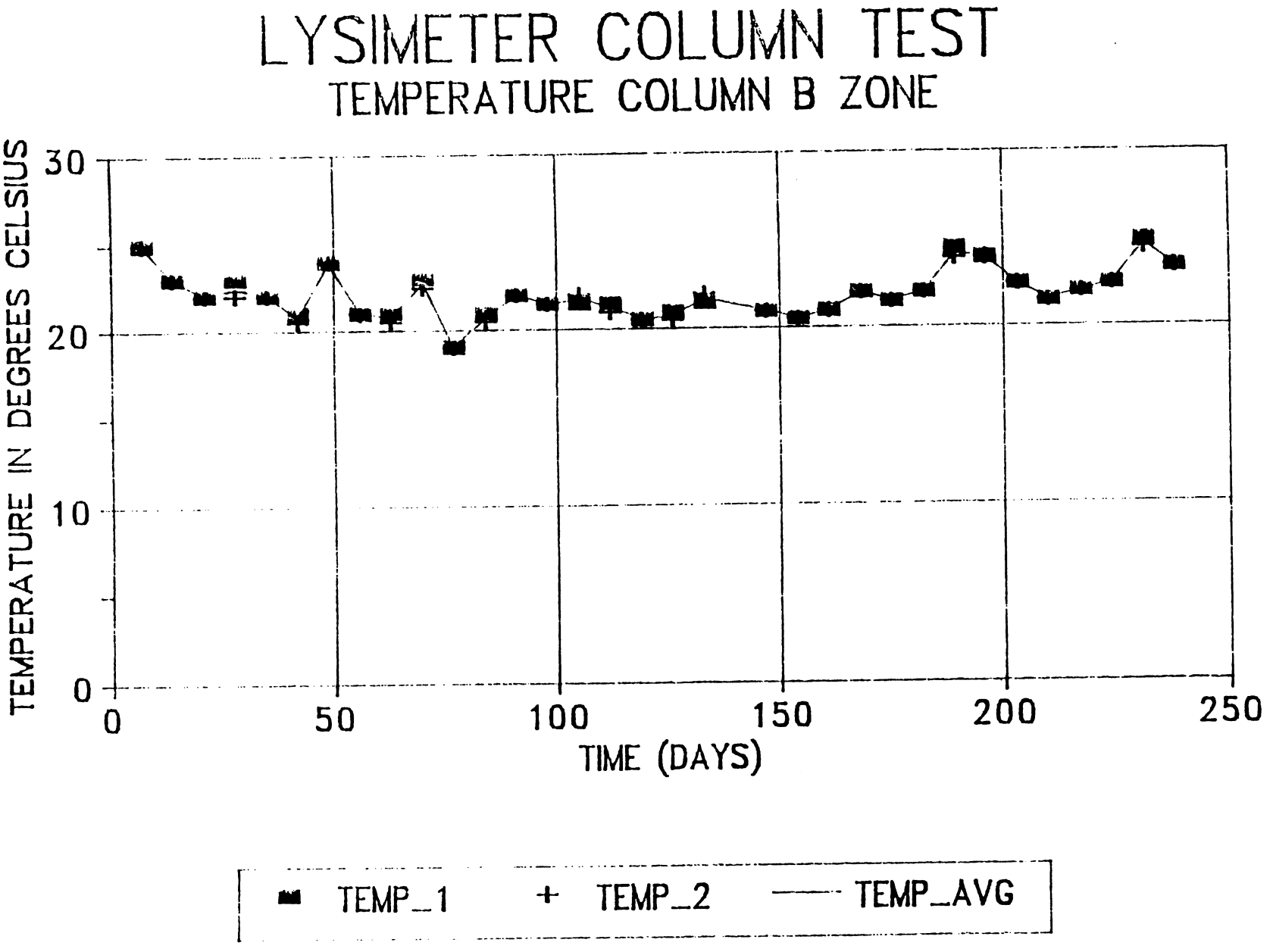


Fig. 7 - Effluent temperature for B Zone columns.

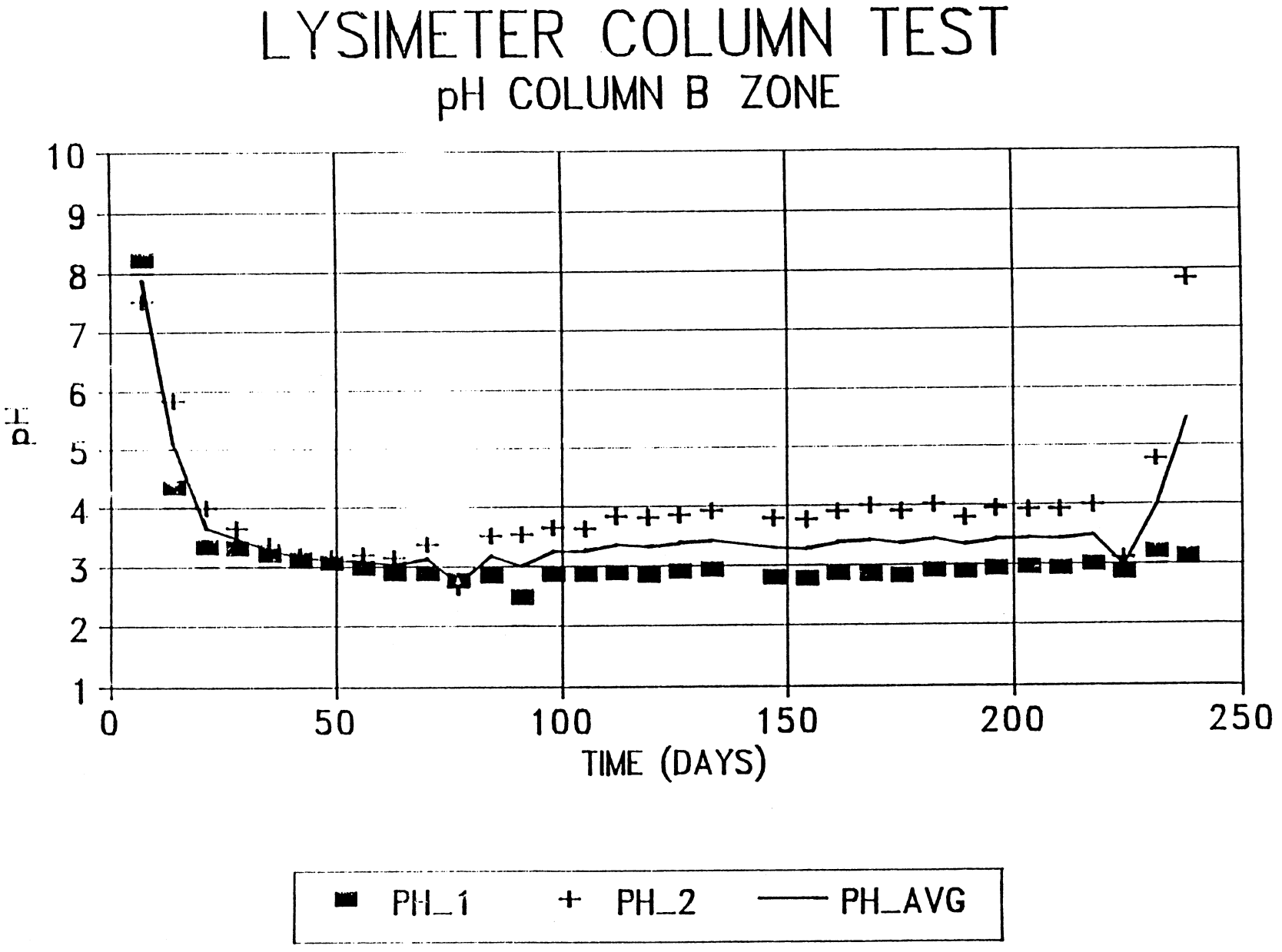


Fig. 8 - Effluent pH for B Zone columns.

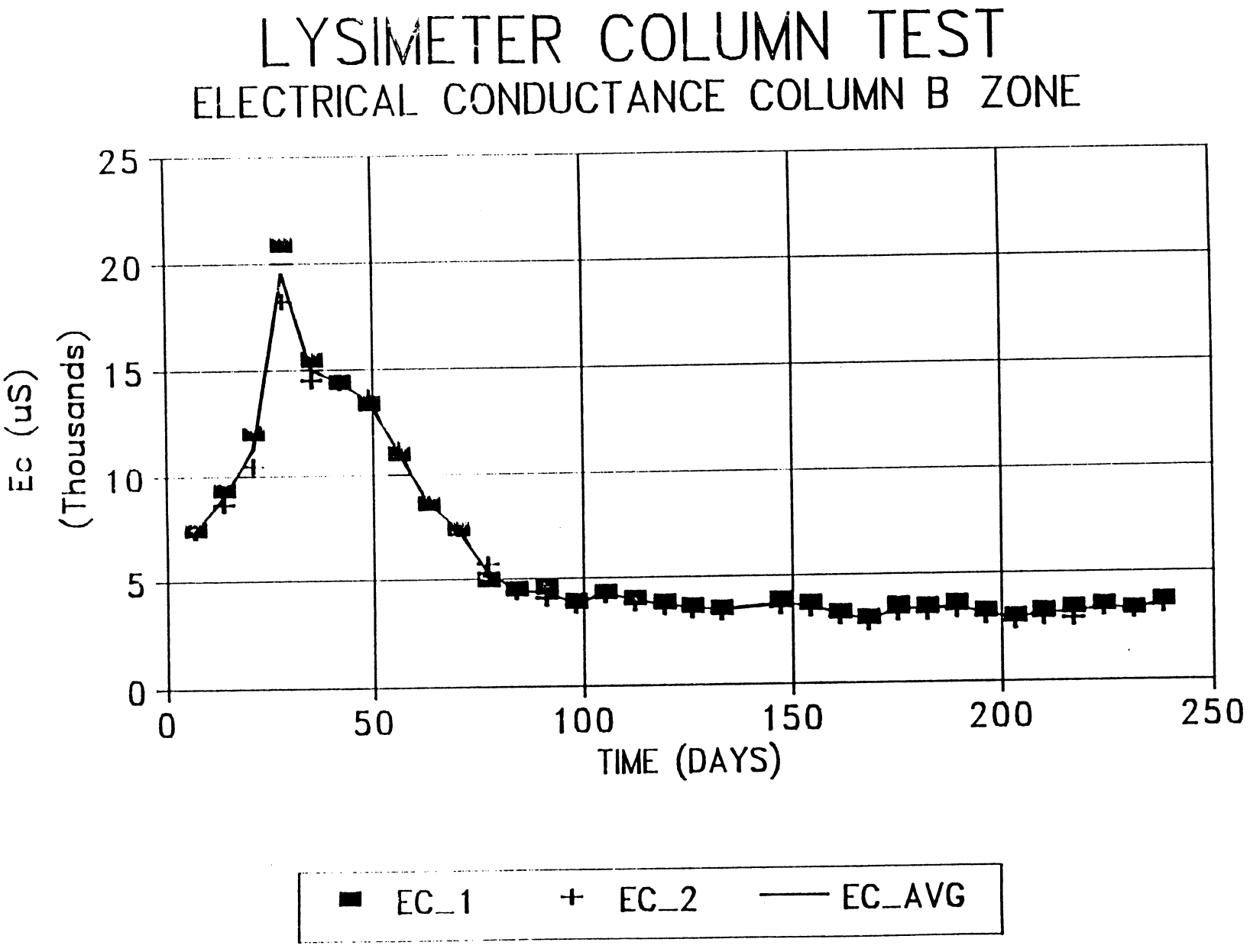


Fig. 9 - Effluent electrical conductance 'Ec' for B Zone columns.

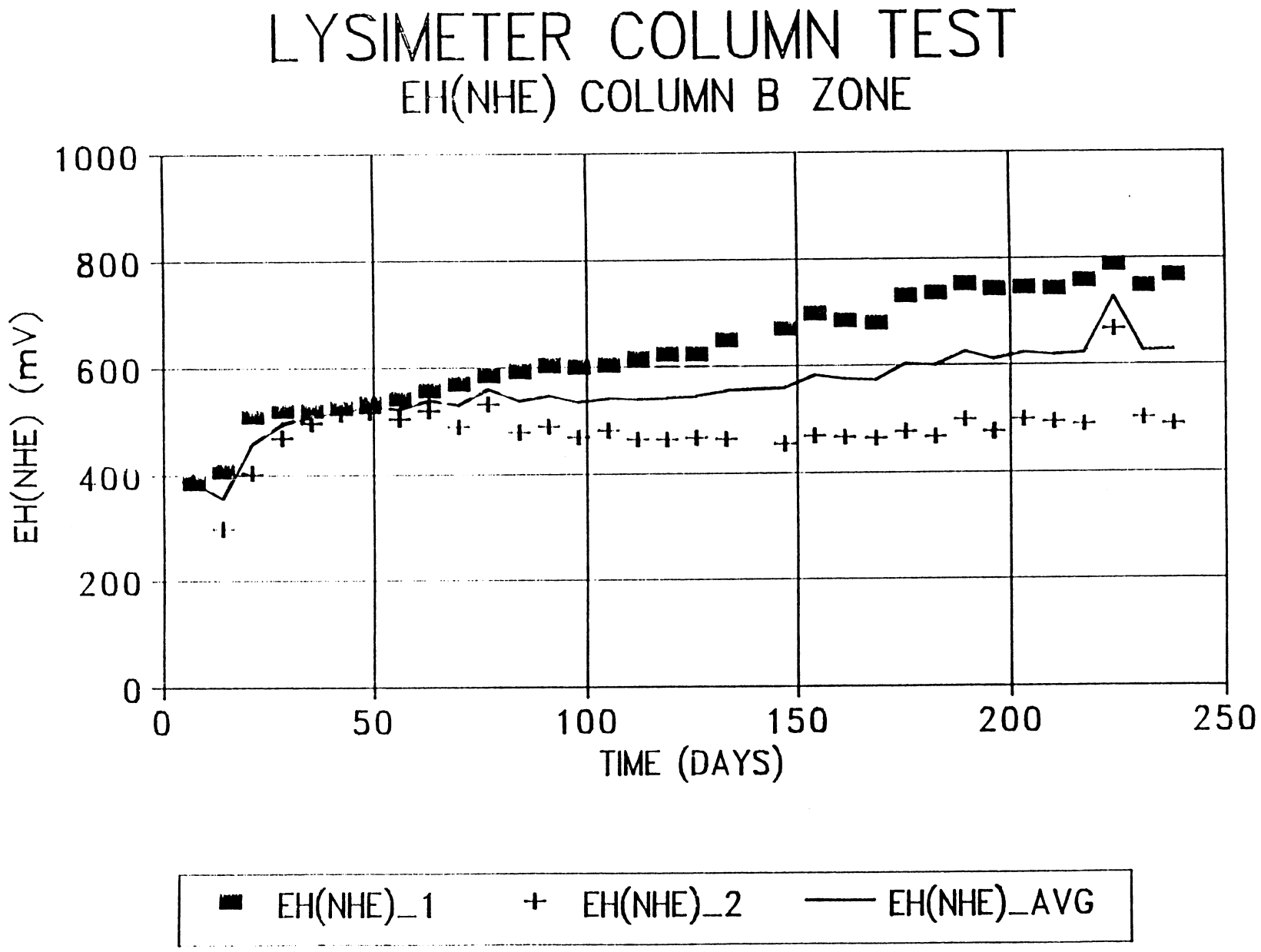


Fig. 10 - Effluent redox potential 'Eh' (absolute) for B Zone columns.

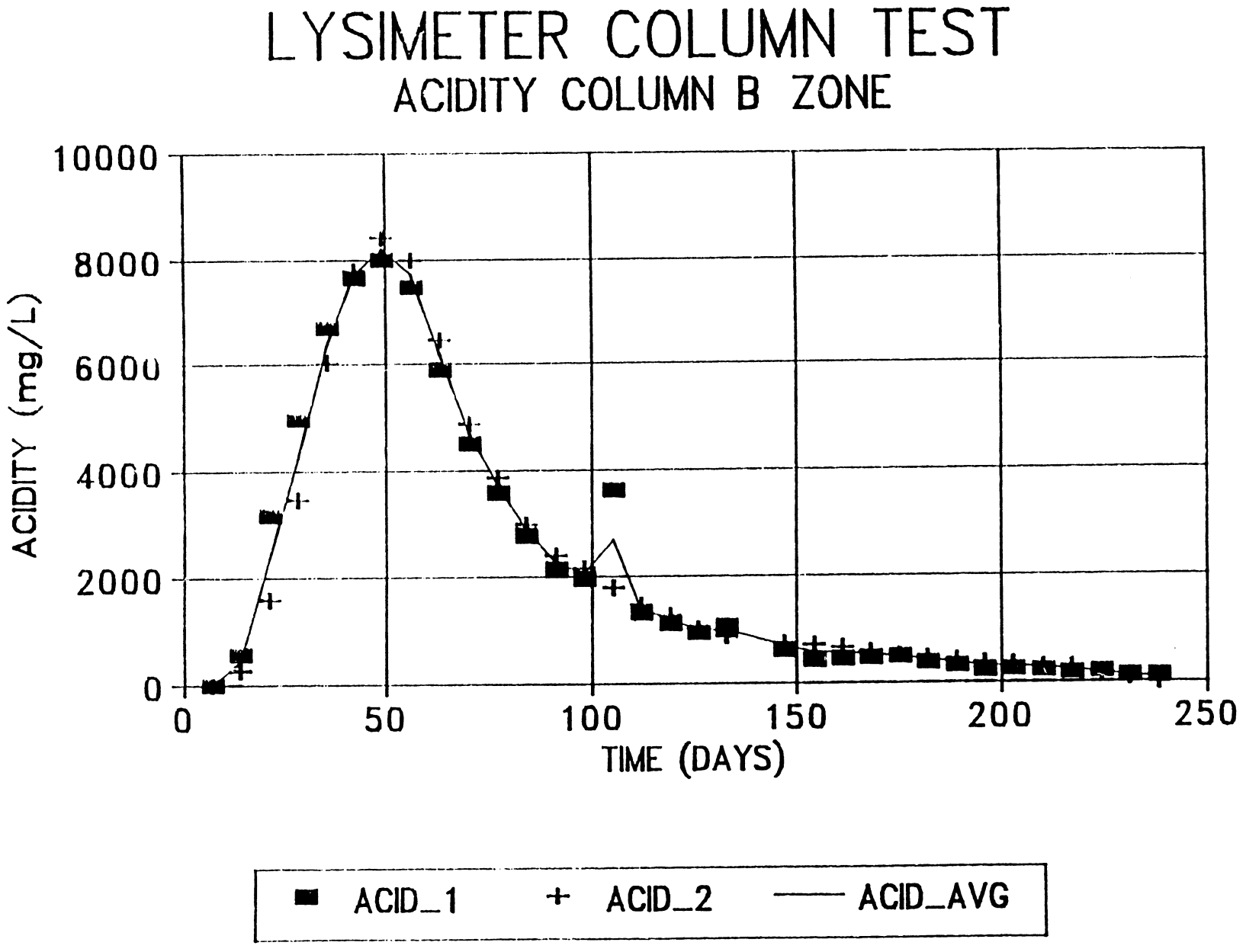


Fig. 11 - Effluent acidity for B Zone columns.

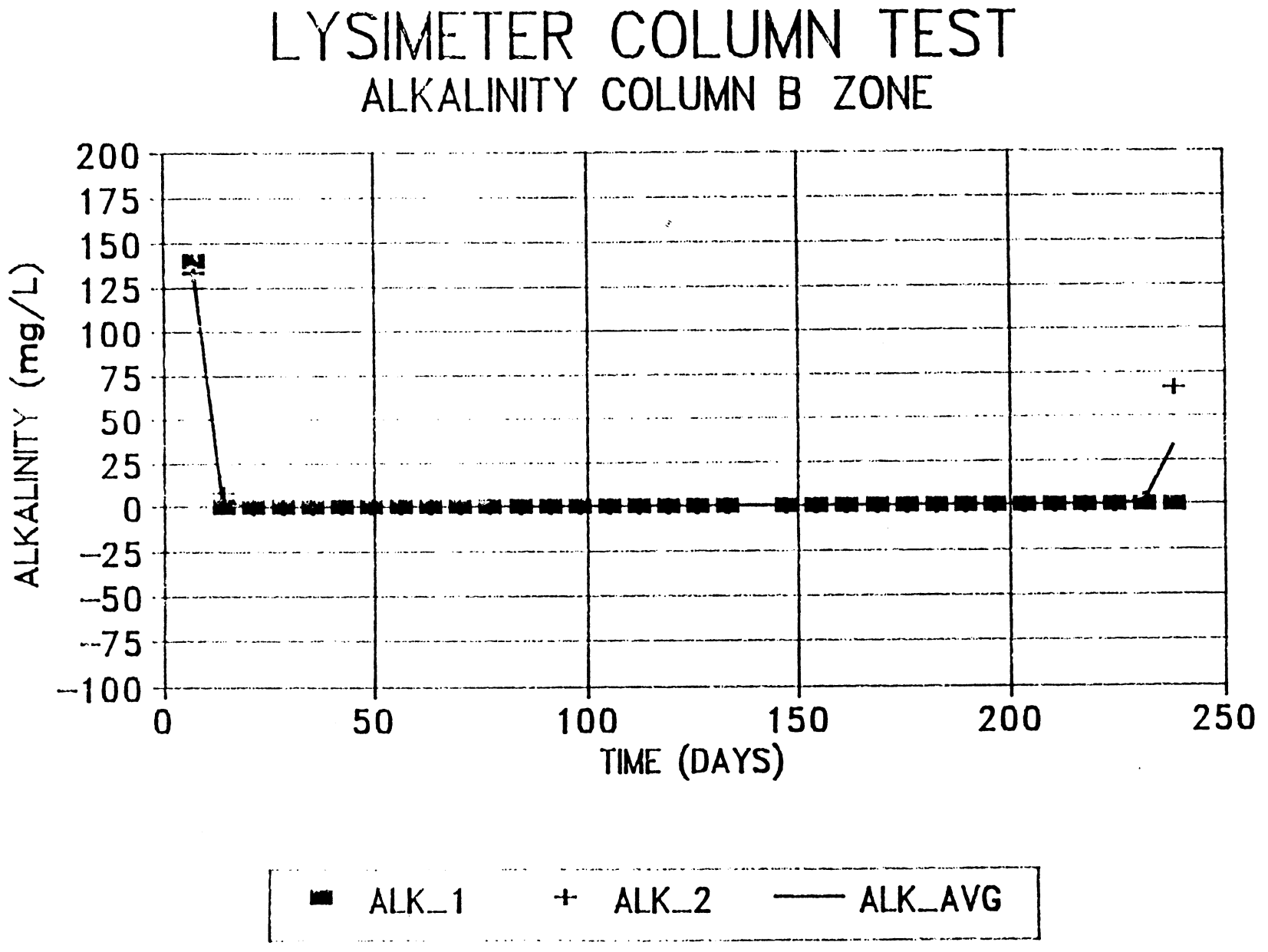


Fig. 12 - Effluent alkalinity for B Zone columns.

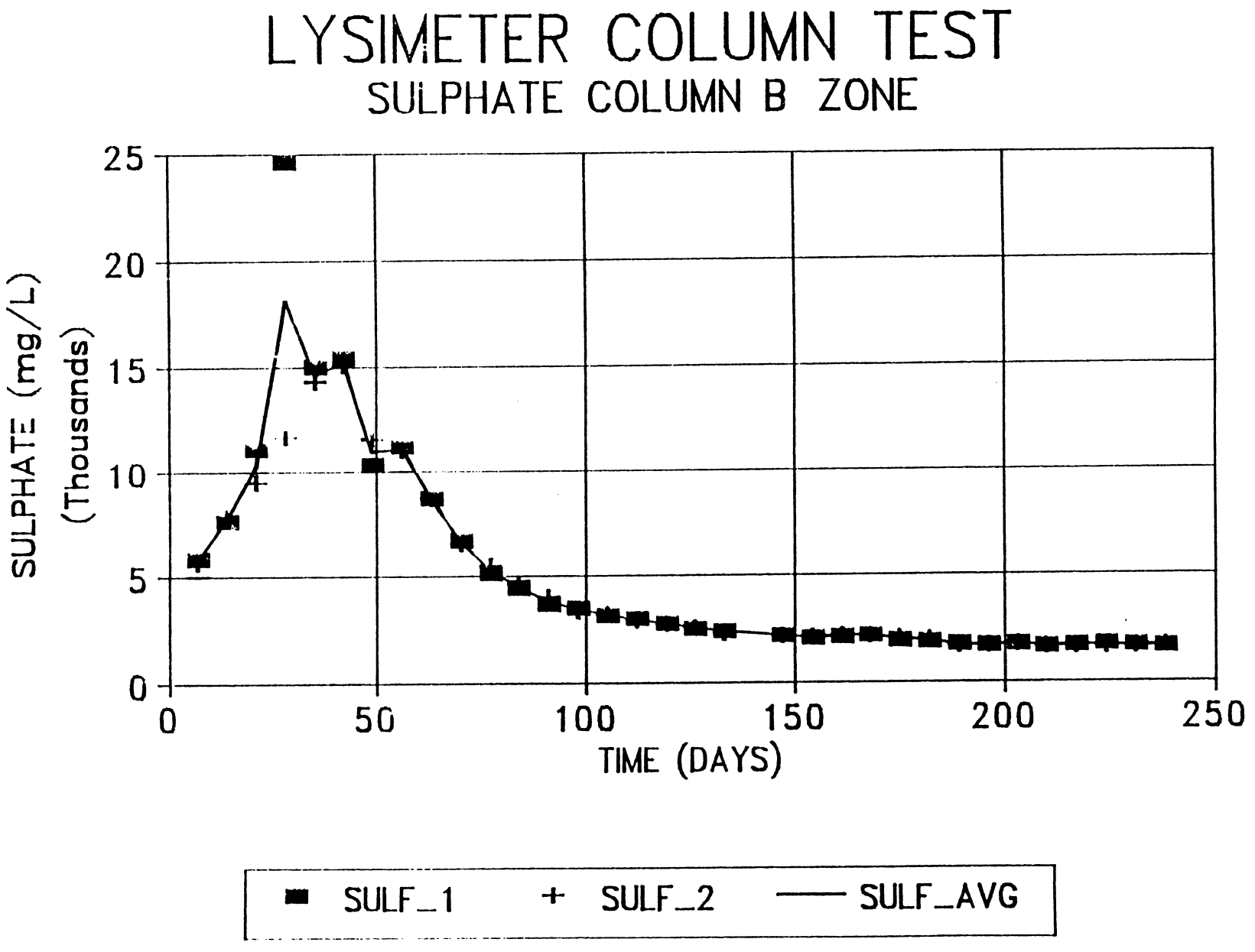


Fig. 13 - Effluent total sulphate (SO_4^{-2}) concentration for B Zone columns.

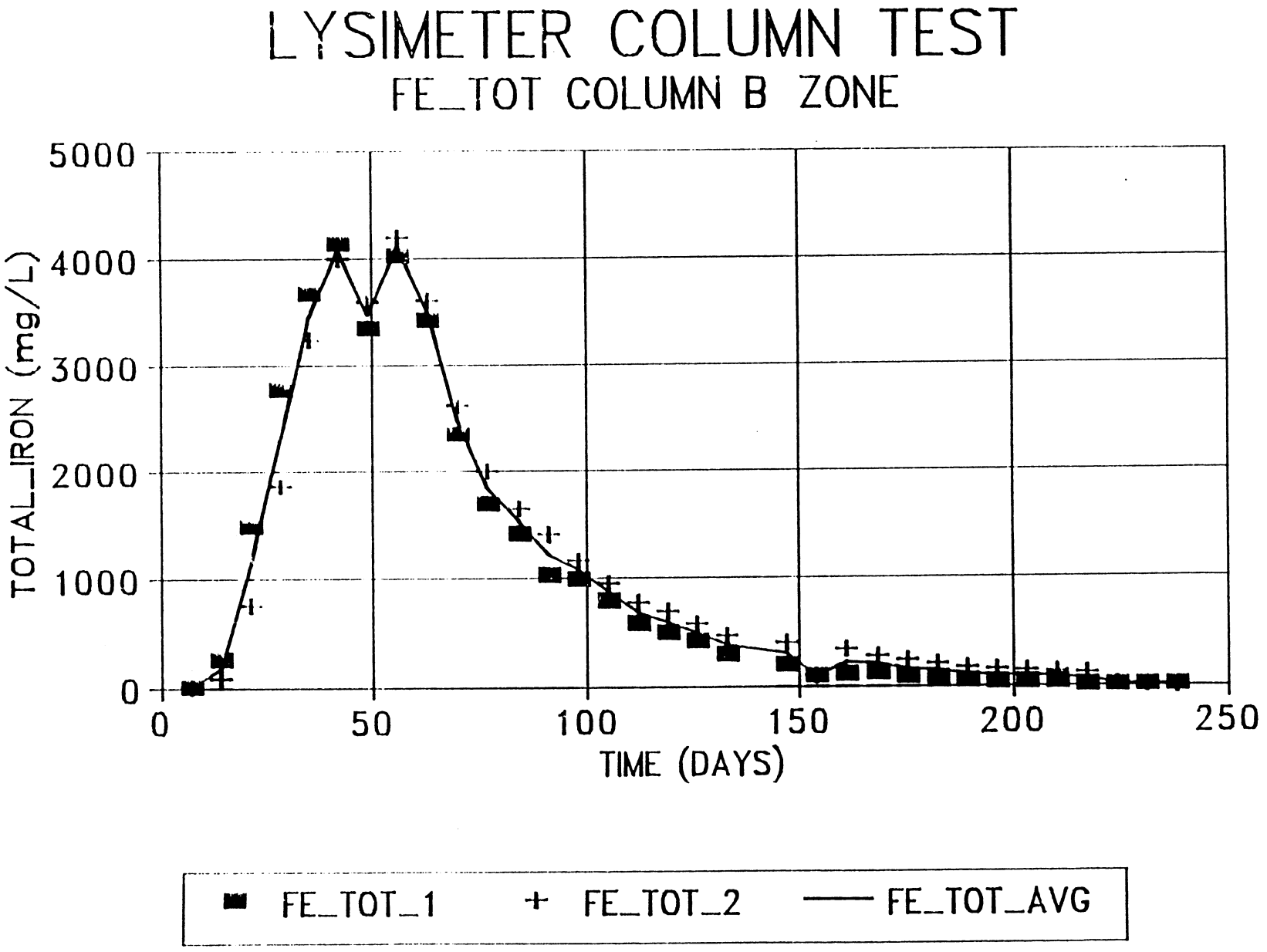


Fig. 14 - Effluent total iron (Fe) concentration for B Zone columns.

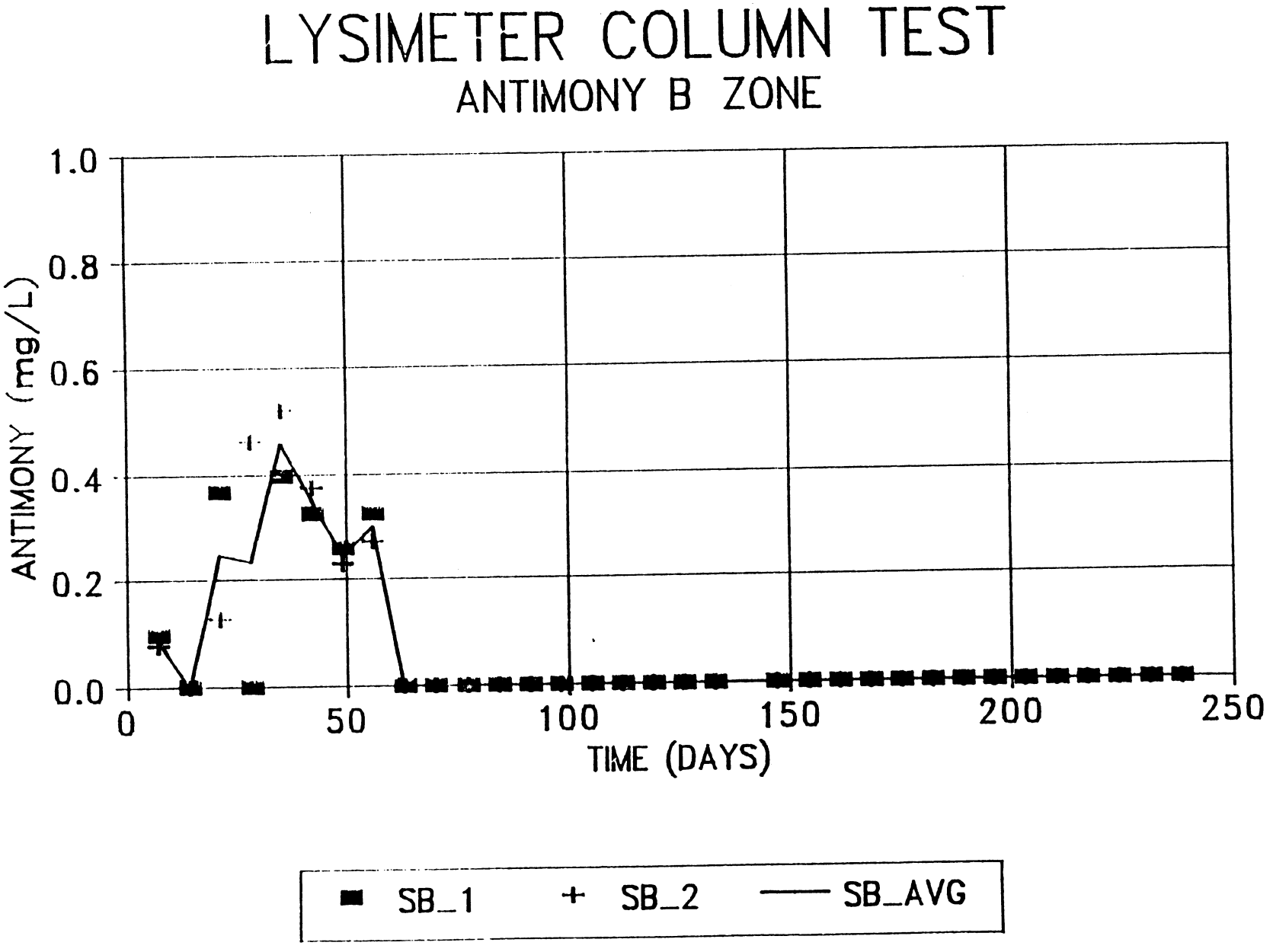


Fig. 15 - Effluent total antimony (Sb) concentration for B Zone columns.

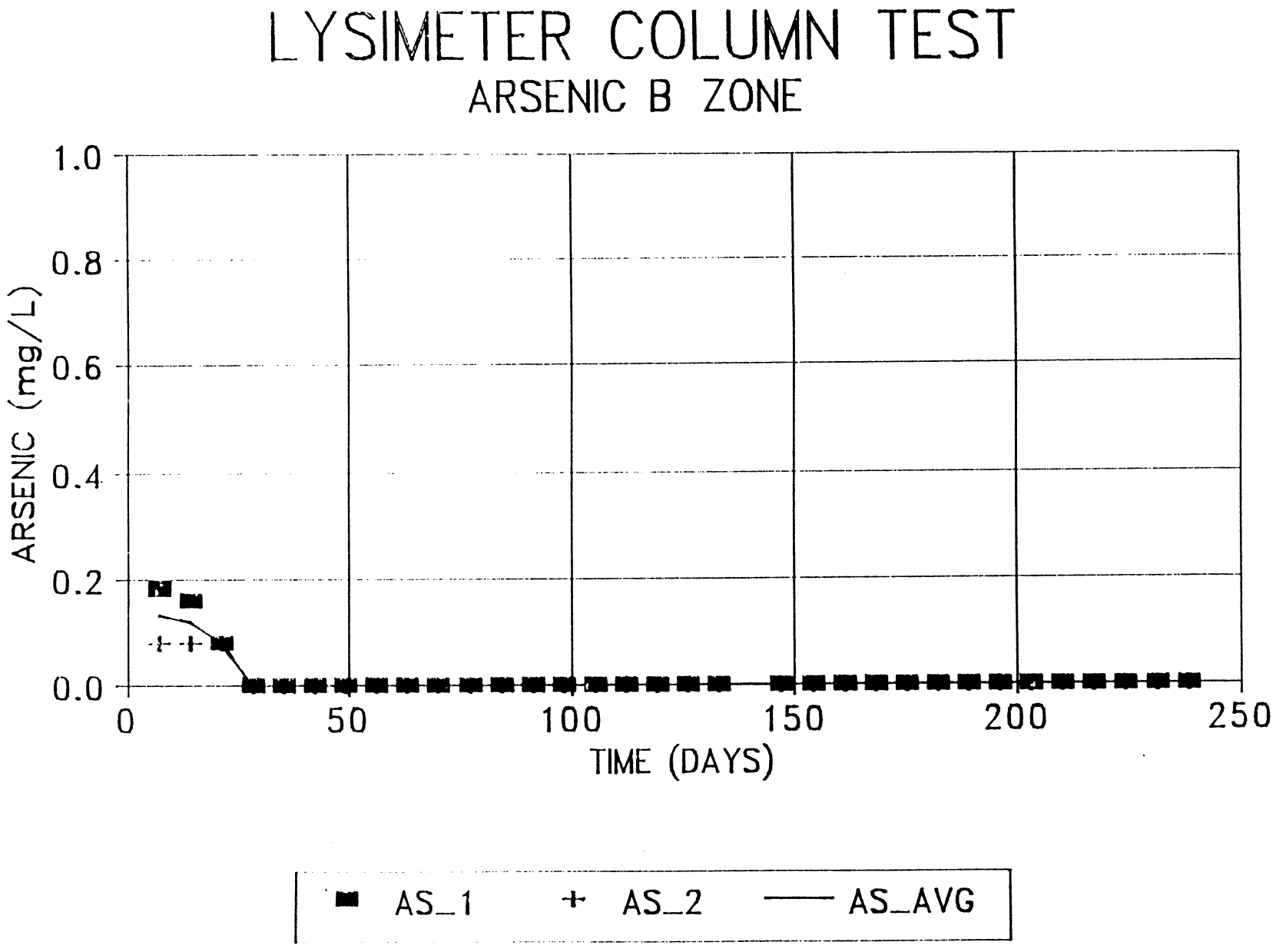


Fig. 16 - Effluent total arsenic (As) concentration for B Zone columns.

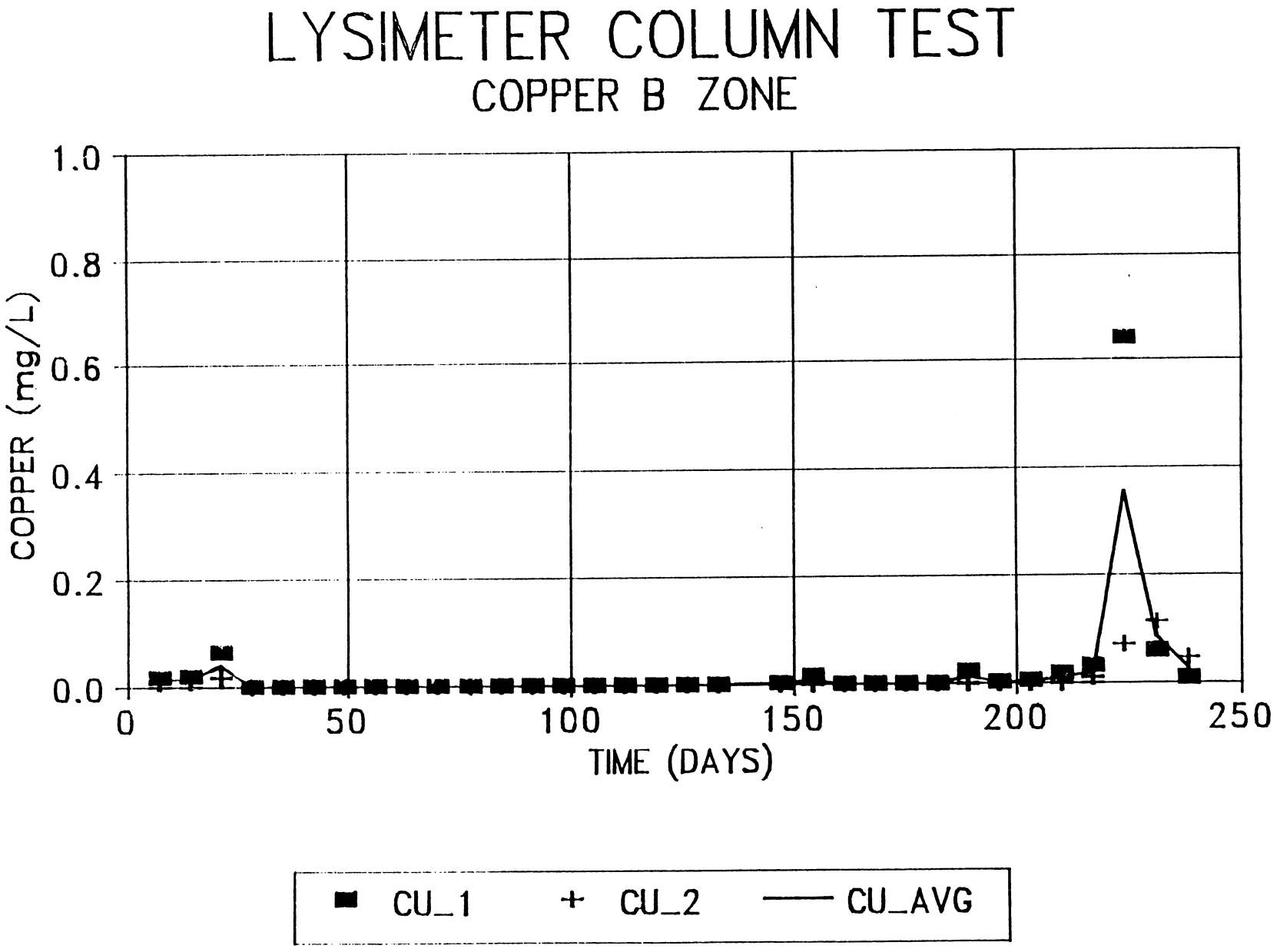


Fig. 17 - Effluent total copper (Cu) concentration for B Zone columns.

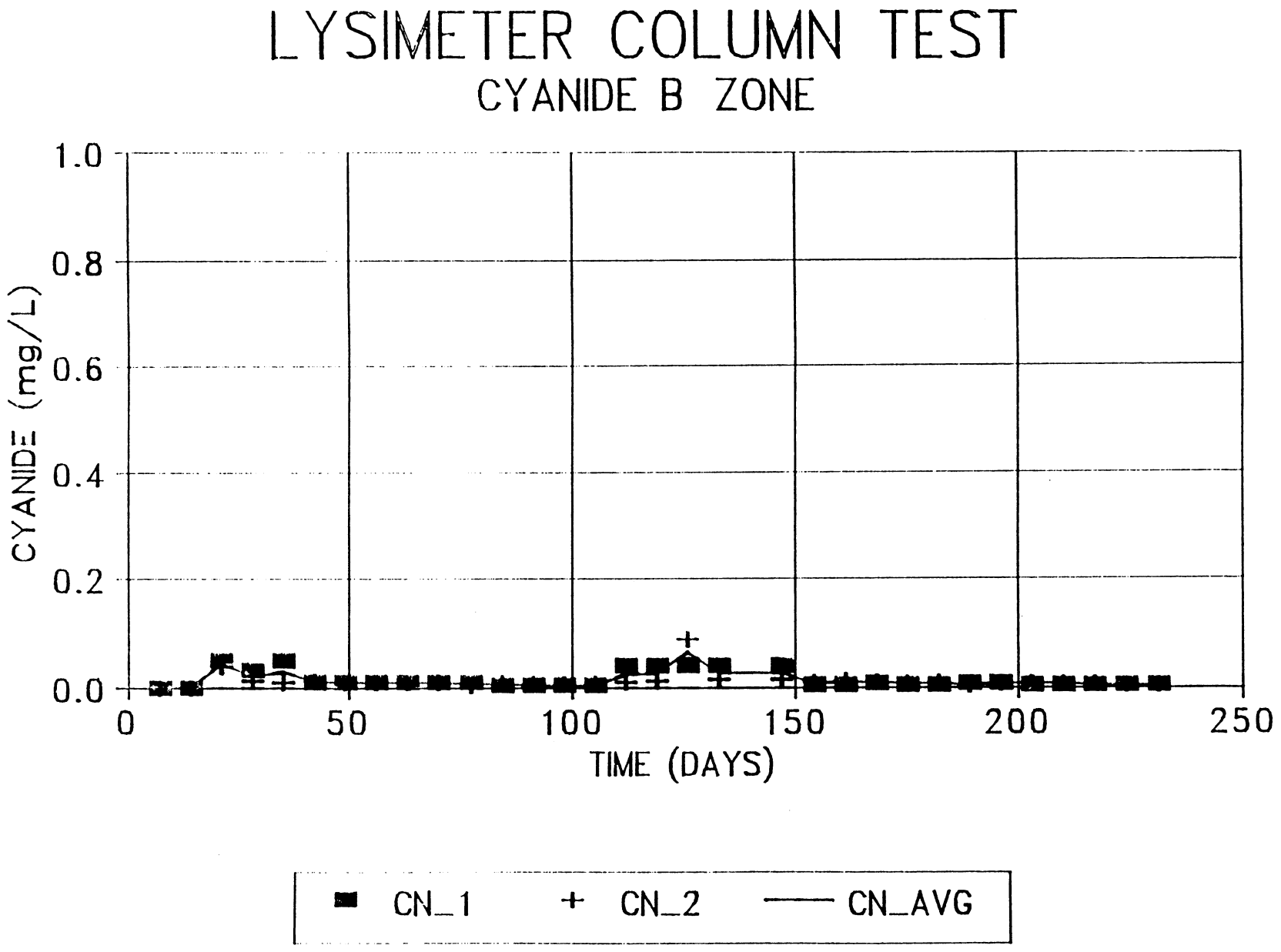


Fig. 18 - Effluent total cyanide (CN^-) concentration for B Zone columns.

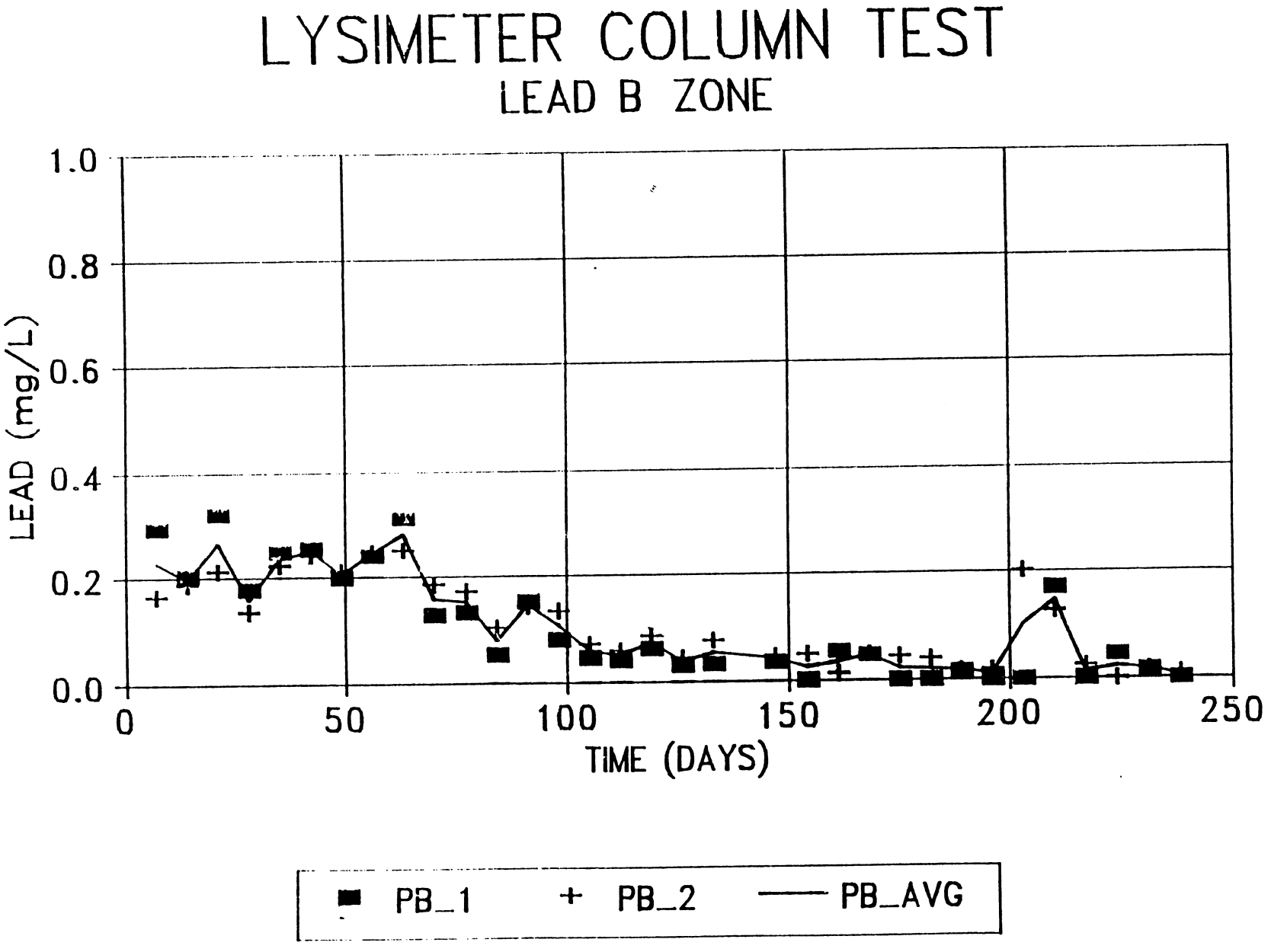


Fig. 19 - Effluent total lead (Pb) concentration for B Zone columns.

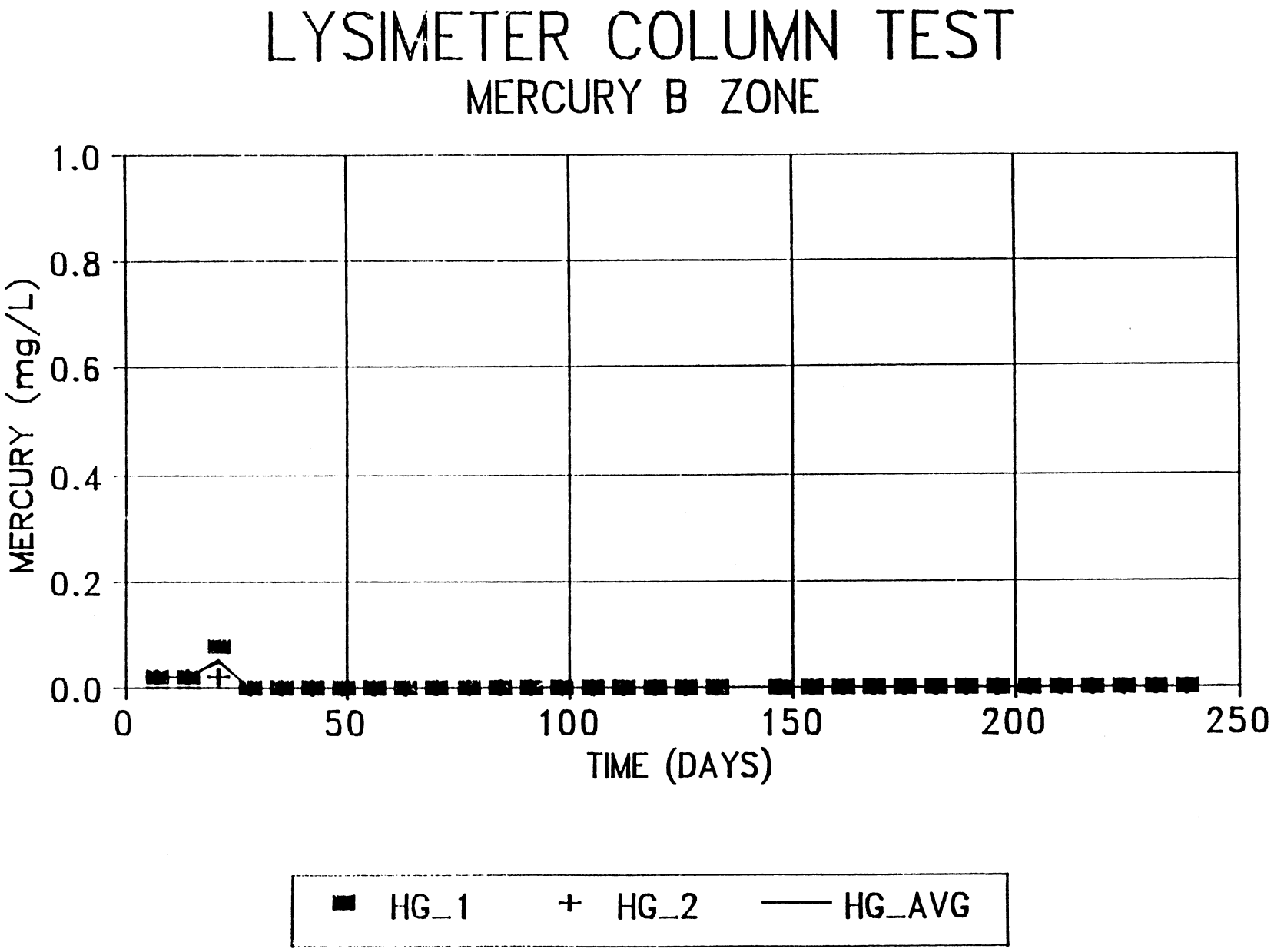


Fig. 20 - Effluent total mercury (Hg) concentration for B Zone columns.

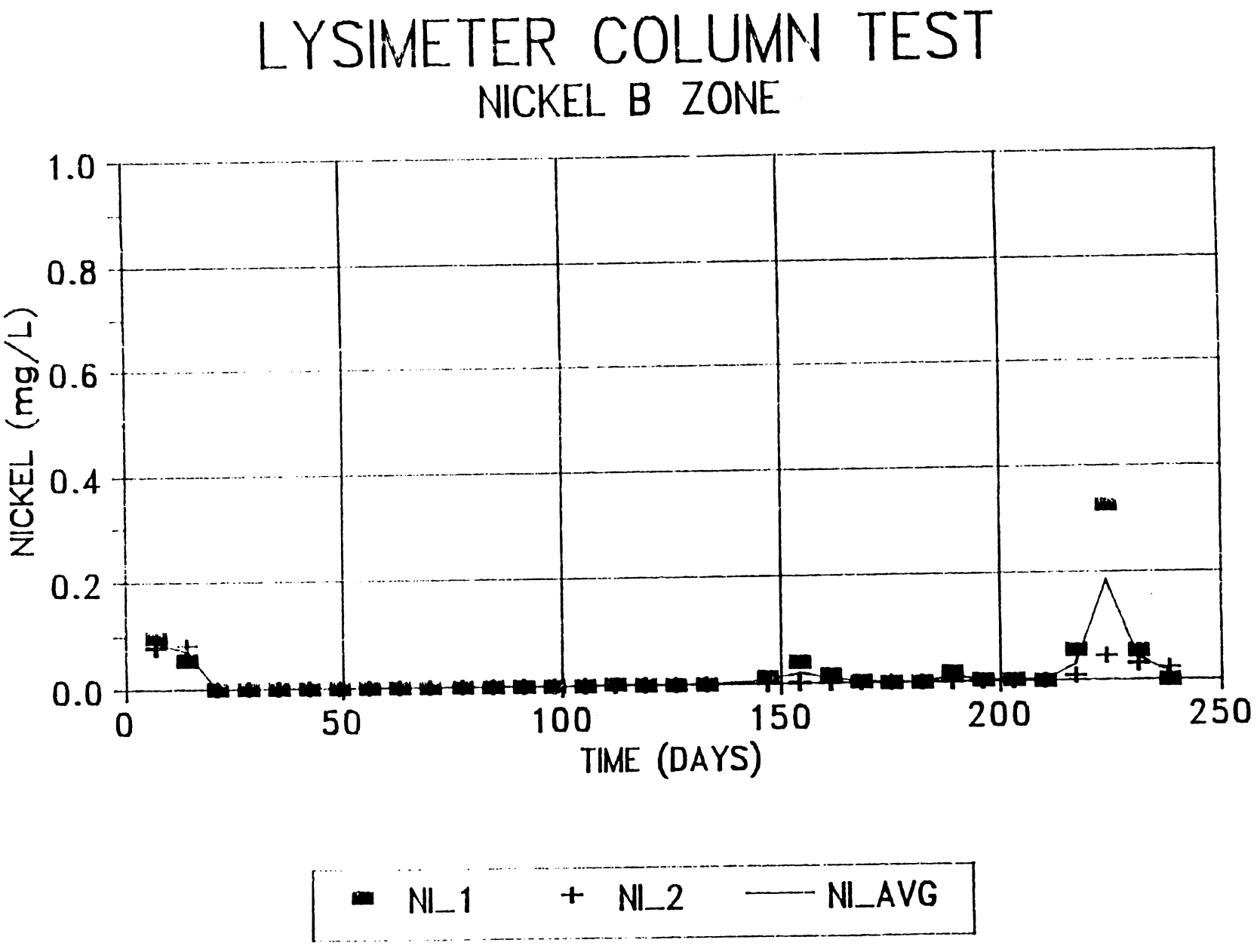


Fig. 21 - Effluent total nickel (Ni) concentration for B Zone columns.

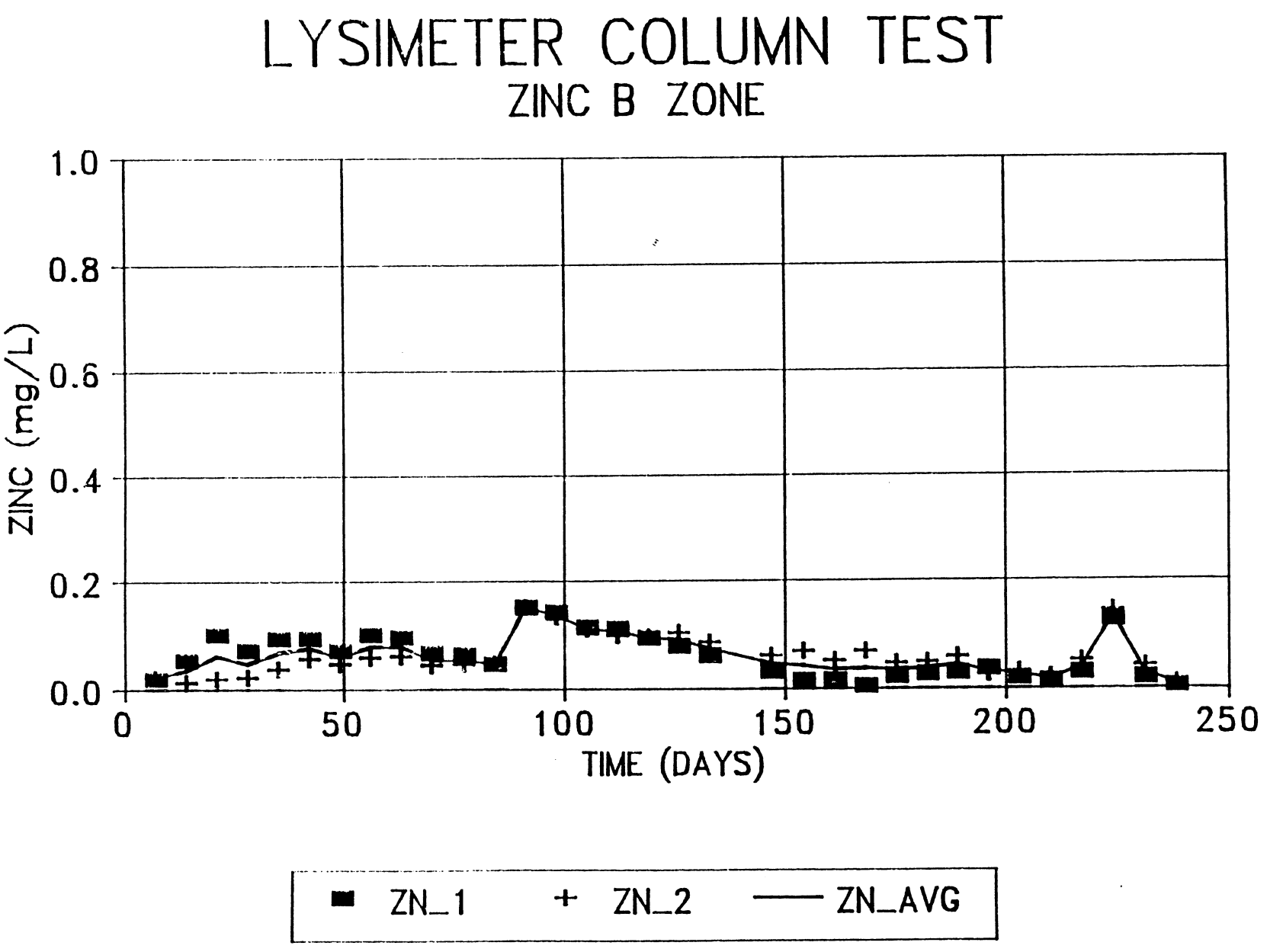


Fig. 22 - Effluent total zinc (Zn) concentration for B Zone columns.

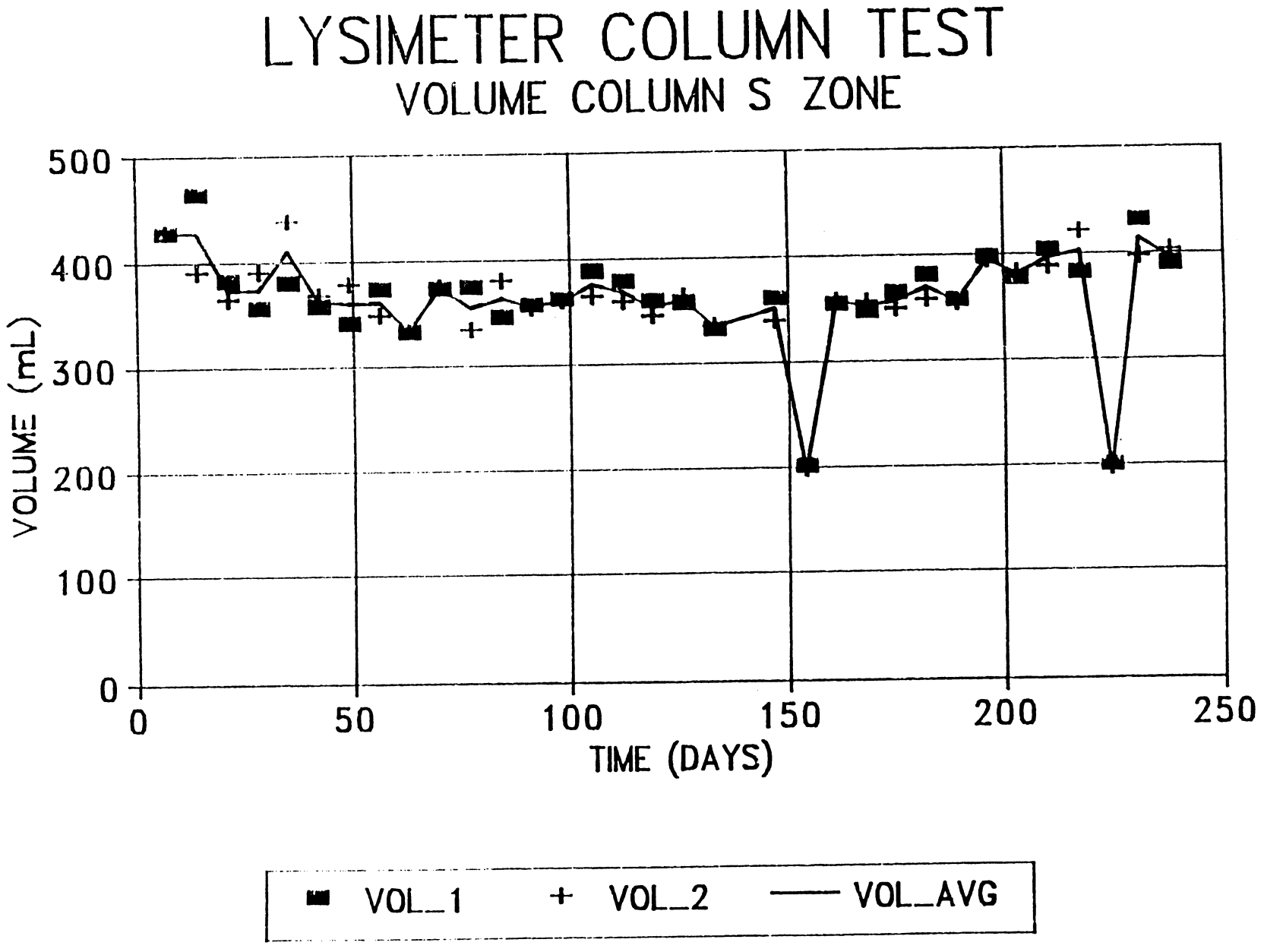


Fig. 23 - Weekly leachate flow volume for S Zone column.

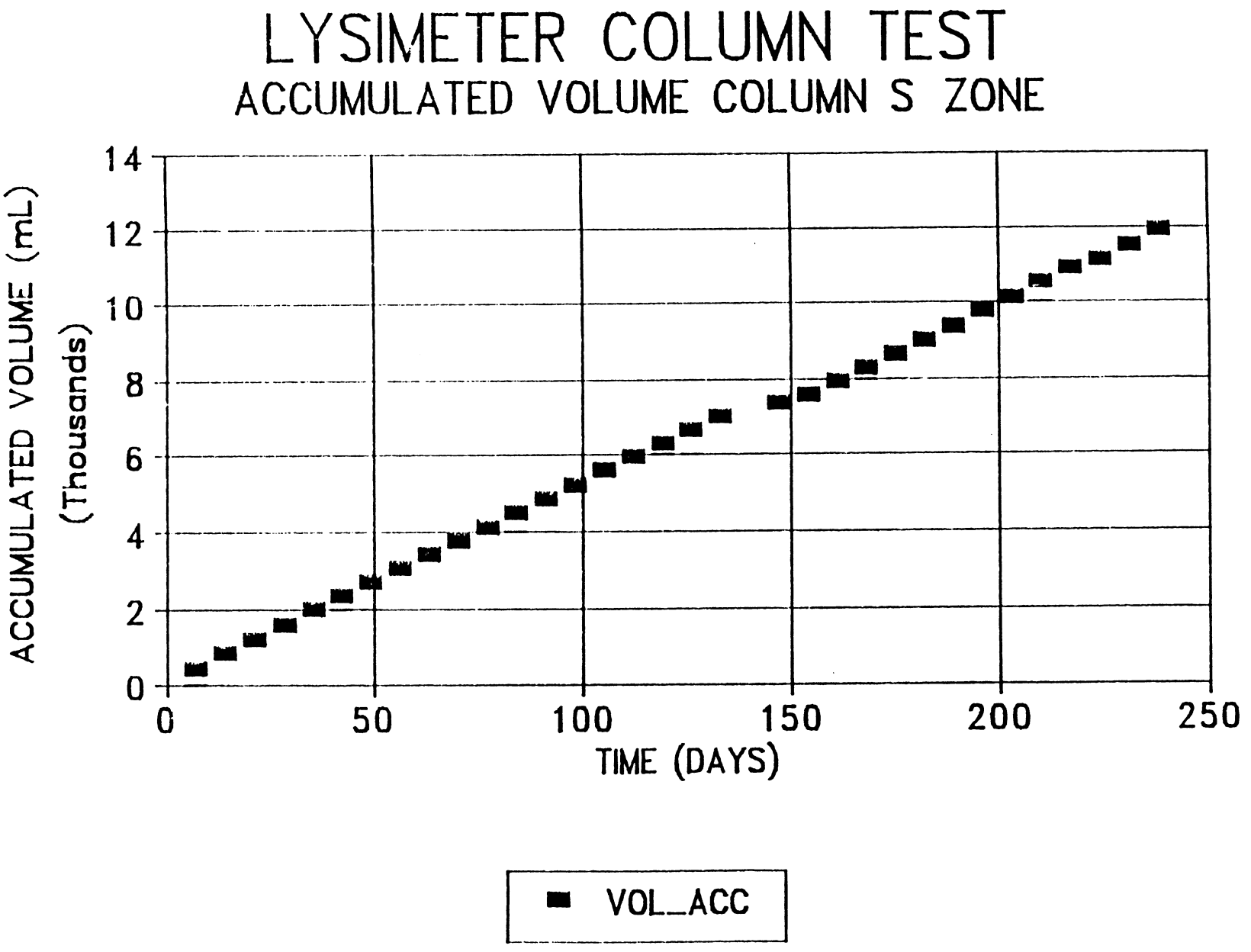


Fig. 24 - Total accumulated volume (average) per column for S Zone.

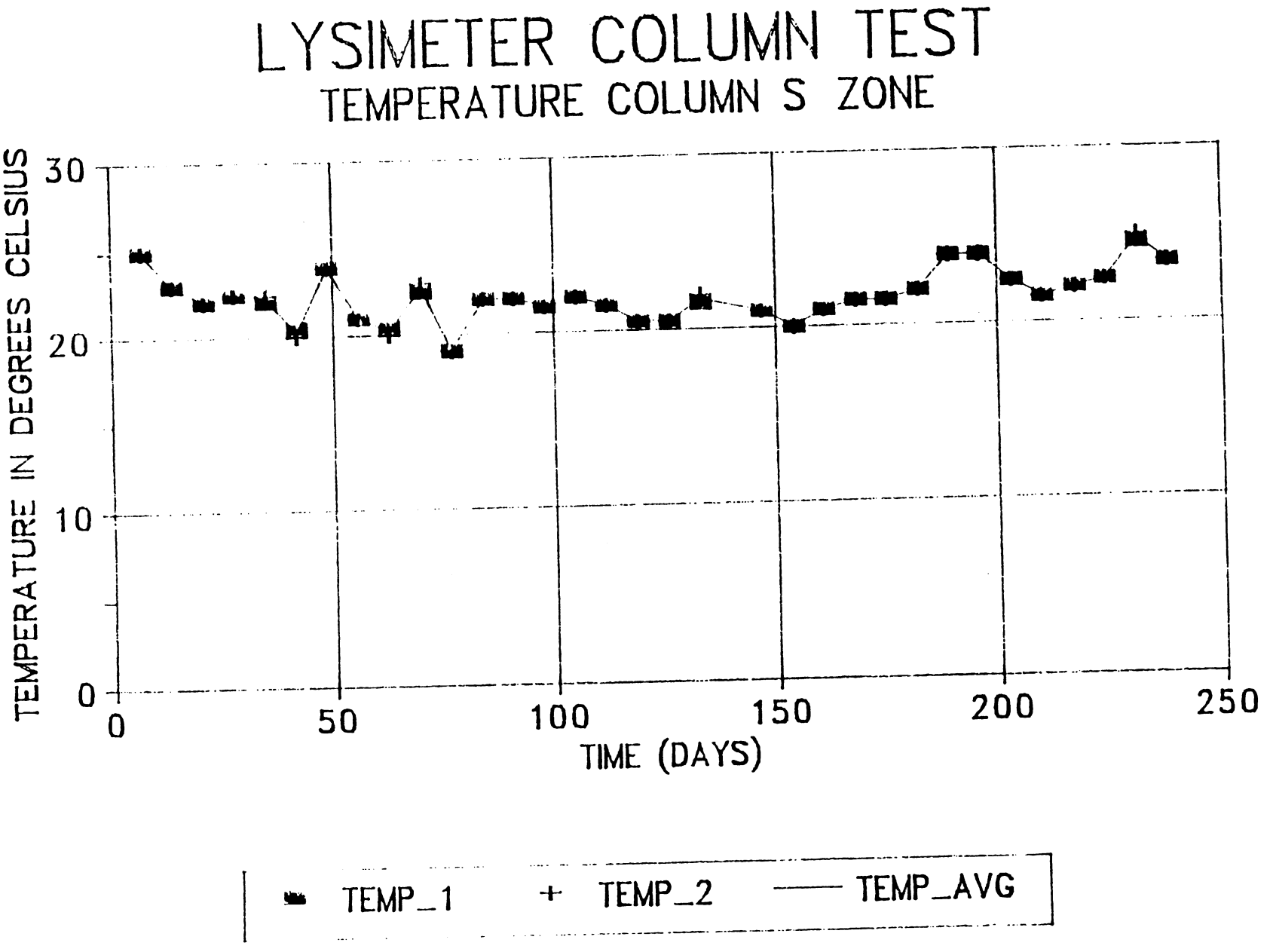


Fig. 25 - Effluent temperature for S Zone columns.

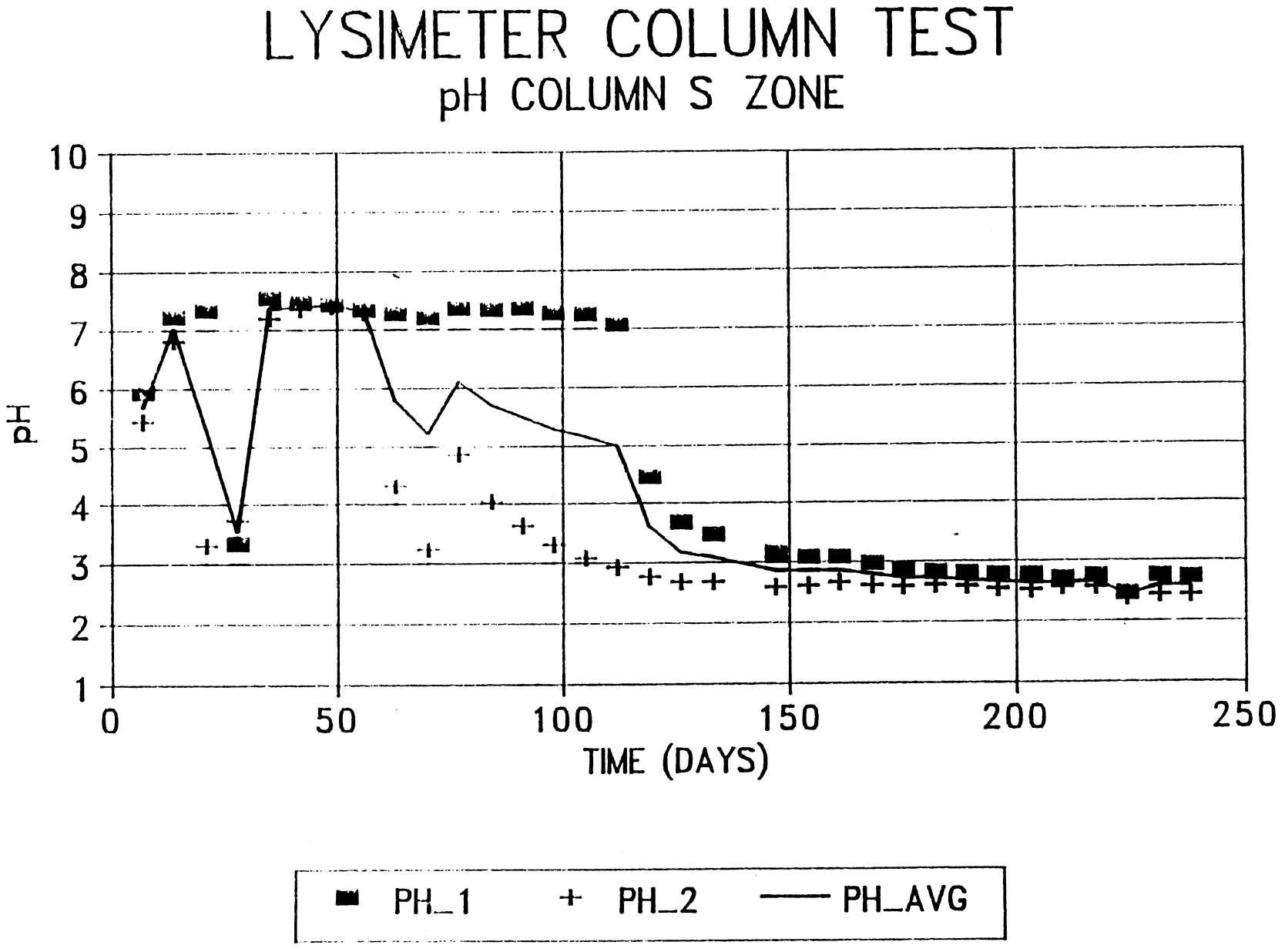


Fig. 26 - Effluent pH for S Zone columns.

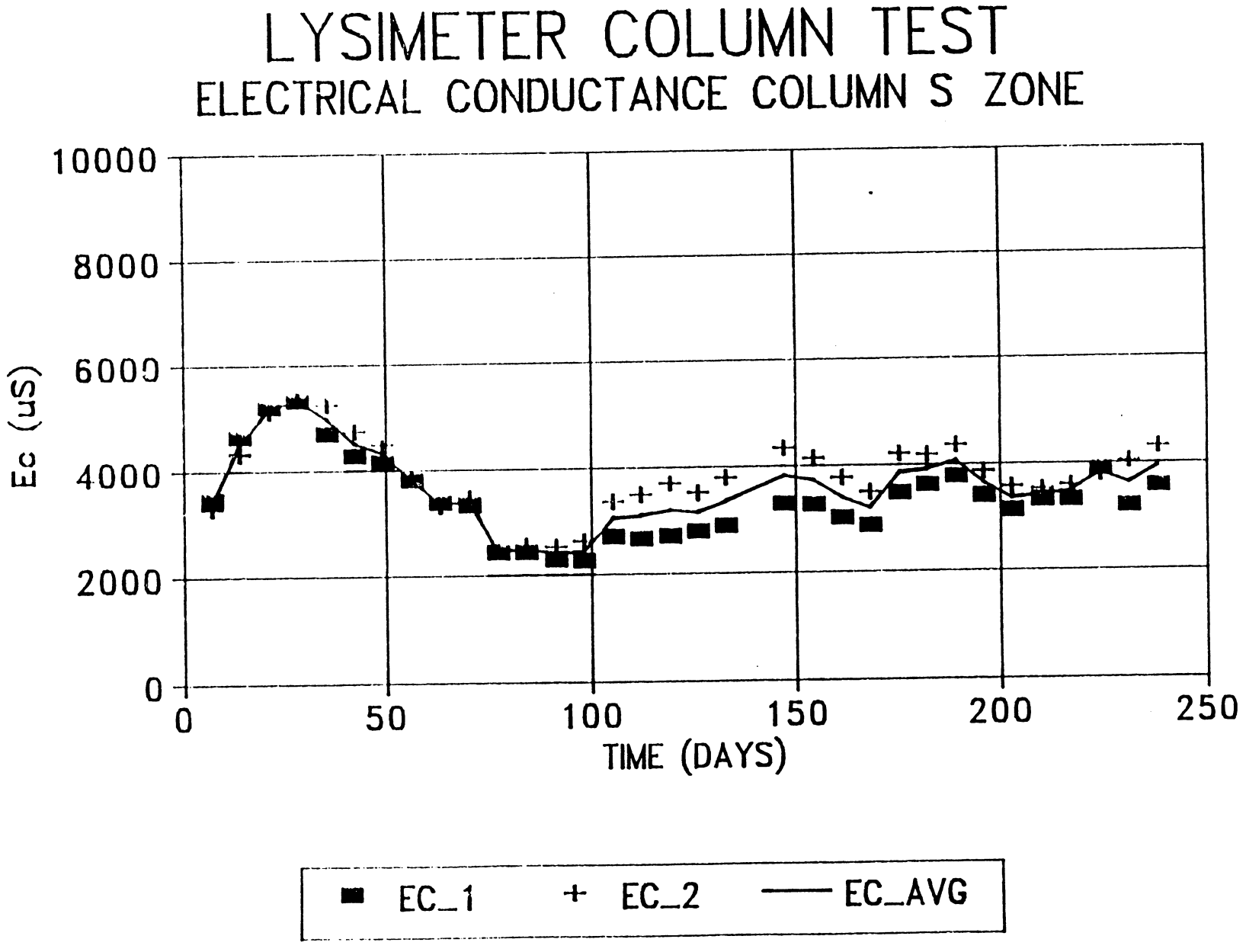


Fig. 27 - Effluent electrical conductance 'Ec' for S Zone columns.

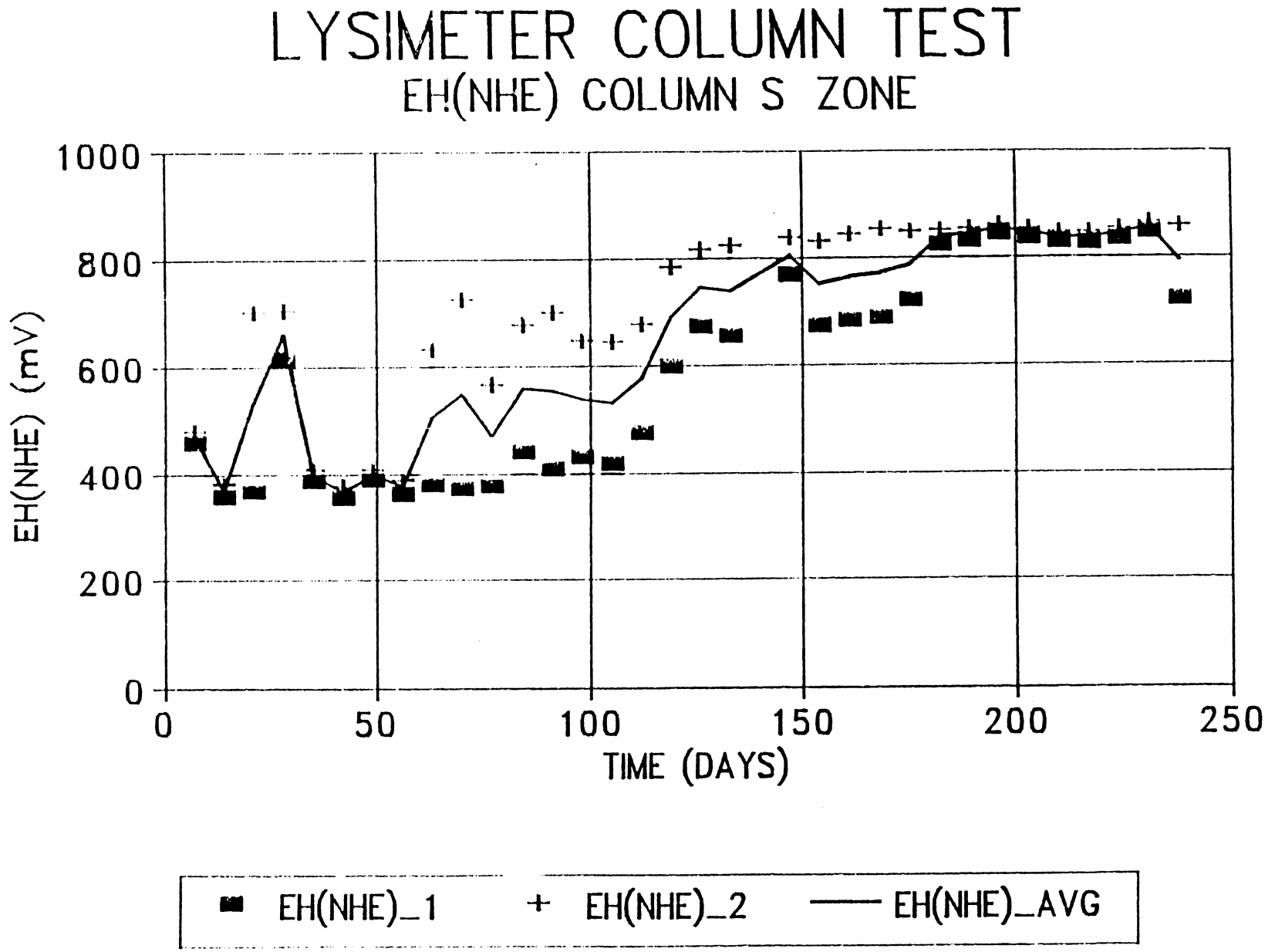


Fig. 28 - Effluent redox potential 'Eh' (absolute) for S Zone columns.

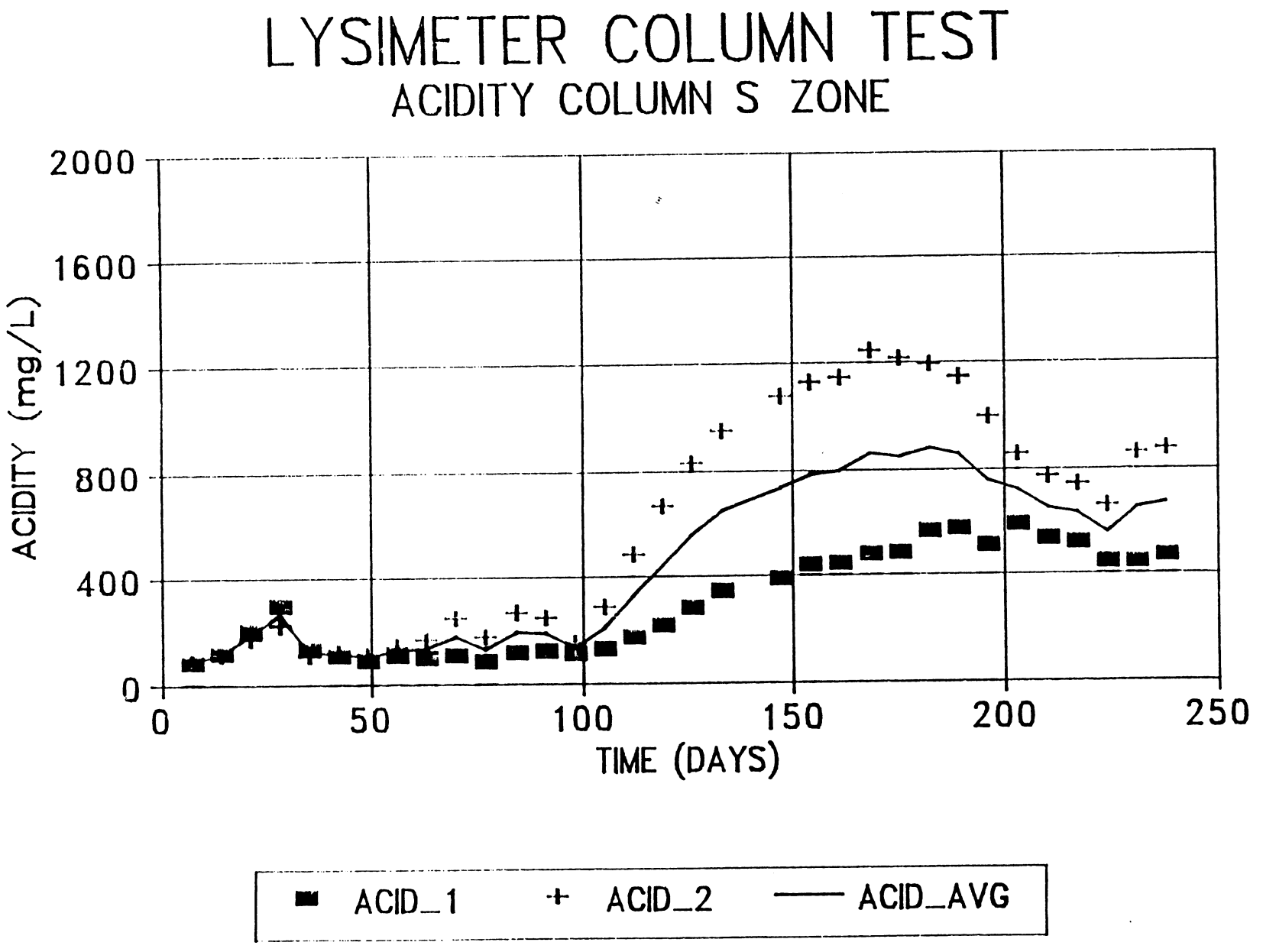


Fig. 29 - Effluent acidity for S Zone columns.

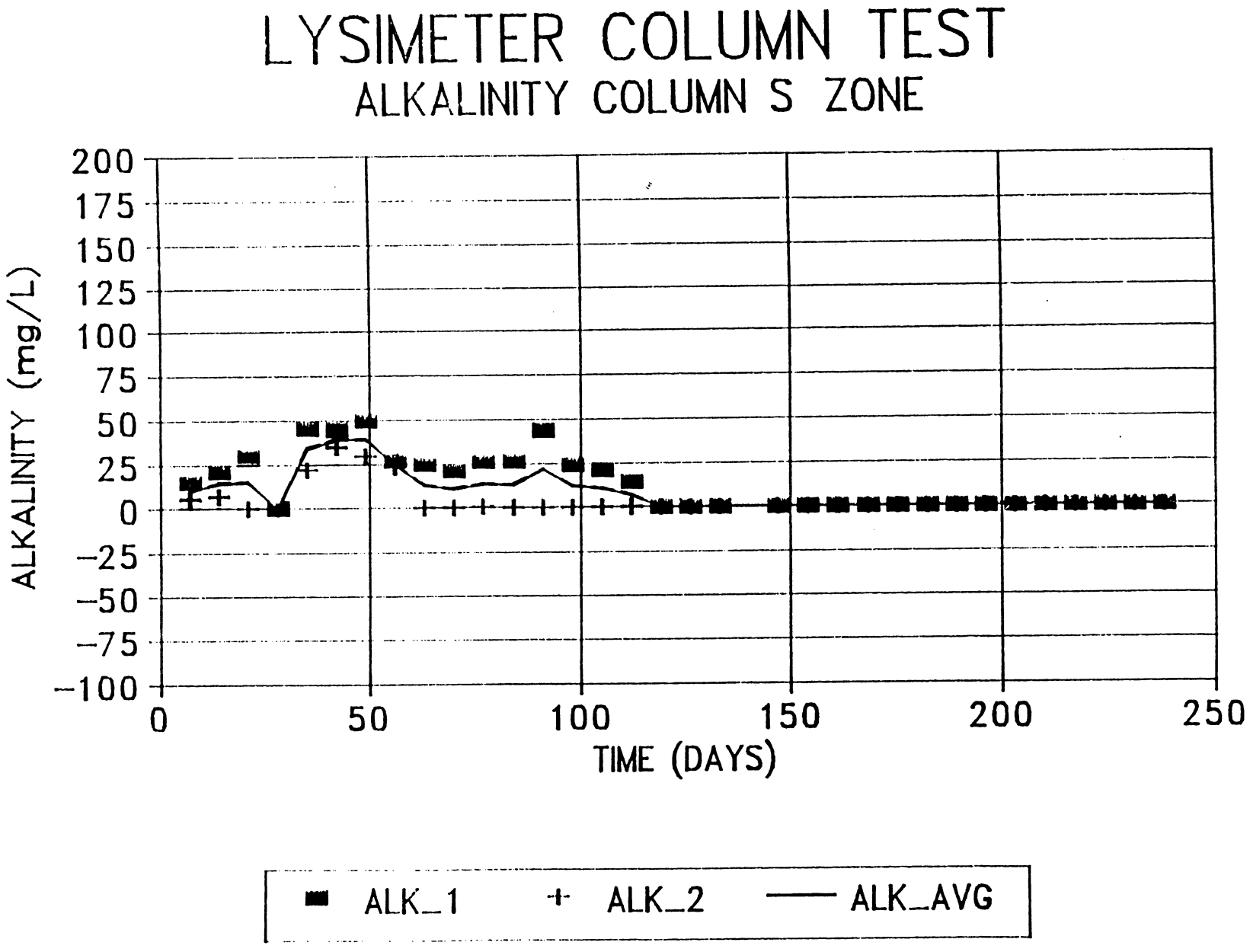


Fig. 30 - Effluent alkalinity for S Zone columns.

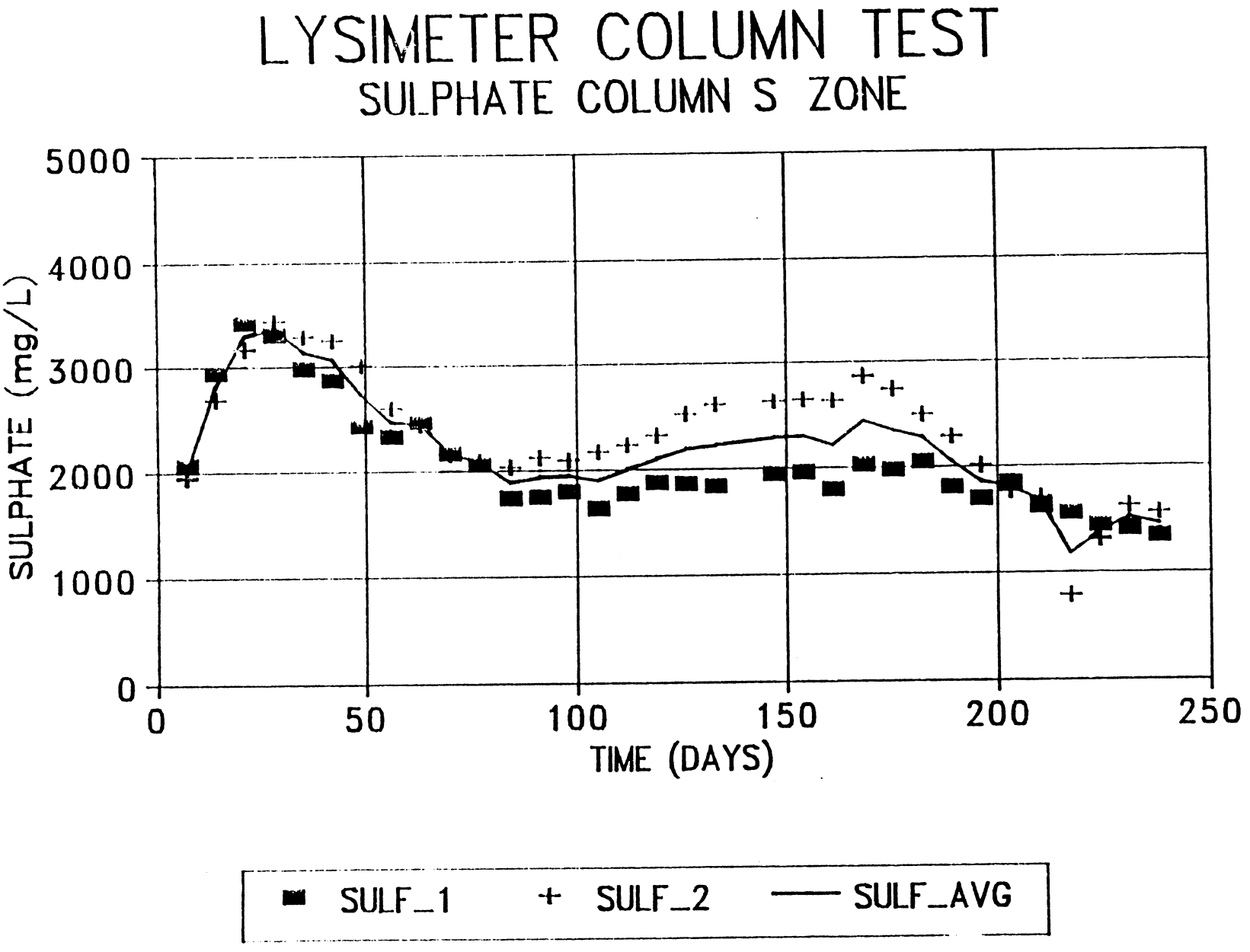


Fig. 31 - Effluent total sulphate (SO_4^{-2}) concentration for S Zone columns.

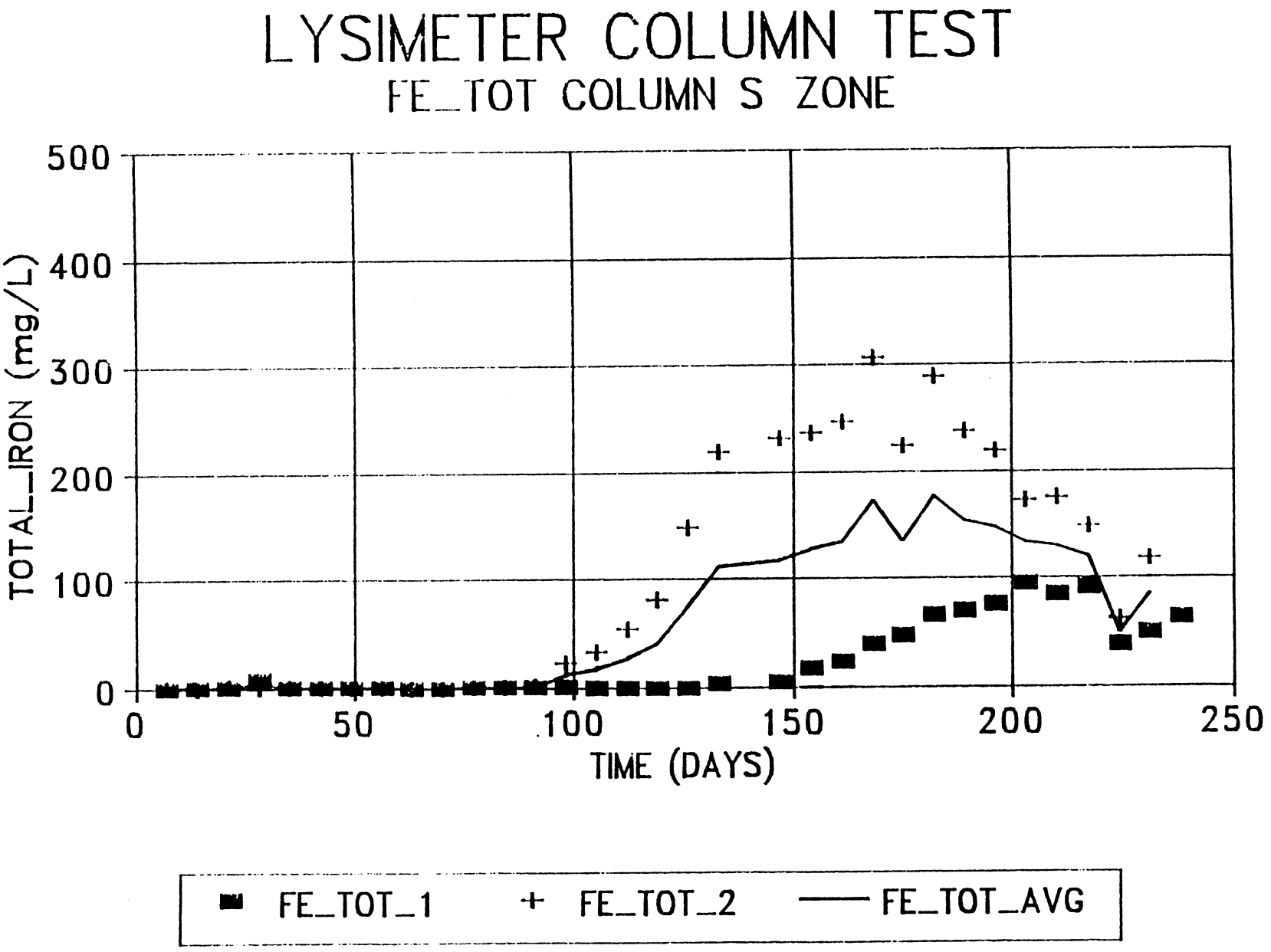


Fig. 32 - Effluent total iron (Fe) concentration for S Zone columns.

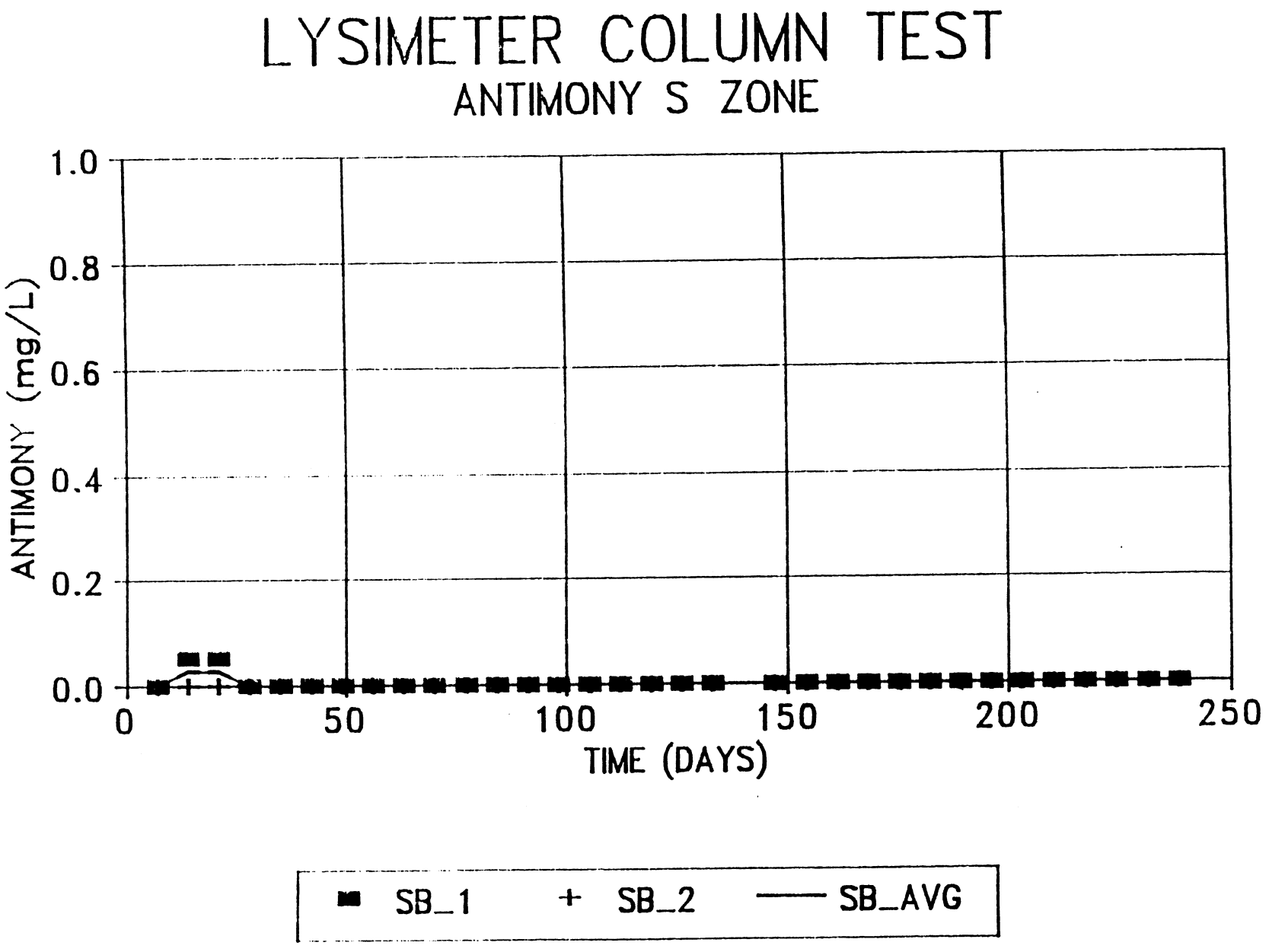


Fig. 33 - Effluent total antimony (Sb) concentration for S Zone columns.

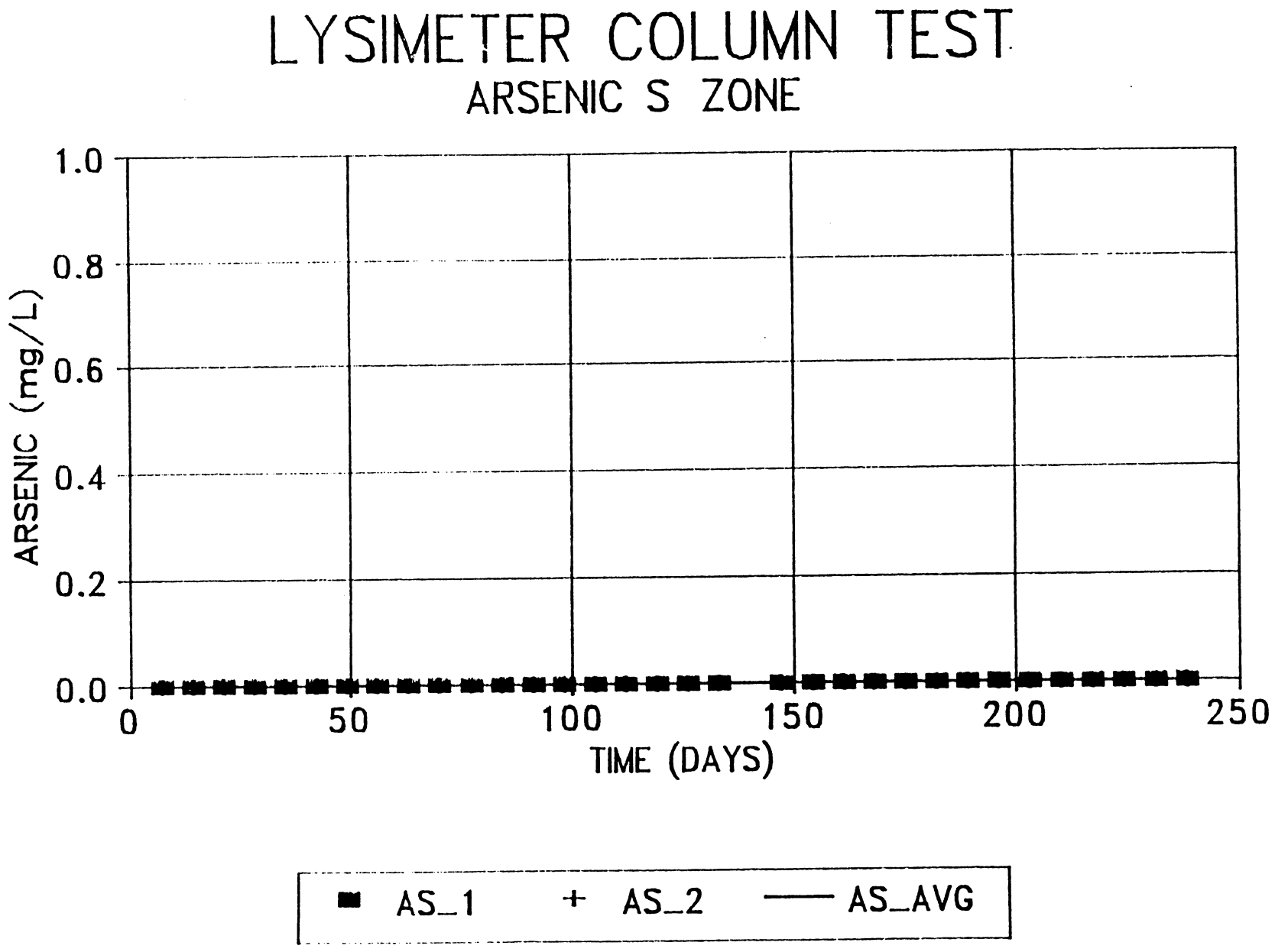


Fig. 34 - Effluent total arsenic (As) concentration for S Zone columns.

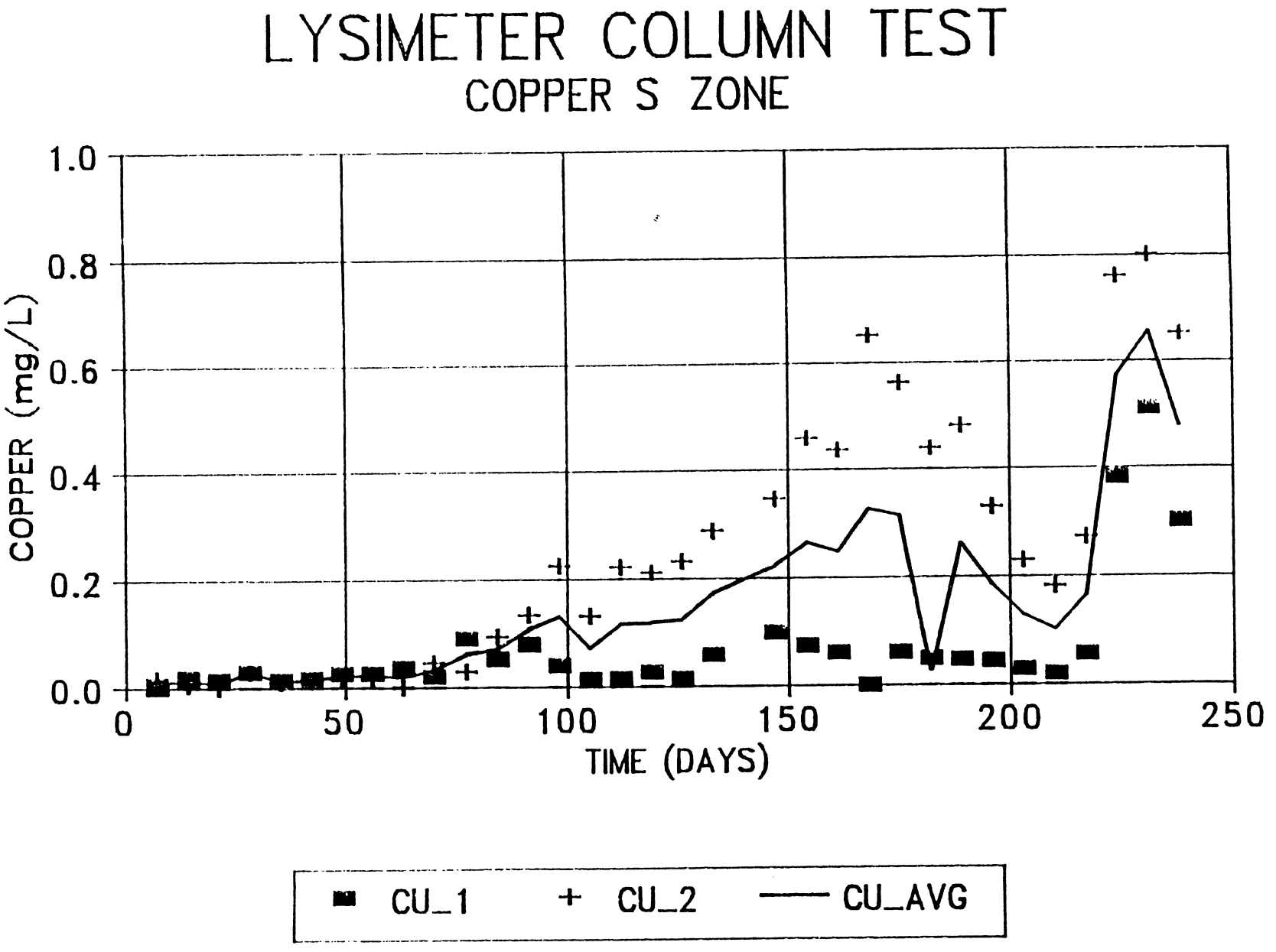


Fig. 35 - Effluent total copper (Cu) concentration for S Zone columns.

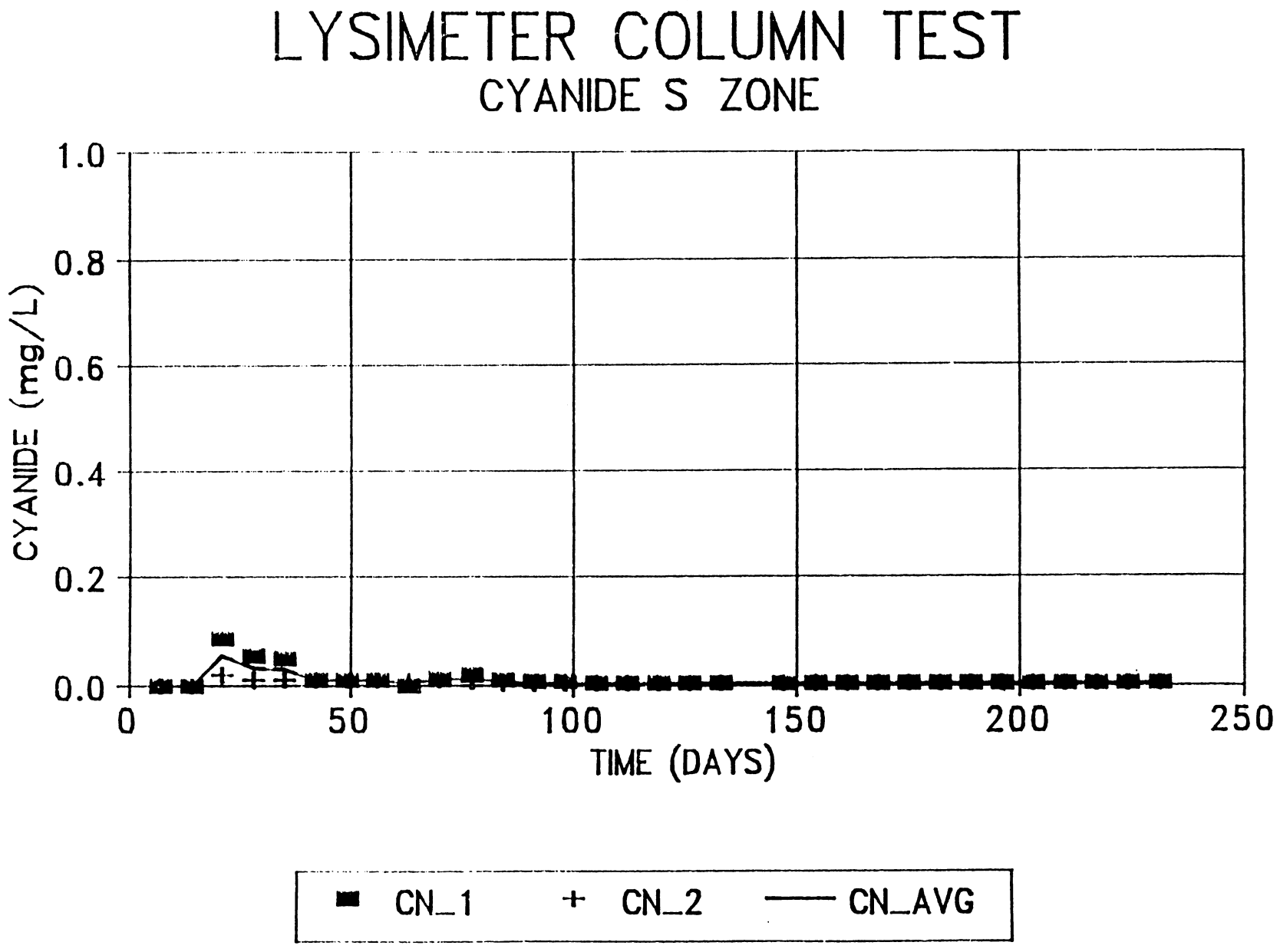


Fig. 36 - Effluent total cyanide (CN^-) concentration for S Zone columns.

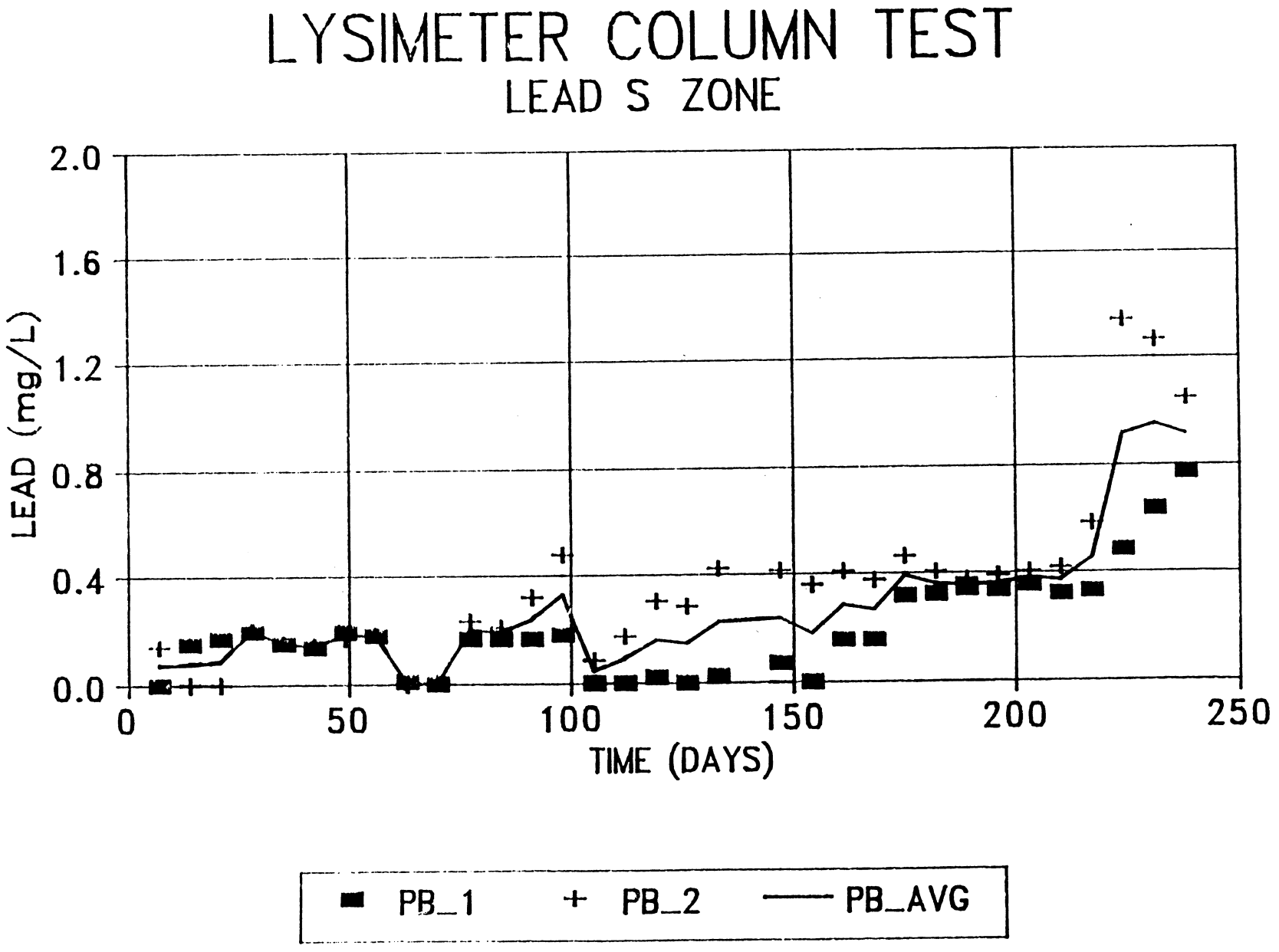


Fig. 37 - Effluent total lead (Pb) concentration for S Zone columns.

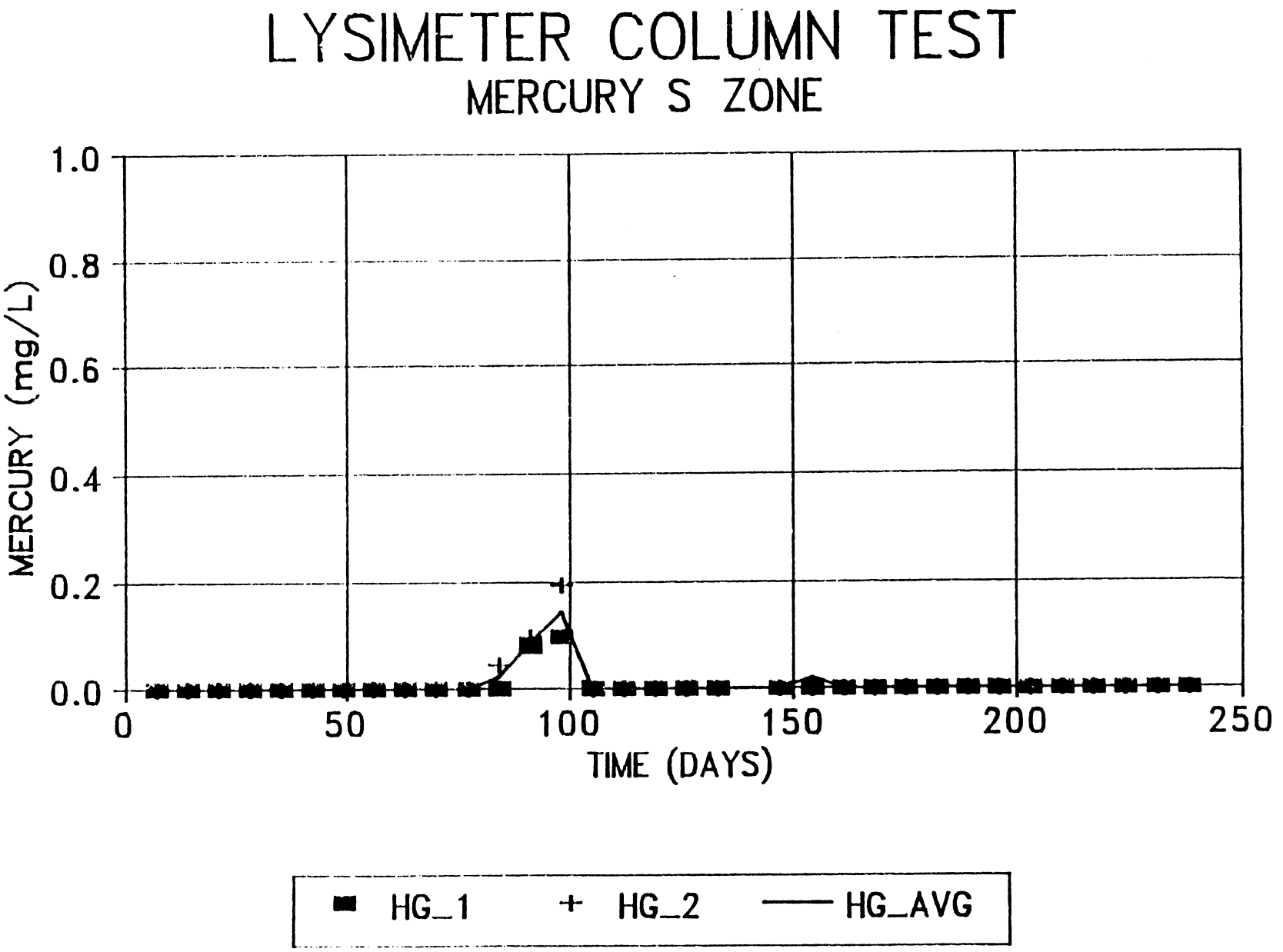


Fig. 38 - Effluent total mercury (Hg) concentration for S Zone columns.

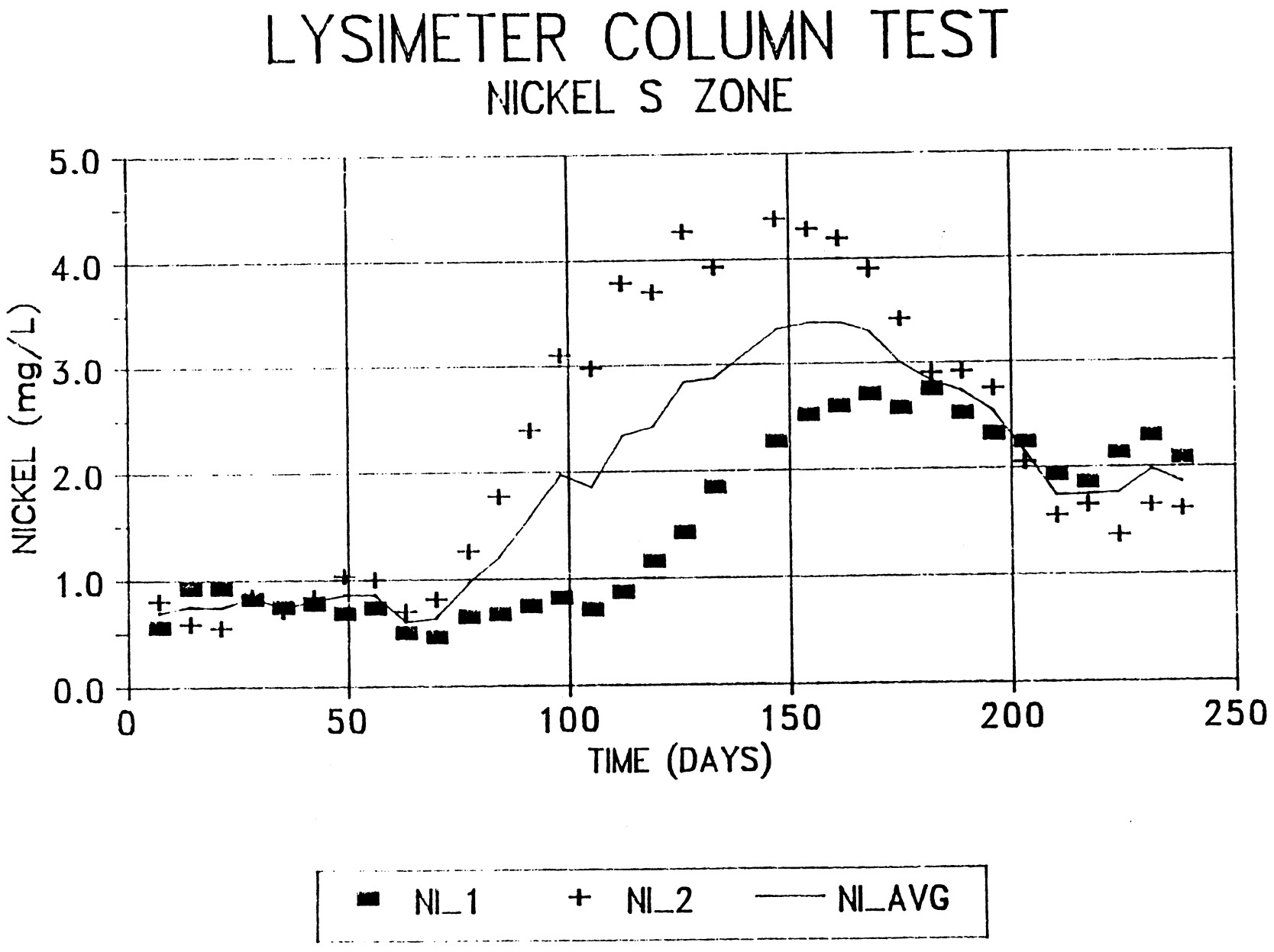


Fig. 39 - Effluent total nickel (Ni) concentration for S Zone columns.

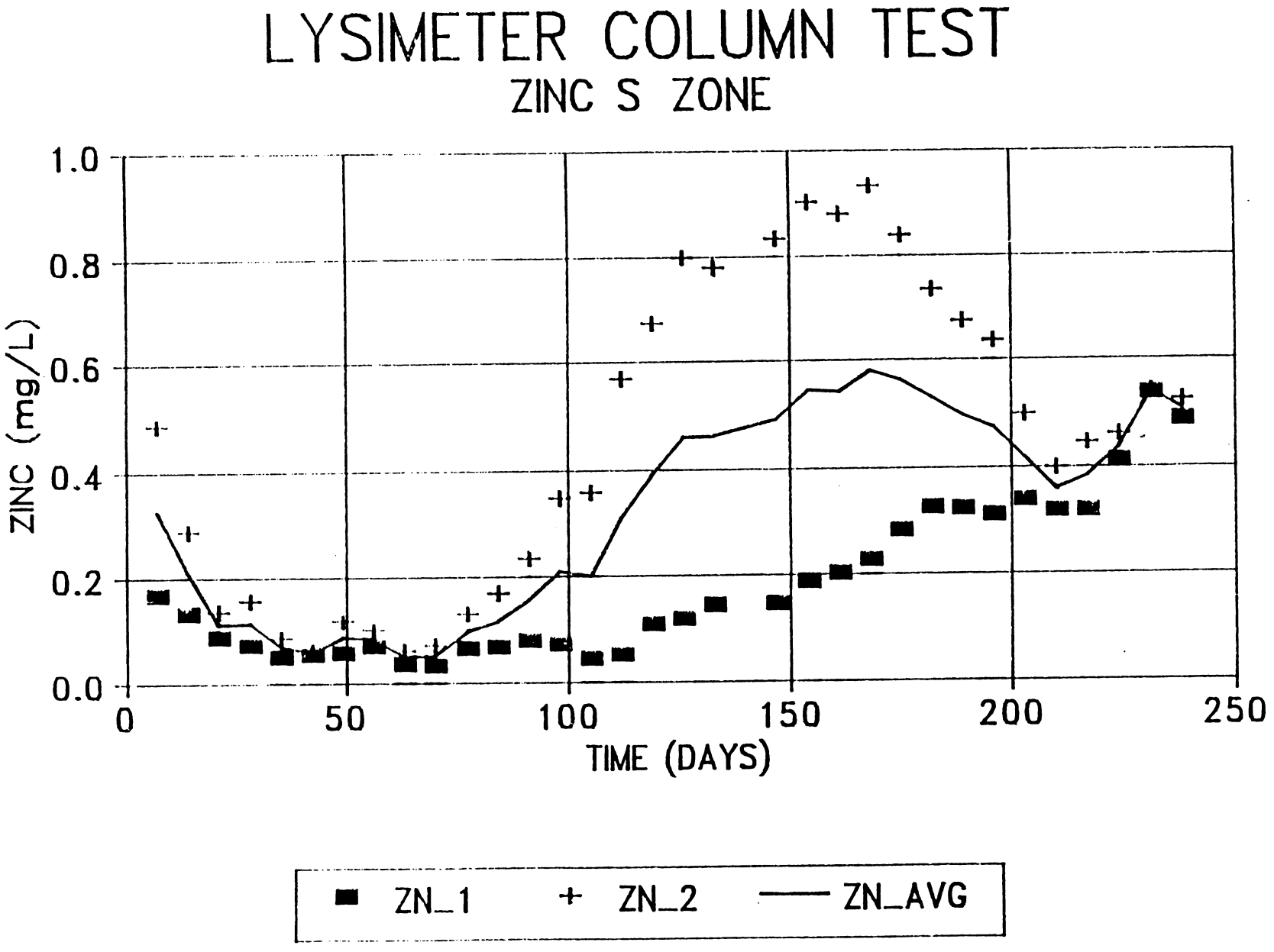


Fig. 40 - Effluent total zinc (Zn) concentration for S Zone columns.

GRAIN SIZE ANALYSES - ASTM D 422

SAMPLES #B1,#B2

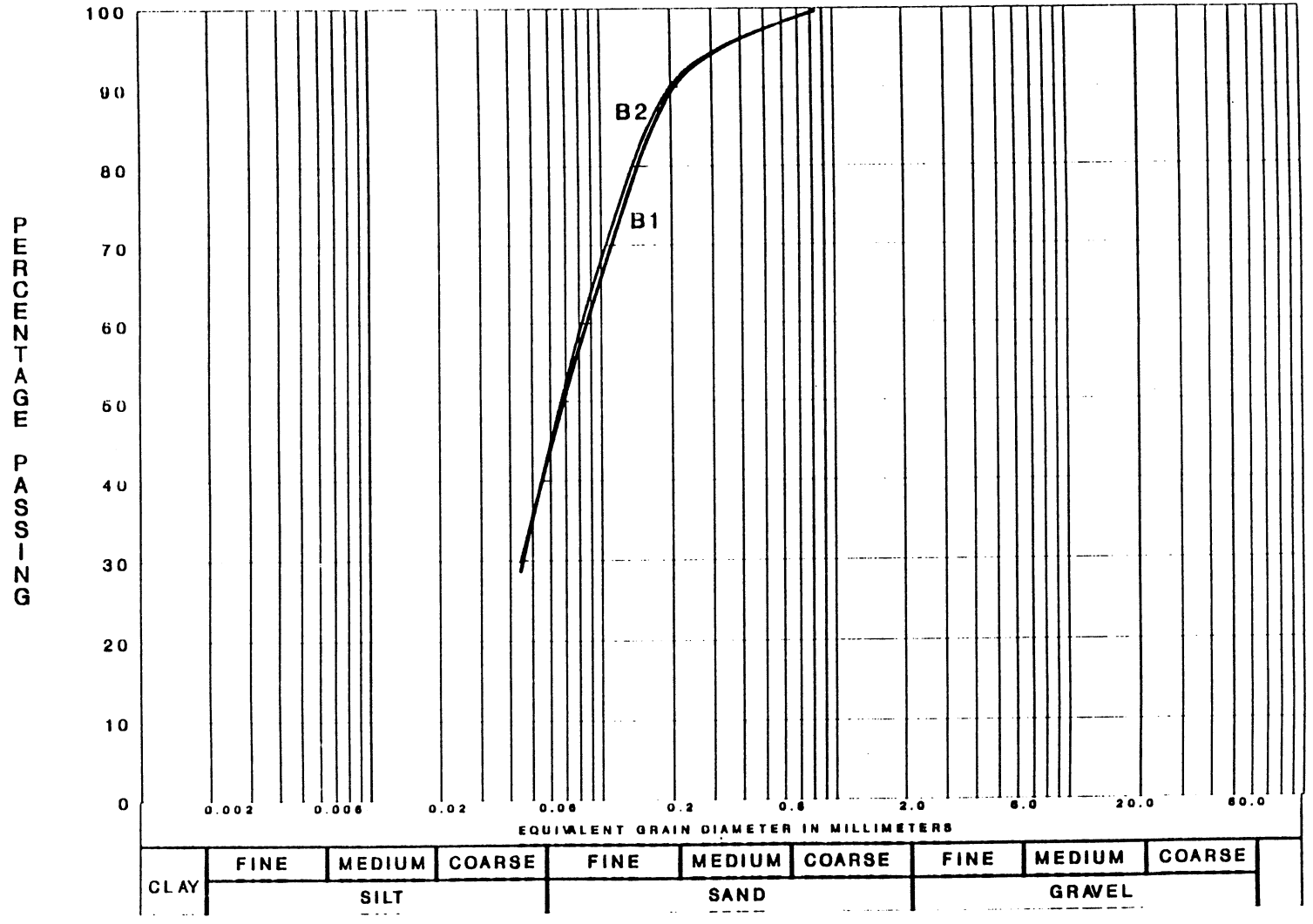


Fig. 41 - Grain size distribution of B Zone tailings.

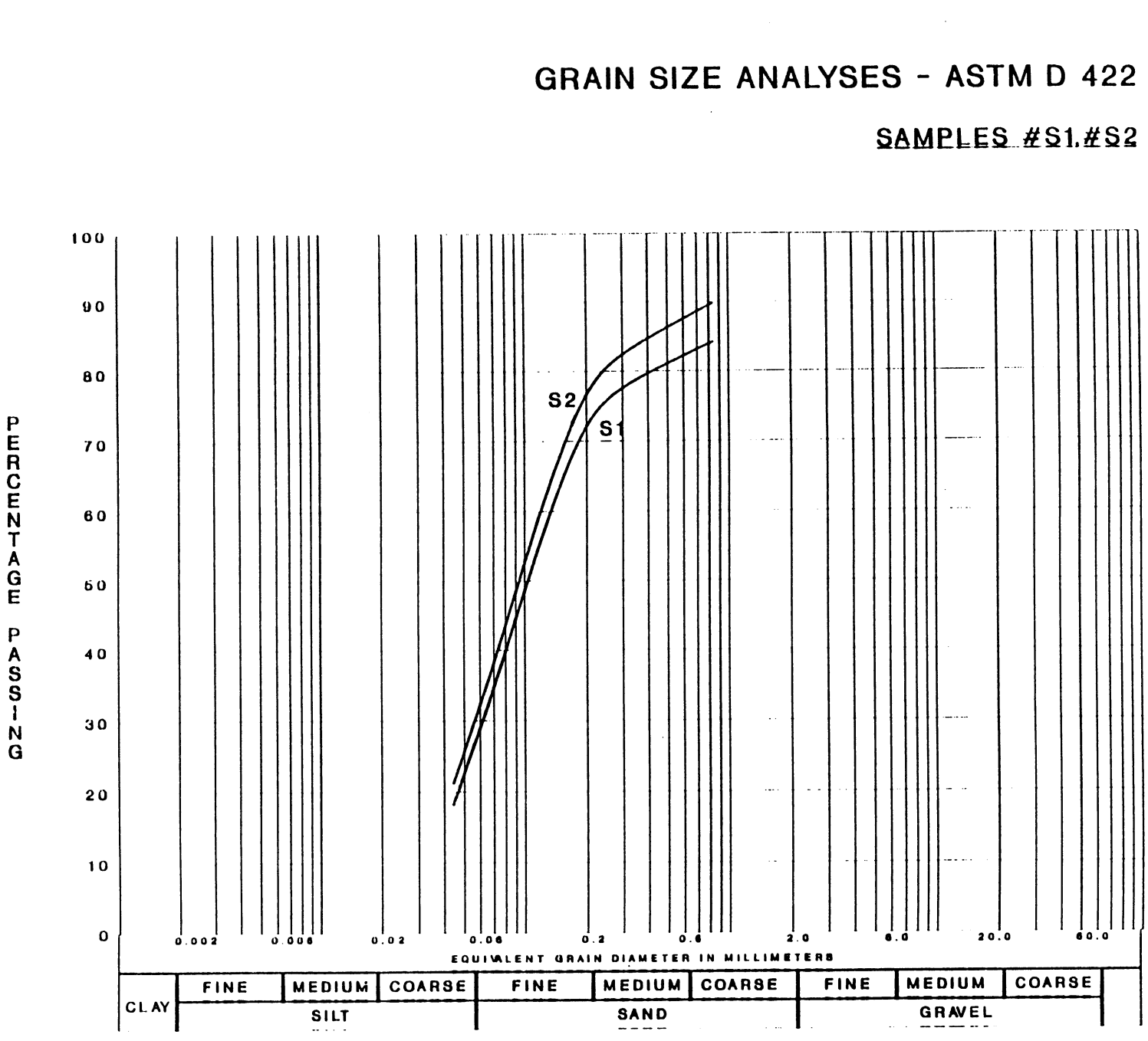


Fig. 42 Grain size distribution of S Zone tailings.

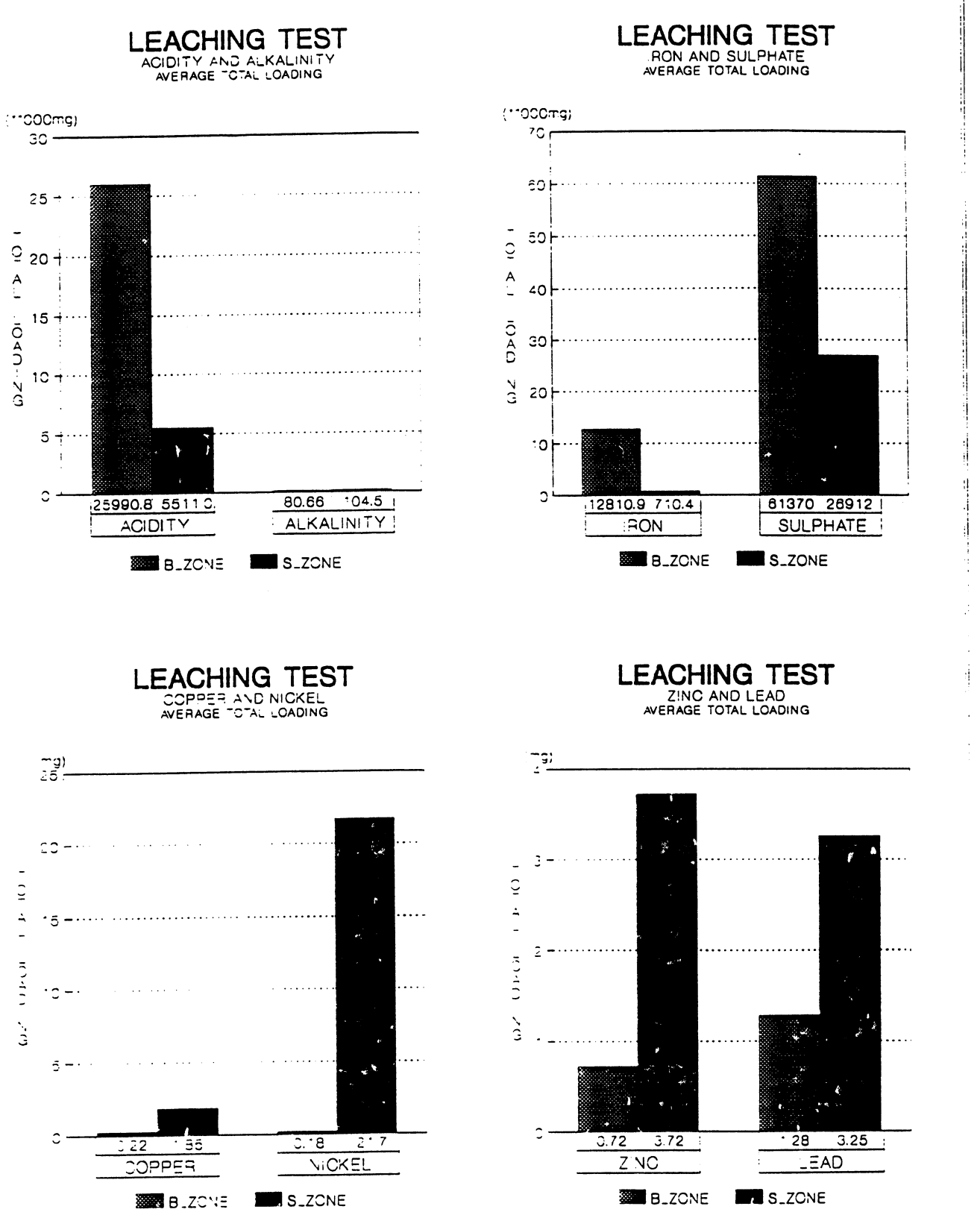


Fig. 3 - Total loading for acidity, alkalinity, iron, sulphate, copper, nickel, zinc and lead for B and S Zone tailings.

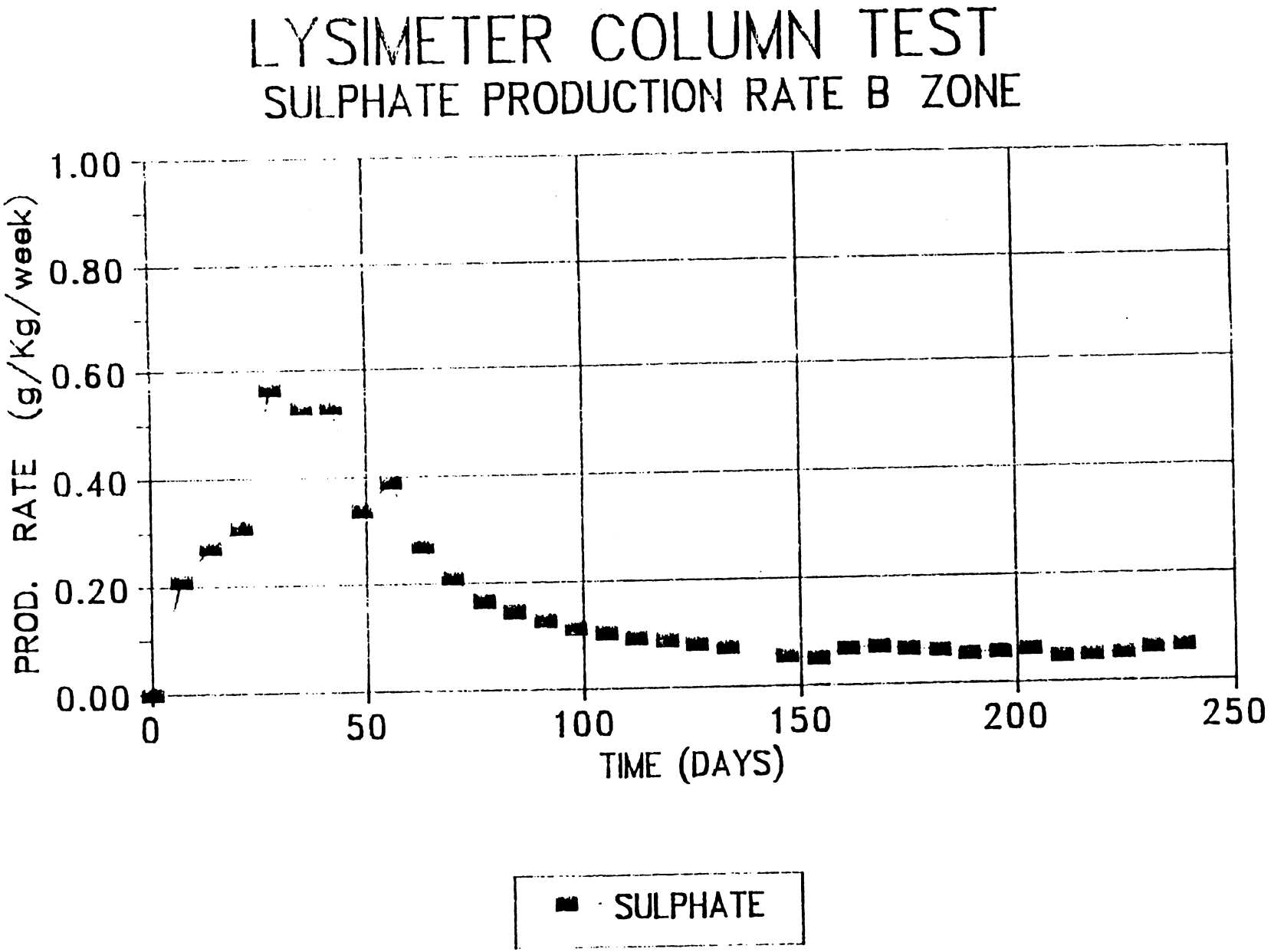


Fig. 44 - Rate of sulphate production per kg of tailings (dry weight) for B Zone tailings.

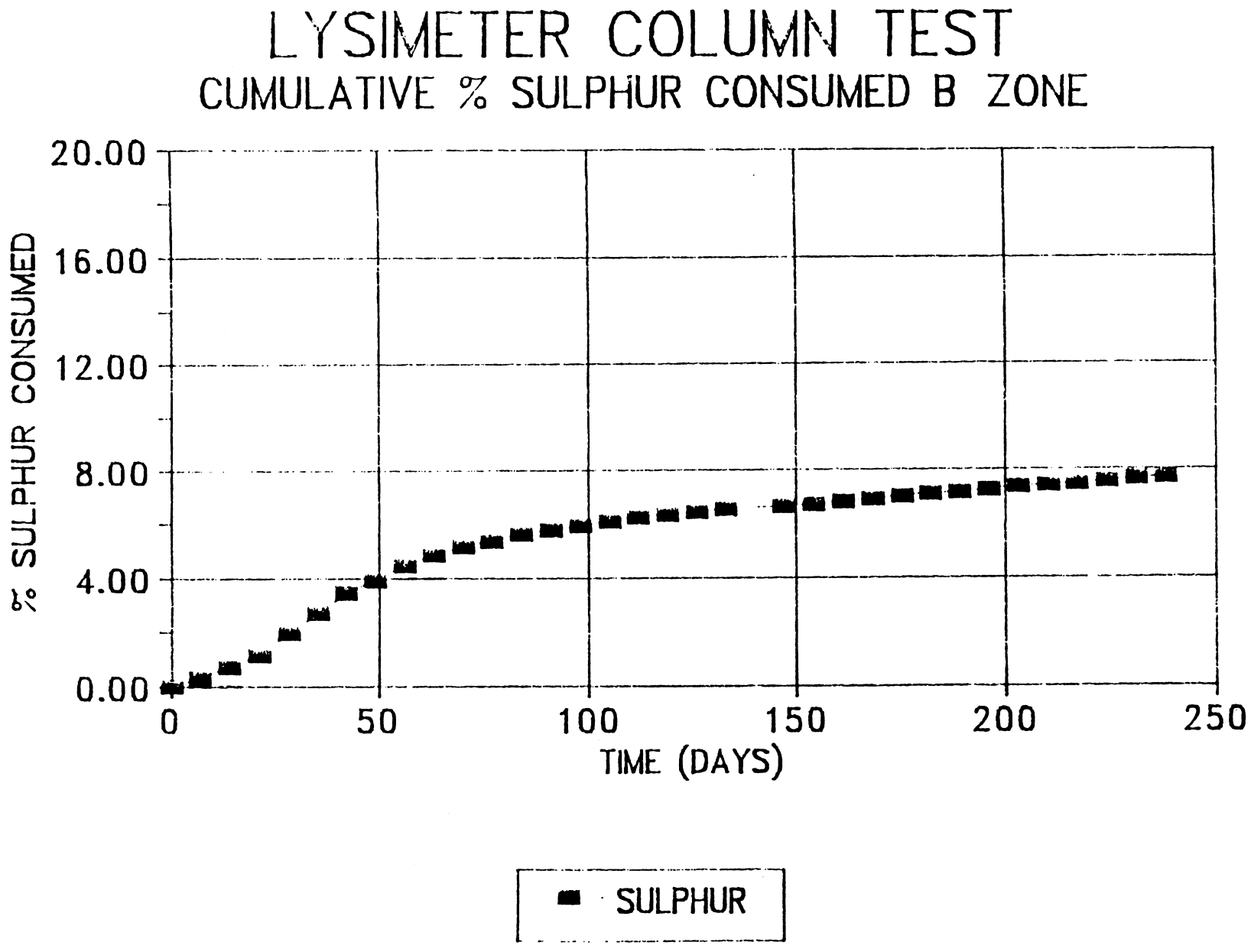


Fig. 45 - Cumulative rate of sulphur consumption (percent) for B Zone tailings.

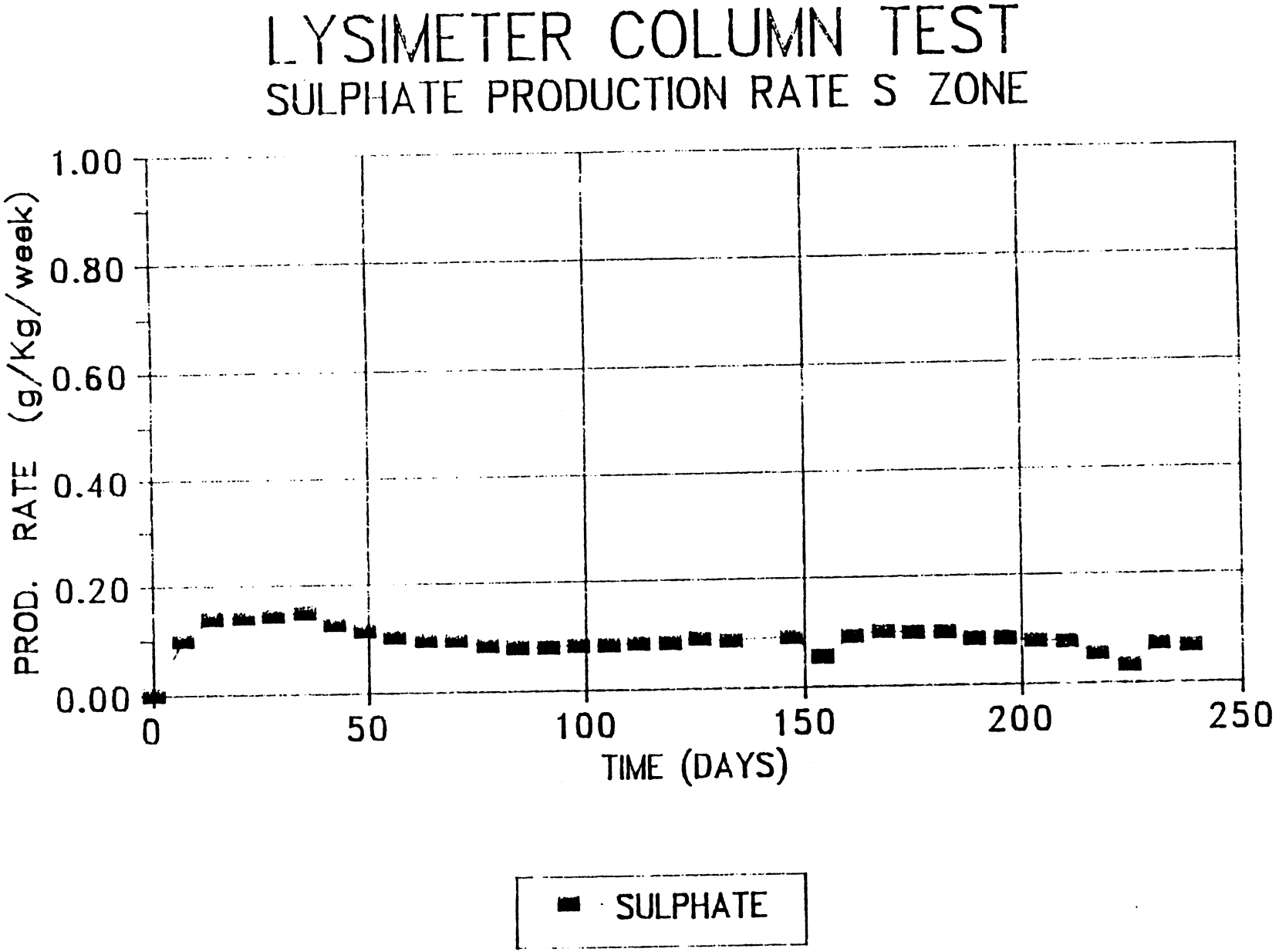


Fig. 46 - Rate of sulphate production per kg of tailings (dry weight) for S Zone tailings.

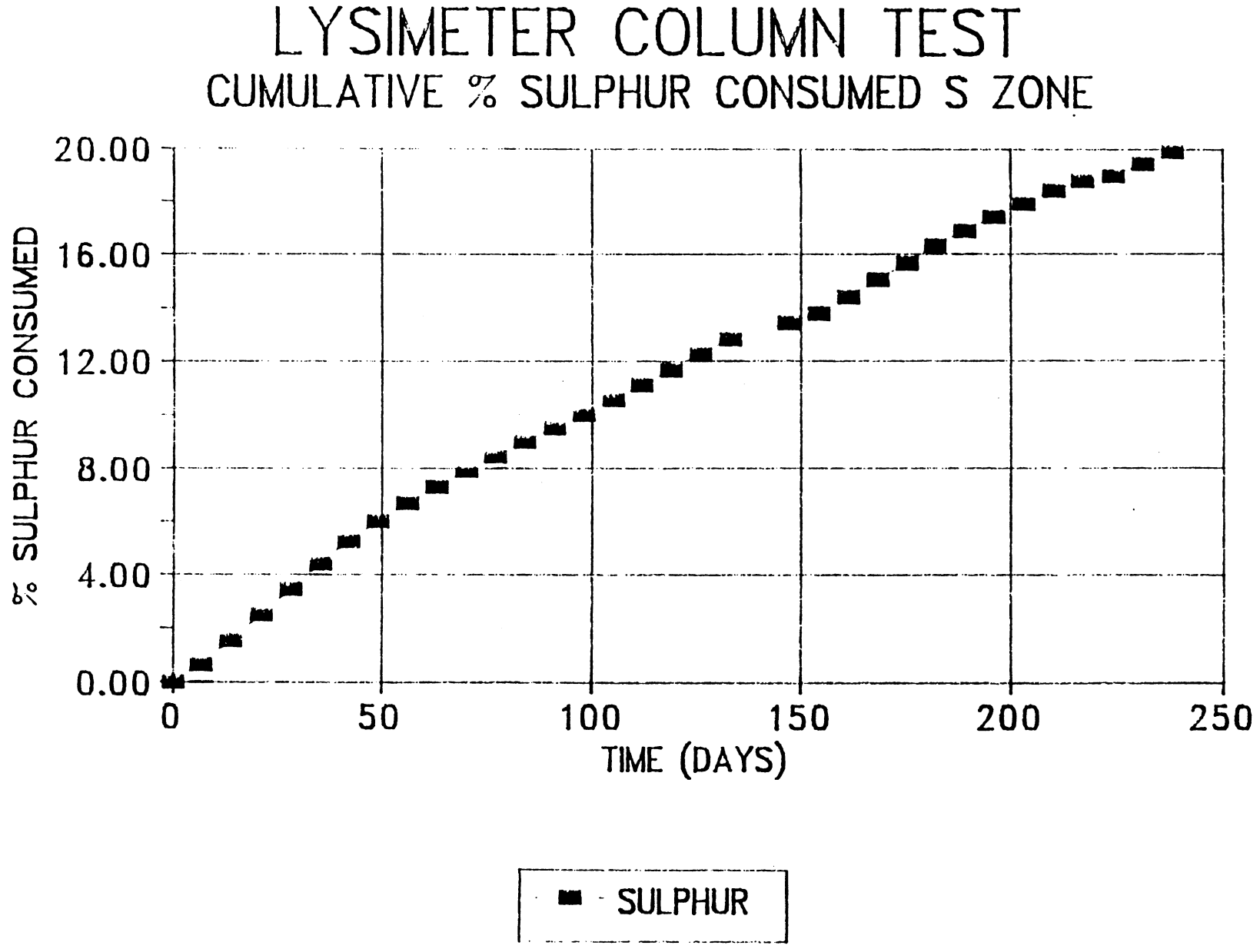


Fig. 47 - Cumulative rate of sulphur consumption (percent) for S Zone tailings.

CORONA CORPORATION

666 Burrard Street
Suite 2500
Vancouver, Canada
V6C 2X8

Fax (604) 669-7177
Telephone (604) 669-1011

October 16, 1990

Dr. N. Davé
Research Scientist
Energy Mines and Resources
CANMET
Elliot Lake Laboratory
P.O. Box 100, 99 Spine Rd.
Elliot Lake Ontario
P5A 2J6

Dear Dr. Davé,

Re: Contract work for Corona Corporation

Further to your discussions with Mr. W. Napier, we are prepared to contract the following work to your laboratory:

1. Cullaton Lake: Column Leaching Study

Two samples of Cullaton Lake Tailings have been sent to the CANMET laboratory. The purpose of the testwork is to acquire the necessary information to develop a Final Abandonment and Restoration Plan. If the tailings are non-acid generating, then covering the exposed beaches with overburden will be proposed. If the tailings are acid generating, then other decommissioning strategies will be considered. To satisfy our objective, a number of tests could be done, including humidity cell tests. We concur, however, with your view that leaching test columns should be adequate to provide us with the desired information.

(i) Prior to starting the column study the tailings samples will be analysed for sulphide speciation and a paste pH will be determined;

(ii) Four Schedule 80 PVC, 15 cm diameter, 2.4 m columns will be set up containing samples of tailings (one for each zone plus replicates);

(iii) The columns will be filled with tailings and underlain with a sand and gravel filter bed;

(iv) The columns will be innoculated with *Thiobacilli ferro oxidans* and will be leached using untreated natural lake water;

(v) The columns will be operated under trickle leach conditions with the water level at the sand and gravel interface;

(vi) The leachate will be collected and analysed weekly for a thirty week period.

Parameters to be analysed are pH, Eh, Ec, CN_{tot}, acidity alkalinity, sulphate, and dissolved metals such as iron, lead, copper, nickel, zinc, arsenic, mercury and antimony.

(vii) CANMET will prepare a summary report presenting and interpreting the data. The report shall be submitted no later than two months after the thirty week sampling period is completed.

2. Renabie Mine: Muskeg Bog Treatment

Renabie Mine is interested in demonstrating bog treatment for a portion of our supernatant discharge. Although the absorption/adsorption behaviour of bog plants is not well understood, experience shows that some plants have a natural affinity for certain types of metals and compounds. Next spring we would like to set up a pilot test along the south east corner of our tailings area. We would like to sprinkle approximately 300 to 5000 gpm of decant water into a spagnum moss bog and monitor any changes in effluent.

CANMET will be contracted to undertake the following work:

(i) provide a summary report on relevant studies applicable to our investigation;

(ii) analyze six soil samples for background concentrations of nickel, lead, zinc, copper, lead, sulphate, acidity, alkalinity and cyanide;

(iii) analyze another set of soil samples once the test work is completed;

(iv) during the test period {up to eight weeks} analyze water samples collected at the inflow and outflow of the bog; and

(v) prepare a report describing the results of the test work and speculate on the absorption/ adsorption characteristics of plants.

The cost for the above mentioned work, excluding travel arrangements, is estimated to be the following:

the cost for the Cullaton Lake Column tests is	$16,000
the cost for bog treatment at Renabie Mine is	$ 5,000

Should you wish further clarification or to discuss this matter further, please do not hesitate to contact the undersigned or Mr. W. Napier.

Yours truly

R. A. McCallum, P. Eng.
Vice-President
Operations

CULLATON LAKE GOLD MINES LIMITED

193 Hayes Road, Thompson, Manitoba R8N 1M5 (204) 778-7081 TELEX: 0766-4515

0 0 3 4 5

NORTHERN AFFAIRS BRANCH YELLOWKNIFE

MAR 12 10 34 '85

February 26, 1985

Northern Affairs Program
Water Resources Division
P.O. Box 1500,
Yellowknife, N.W.T.
X1A 2R3

Dear Sir:

Please find enclosed the Cullaton Lake Gold Mine report for 1984 on water consumption, waste discharge, and water sampling as required by Part A, Section 5 of our water license.

Should you require any further information please do not hesitate to contact my self or Dave Scrimger, our Safety Superintendent.

Yours sincerely,

D. G. Irwin,
Engineering Superintendent.

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12 1985
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

CULLATON LAKE
GOLD MINES LIMITED

193 Hayes Road, Thompson, Manitoba R8N 1M5 (204) 778-7081 TELEX: 0766-4515

1984 ANNUAL REPORT

Annual report for 1984 as per Part A, Section 5 of the Cullaton Lake water license.

ITEM A) Table 1 enclosed is the monthly water consumption, tailings discharge and tonnes milled.

B) No water was discharged from underground to the tailings pond. Water loss from mucking and mine air is such that in a perma-frost mine it is not necessary to discharge water.

C) Table II tabulates water samples taken from the Kognac River.

D) Table III is a summary of tailings pond sampling for the year.

E) Table IV tabulates mill tailings box samples for 1984.

F) During 1984, #1 dyke was raised approximately 2 meters. # 2 dyke was raised 1.5 meters.

G) Decanting from #2 pond was done through October and November, some 45 million gallons were discharged to the swamp east of the tailings dams.

H) Tables V and VI show results from samples taken from the discharged effluent.

Department of Indian &
Northern Affairs
Northern Operations
MAR 12 1985
WATER
YELLOWKNIFE, N.W.T.

D. G. Irwin,

Engineering Superintendent.

TABLE #1

MONTH	FRESH WATER Cu M.	TAILINGS Cu M.	TONNES MILLED
JANUARY	18,555	24,804	15,907
FEBRUARY	16,562	19,870	8,421
MARCH	17,079	20,309	8,222
APRIL	18,428	22,321	9,910
MAY	20,339	24,328	10,153
JUNE	21,720	25,238	8,955
JULY	23,460	27,853	11,183
AUGUST	26,847	32,770	15,077
SEPTEMBER	20,892	27,006	15,563
OCTOBER	23,742	28,796	12,864
NOVEMBER	23,808	27,828	10,232
DECEMBER	21,824	25,061	8,239
TOTAL	253,256	306,184	134,726

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12 1981
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

TABLE II

KOGNAK RIVER - SAMPLE #940-1

DATE TAKEN	AS ug/l	Hg ug/l	Alk. mg/l	Cu mg/l	Ni mg/l	Fe mg/l	Zn mg/l	Pb mg/l	Ca mg/l	Mg mg/l	Hard mg/l	SO_4 mg/l	Cl mg/l	N mg/l	SC umho/cm	pH	TSS mg/l
May 30/84	17	0.05	8	0.005	0.005	3.2	0.015	0.01	1.7	0.71	7	4.8	5.4	0.11	110	6.94	17
Dec 09/85	0.8	0.05	7	0.006	0.005	0.010	0.036	0.02	2	1	9	2	2	0.02	18	7.1	2

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12
WATER MANAGEMENT
YELLOWKNIFE

Northern Affairs
Northern Operations Branch
MAR 12 1985
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

TABLE III

TAILINGS POND WATER

SAMPLE 940-2

SAMPLE DATE		NH_3 mg/l	CN ug/l	AS ug/l	Cd mg/l	Cu mg/l	Fe mg/l	Ni mg/l	Pb mg/l	Zn mg/l	TSS mg/l	SC umho/cm	pH
May	13	17	272	130	-	4.5	-	1.3	0.005	0.4	30		
	24	19	388	202	0.005	2.9	5.5	0.55	0.03	0.11	78	2460	8.94
	31	7.8	78	29	0.005	0.32	0.52	0.18	0.02	0.007	4	834	7.13
June	07	10	132	243	0.005	0.15	2.1	0.024	0.02	0.008	5	1550	9.27
	14	7.6	122	238	0.005	0.30	1.7	0.047	0.02	0.027	16	1470	9.27
	21	9.6	125	215	0.005	0.34	1.1	0.068	0.02	0.013	9	1400	8.97
	28	7.2	125	340	0.005	0.29	0.48	0.073	0.02	0.005	39	1310	8.99
July	05	5.6	125	285	0.005	0.24	0.94	0.15	0.02	0.010	59	1380	8.63
	12	4.3	145	210	0.005	1.8	1.6	0.32	0.02	0.009	28	1430	8.97
	19	4.0	120	250	0.005	1.8	1.6	0.30	0.02	0.018	117	1470	7.94
	26	4.9	128	455	0.005	1.4	1.2	0.3	0.02	0.10	117	1468	8.21
Aug	05	3.6	120	208	0.005	1.4	0.79	0.30	0.02	0.013	22	1480	8.51
	12	4.6	90	210	0.005	1.6	1.2	0.30	0.03	0.005	46	1560	8.82
	20	5.4	140	210	0.005	1.4	1.1	0.34	0.02	0.024	46	1440	8.51
	26	4.0	140	300	0.005	1.6	0.94	0.30	0.02	0.017	29	1430	9.00
Sept	02	3.2	130	220	-	1.5	-	0.29	0.02	0.014	146		
	09	3.1	90	195	0.005	1.5	0.85	0.27	0.02	0.016	48	1360	8.98
	17	4.2	120	240	-	1.6	-	0.30	0.02	0.027	241	1000	7.4
	23	3.8	120	230	-	1.6	-	0.30	0.02	0.031	80	1000	7.4
	30	4.8	120	160	-	1.7	-	0.34	0.02	0.067	8	890	9.5
Oct	14	-	180	58	-	1.49	-	0.28	0.010	0.06	13	1050	9.4

TABLE IV

MILL TAILINGS BOX - SAMPLE #940-4

Sample Date	NH_3 mg/l	CN mg/l	Hg ug/l	AS ug/l	Cd mg/l	Cu mg/l	Fe mg/l	Ni mg/l	Pb mg/l	Zn mg/l	SC umho/cm	pH	TSS
Jan. 11	9.6	281	-	134	0.010	2.6	1.9	0.44	0.33	0.48	1940	10.84	3
Feb. 07	20	453	-	349	<0.005	4.7	3.4	0.46	< 0.02	0.46	2950	11.26	3
May 13	8.8	308	-	156	-	4.5	1.3	-	< 0.005	0.4	2470	11.18	5
June 10	8.4	282	-	202	<0.005	2.8	0.11	0.36	<0.02	14	2450	11.25	4
Aug. 05	34	358	-	10	0.010	3.4	0.14	0.34	<0.02	0.81	4020	11.64	< 1
Sept 02	32	320	-	7	-	3.1	-	0.37	<0.02	0.70			11
Oct. 01	36	290	-	2	-	2.2	-	0.33	<0.02	1.4			< 1
Nov. 01	27.5	202	-	4	-	3.24	-	0.33	.001	0.53	1650	11.1	14
Dec. 09	21	280		10	-	1.9	-	0.14	0.013	0.40	1220	11.2	2
Jan. 06	35.7	200	-	7	-	1.9	-	0.13	<0.005	0.51	2000	11.6	<1

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12 1985
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

TABLE V

SECOND TAILINGS POND DISCHARGE

Sample Date	CN	CU	TSS	SC	Ni	Zn
October 01	0.1	0.06	73	-	0.11	0.03
October 02	0.3	0.02	16			
	0.2	0.03	13			
October 04	0.2	0.03	21			
October 05	0.2	< 0.01	22			
October 06	0.2	0.02	18			
October 07	0.2	0.02	16			
October 08	0.2	0.04	14			
October 09	0.2	0.04	6			
October 10	0.3	0.04	35	-	0.06	< 0.1
October 11	< 0.1	< 0.01	17			
October 12	0.1	0.03	< 5			
October 13	< 0.1	0.02	21			
October 14	< 0.1	0.03	14	1200		
October 15	< 0.1	0.01	16			
	< 0.1	0.03	22			
October 16	0.1	0.02	23			
October 17	< 0.1	0.02	18			
October 18	< 0.1	0.03	20	1050		
	< 0.1	0.03	-			
October 20	0.1	0.01	16		0.04	0.01
October 22	< 0.1	0.01	27			
October 24	< 0.1	0.01	7	1100		
October 26	< 0.1	0.02	11			
October 28	0.7	0.01	11			
	-	0.02	11			
October 30	0.4	0.02	16			
November 01	0.2	0.02	35			
November 05	< 0.1	0.03	< 5	1770		
November 07	< 0.1	0.04	30	1600		
November 08	< 0.1	0.04	83	1420		
November 11	< 0.1	< 0.01	97	1590		

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12 1982
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

TABLE VI

Samples taken down stream from #2 Tailings Pond Discharge (Table V). Marsh site 8 and 9 are the same sites used on related water reports. Outlet site is the site that water discharged from the #2 Tailings Pond intersected with the Kognak River.

SAMPLE DATE	SITE	CN	Cu	TSS	SC	Ni	Zn
October 01	Marsh 8	< 0.1	0.01	18.5			
	Marsh 9	< 0.1	< 0.01	< 5			
October 04	Marsh 8	< 0.1	0.02	< 5			
	Outlet	< 0.1	0.01	< 5			
October 07	Marsh 8	0.2	< 0.01	7			
	Outlet	< 0.1	< 0.01	< 5			
October 10	Marsh 8	0.2	0.02	5			
	Outlet	0.2	0.01	< 5			
October 14	Marsh 8	< 0.1	0.02	10	900		
	Outlet	< 0.1	0.01	7	850		
October 18	Marsh 8	< 0.1	0.02	10	850		
	Outlet	< 0.1	0.02	17	800		
October 24	Marsh 8	< 0.1	0.01	< 5	1000	0.05	0.01
	Outlet	< 0.1	< 0.01	< 5	1300	0.05	0.01

Department of Indian & Northern Affairs
Northern Operations Branch
MAR 12 1985
WATER MANAGEMENT
YELLOWKNIFE, N.W.T.

TABLE #1

ITEM	FRESHWATER	TAILINGS	ORE MILLED
UNITS	CUBIC METRES	CUBIC METRES	TONNES
January	15,184	16,320	6449
February	14,786	18,252	6285
March	16,965	19,748	6563
April	16,906	19,981	6626
May	17,685	17,878	7807
June	16,624	23,617	8456
July	16,876	22,205	8715
August	18,113	29,937	8265
September	18,225	23,292	9718
October	18,035	22,555	8765
November	18,167	29,937	8265
December	18,478	22,600	8467
TOTAL	189,413	264,451	96748

*Note: No mine water was discharged to tailings.



Tamias Associates

0940

AUG 1 4 1996

Column Leaching Characteristics of Cullaton Lake B and Shear (S) - Zones Tailings

Phase 2: Cold Temperature Leaching

Final Report

Victor Clulow

Laurentian University

June 1996

Work performed for Homestake Canada Inc., in participation with the Canada Centre for Mineral and Energy Technology (CANMET), Elliot Lake Laboratory.

Preface

This report contains the results of work carried out by Dr. Nand Davé of the Elliot Lake laboratory, Canada Center for Mineral and Energy Technology (CANMET), Natural Resources Canada (NRCan), Elliot Lake, Ontario.

Dr. Davé heads the Surface Environmental Research Laboratory in Elliot Lake and researches mechanisms of Acid Rock Drainage, and tests methods of controlling this phenomenon. This report describes experiments conducted to understand the Acid Rock Drainage mechanism at cold temperatures.

The assistance of Ms. D. Horne, Ms. Y. Boucher, and Mr. T. P. Lim in this work is gratefully acknowledged.

Column Leaching Characteristics of Cullaton Lake B and Shear (S) - Zones Tailings Phase 2: Cold Temperature Leaching

Victor Clulow

Professor, Department of Biology, Laurentian University, Sudbury, Ontario, Canada, P3E 2C6

EXECUTIVE SUMMARY

Cold temperature column leaching tests at 2 °C and 10 °C were conducted for Cullaton Lake B and Shear (S) - Zones tailings to evaluate their oxidation and leaching characteristics at low ambient temperatures. The tests were an extension of an earlier room temperature study at 25 °C (Phase 1) in which both B and S - Zones tailings produced acidic drainage under laboratory simulation conditions (Davé, 1992).

The low temperature leaching studies were designed to simulate conditions similar to those expected within the tailings at the Cullaton Lake site after implementation of a decommissioning plan of covering the tailings with approximately 1.5 m of wasterock and overburden for promoting freezing and permafrost conditions within the tailings. It was anticipated that during the frost free period some of the tailings might thaw to temperatures ranging between 0 °C and 10 °C.

These tests were conducted in clear acrylic columns, 12.5 cm in diameter and 80 cm high. Duplicate columns were filled with well mixed tailings from each zone, inoculated with a solution containing *Thiobacillus ferrooxidans* culture and placed in a walk-in refrigerated experimental cold chamber. The tailings were allowed to weather under unsaturated

conditions at the desired cold temperatures of 2 °C and 10 °C, and leached by rinsing with well aerated natural lake water chilled to the same experimental temperature.

The leaching scheme consisted of batch additions of 1 l (litre) natural lake water, once every one or two weeks, to each experimental column undergoing weathering. The columns were allowed to drain freely during the intermediate period. Effluent was collected and analyzed for pH, redox potential (Eh), electrical conductance (Ec), total acidity, total alkalinity, and dissolved concentrations of SO_4^{2-}, total Fe, Ca, Mg, Al, Mn, Sb, As, Cu, Ni, Zn, Pb, Hg, Si, and CN^{1-}. The tailings were first weathered and leached at 2 °C for two years, and then at 10 °C for another year. For starting the leaching experiment at 10 °C, the experimental chamber and tailings were warmed to the desired temperature, individual tailings homogenized and the columns recharged. The column leaching results are as follows:

- Oxidation and acid generation occurred in both B and S - Zones tailings at low (2 °C) and intermediate (10 °C) temperatures. The rate of acid generation was low and the occurrence of acidic drainage was delayed at these temperatures compared to those observed at 25 °C in the previous study by Davé (1992).

- The B - Zone tailings contained relatively high sulphide (2.31% as S) and high total available alkalinity (45.36 kg $CaCO_3$/tonne tailings), and had a large negative net neutralization potential (NNP) of -26.84 kg $CaCO_3$/tonne tailings. The acid generation rate in the tailings at 2°C was low such that a reasonable degree of acid neutralization was achieved and acidic drainage prevented during most of the leaching period at this temperature.

- Acidic drainage occurred near the end of the leaching period at 2 °C but the overall impact in terms of total acidity and effluent metal loading was low.

- Near the end of the two year leaching at 2 °C, the drainage effluent was characterized by a pH of ~ 6.6, acidity ~ 300 mg $CaCO_3$ /l, and concentrations of SO_4^{2-} at ~ 2,000 mg/l, Fe ~ 150 mg/l, Ca ~ 500 mg/l, Mg ~ 100 mg/l, Al ~ 0.15 mg/l, and Mn ~ 20 mg/l. Trace amounts of As ~ 0.1 mg/l, Ni ~ 0.1 mg/l, and Pb ~ 0.5 mg/l were also observed. Cu, Sb, Hg, and Zn levels were below detection limits.

- A cumulative total of 21% of the total sulphur contained in the B - Zone tailings was mobilized and removed as total sulphate in the effluent during the two year leaching period at 2 °C. Approximately 10% of this total sulphur was present in the soluble form which leached rapidly, within two months, at the beginning of the experiment. The remaining ~ 11% of the total sulphur was removed as a result of acid generation and neutralization at 2 °C.

- The magnitude of acidic drainage initially increased for B - Zone tailings during leaching at 10°C. Concentration peaks for acidity, iron and some metals were observed after approximately two months of leaching. The effluent was characterized by a pH of ~ 5.0, moderate acidity ~ 850 mg $CaCO_3$/l, and concentrations of SO_4^{2-} at ~ 3,500 mg/l, Fe ~ 450 mg/l, Ca ~ 500 mg/l, Mg ~ 100 mg/l, Al ~ 0.2 mg/l, and Mn ~ 22 mg/l. Low concentrations of As ~ 0.2 mg/l, Ni ~ 0.15 mg/l, Pb ~ 0.5 mg/l, and Sb ~ 0.05 mg/l, were also observed, but Cu, Hg, and Zn levels were below detection. After peaking, the magnitude of the acidic drainage gradually decreased with time to a low level in the last six months of leaching.

- A cumulative total of 5.3% of the total sulphur contained in the B- Zone tailings was further mobilized and released during one year of leaching at 10 °C.

- In contrast to the room temperature (25°C) leaching of the B - Zone tailings (Davé, 1992), the above results indicated very slow oxidation at 2°C and an initial slight to moderate oxidation during leaching at 10°C. The overall impact of acidic drainage from B - Zone tailings was low, in the short term, at colder temperatures due to

complete acid neutralization. The tailings retained appreciable amounts of moisture (85-100% pore volume saturation) during laboratory leaching, which further limited oxidation and acidification, thereby controlling acidic drainage and reducing its impact.

- The S - Zone tailings contained relatively low sulphide (0.4% as S) and low total available alkalinity (2.0 kg $CaCO_3$/tonne tailings), and had a moderate negative net neutralization potential (NNP) of -10.5 kg $CaCO_3$/tonne tailings. The acid generation rate in these tailings was also low at 2 °C, but because of low available alkalinity there was insufficient acid neutralization and acidic drainage occurred early in the 2 °C leaching period.

- During the middle of the two year leaching period at 2 °C, acid drainage peaked where effluent was characterized with a pH of ~ 3.0, moderate acidity ~ 600 mg $CaCO_3$/l, and dissolved concentrations of SO_4^{2-} at ~ 700 mg/l, Fe ~ 175 mg/l, Al ~ 25 mg/l, Mn ~ 30 mg/l, As ~ 0.4 mg/l, Cu ~1.2 mg/l, Ni ~ 1.0 mg/l, Zn ~0.4 mg/l, Pb ~ 2.0 mg/l, and Si ~ 50 mg/l. Effluent concentrations of Ca and Mg were low at 30 and 10 mg/l respectively. Sb was present at trace levels, ~ 0.03 mg/l, and Hg levels were below detection.

- A cumulative total of 42% of the total sulphur contained in the S - Zone tailings was mobilized and released during the two year leaching at 2 °C. The tailings contained approximately 25% of the total sulphur in the soluble form which was quickly removed within first two months of leaching at 2 °C. Further leaching at 2 °C resulted in an additional mobilization and removal of sulphate in the amount equivalent to 17% of the total sulphur contained in the tailings.

- With the raising of the leaching temperature to 10 °C, the acidic drainage continued and increased in magnitude for S - Zone tailings. Similar to B - Zone tailings, effluent concentration peaks for acidity, iron and metal loading were also observed initially

during leaching at 10°C. The effluent was characterized by a pH of ~ 3.0, moderate acidity of ~ 650 mg $CaCO_3$/l, and dissolved concentrations of SO_4^{2-} at ~ 1,500 mg/l, Fe ~ 225 mg/l, Ca ~ 500 mg/l, Mg ~ 100 mg/l, Al ~ 25 mg/l, Mn ~ 30 mg/l, As ~ 0.2 mg/l, Cu ~ 1.2 mg/l, Ni ~ 1.5 mg/l, Zn ~ 1.0 mg/l, Pb ~ 2.0 mg/l, and Si at 50 mg/l. As was the case for 2°C leaching, the effluent concentrations of Sb were at trace levels, ~ 0.06 mg/l, and Hg concentrations were below detection. The magnitude of the acid drainage, after peaking, also decreased slowly with time to a low level in the last six months of leaching.

- A cumulative total of 13% of the total sulphur contained in the S- Zone tailings was further mobilized and released during one year of leaching at 10 °C.

- The S - Zone tailings were also characterized by a high moisture retention and poor drainage that limited the oxidation, acidification and overall impact to the well drained upper layer.

- In contrast to what was seen with B - Zone tailings, no significant reduction in acidic drainage from S - Zone tailings was observed during leaching at lower temperatures from that of room temperature (25°C) in the earlier study, reflecting the low total available alkalinity and inadequate neutralization in S - Zone tailings.

- It is recommended that the data should be further examined and analyzed to obtain acid generation and metal loading rates at the three study temperatures (25°C, 10°C, and 2°C). Quantitative microbiological studies should also be undertaken to distinguish between (and measure) chemical and biotic oxidation at low temperatures.

- The tailings facility at the Cullaton Lake site should also be assessed for its current physical, chemical, mineralogical and biological status by undertaking suitable field studies.

Table of Contents

Page

EXECUTIVE SUMMARY iii

1.0 INTRODUCTION 1

1.1 Background to Study 1

1.2 ARD and Its Control 3

1.3 Site Description 6

2.0 EXPERIMENTAL METHODOLOGY 10

2.1 Experimental Arrangement 10

2.2 Sampling Procedures 11

2.2.1 Tailings Sampling, Loading of Columns and Placement in the Cold Temperature Chamber 11

2.2.2 Inoculation with Bacterial Culture 11

2.2.3 Leaching Scheme 12

2.2.4 Water Sampling, Filtration and Sample Preservation 13

2.3 Analytical Procedures and Quality Assurance / Quality Control (QA/QC) 14

2.3.1 Water Samples 14

2.3.1.1 Primary Parameters pH, Eh, Ec, Total Acidity, Total Alkalinity 15

2.3.1.2 Elemental Analysis 16

2.3.1.3 Sulphate Analysis 16

2.3.1.4 Cyanide Analysis 17

2.3.1.5 Minimum Detection Limits 17

2.3.2 Solid Samples 18

2.3.2.1 Sample Digestion 18

2.3.2.2 Sulphur Speciation 19

2.3.2.3 Quality Assurance / Quality Control (QA/QC) 19

3.0 RESULTS 20
3.1 Solid Phase Comparison 20
3.2 Column Leaching Results 21
3.2.1 B - Zone Tailings 22
pH, Eh, Ec, ... 22
Total Acidity and Alkalinity 23
Sulphate and Iron 24
Calcium and Magnesium 25
Aluminium and Manganese 26
Other Metals
Sb, As, Cu, Pb, Hg, Ni, Si (dissolved) and Zn 26
Total Dissolved Cyanide 27
3.2.2 Shear (S) - Zone Tailings 27
pH, Eh, Ec, ... 27
Total Acidity and Alkalinity 28
Sulphate and Iron 29
Calcium and Magnesium 30
Aluminium and Manganese 31
Other Metals
Sb, As, Cu, Pb, Hg, Ni, Si (dissolved) and Zn 31
Total Dissolved Cyanide 32
4.0 DISCUSSION 32
5.0 SUMMARY AND CONCLUSIONS 35
6.0 RECOMMENDATIONS 36
7.0 REFERENCES 37

List of Figures

Figure		page
1.	Location of Cullaton Lake mine, Northwest Territories	39
2.	Location of B - and Shear - Zones at the Cullaton Lake mine property	40
3.	Vertical section of a leaching column	41
4.	Experimental arrangement of leaching columns	42
5.	B - Zone: effluent sample temperatures at cold and room conditions	43
6a.	B - Zone: effluent pH's at 2 °C and room temperature	44
6b.	B - Zone: effluent pH's at 10 °C and room temperature	45
7a.	B - Zone: effluent normalized redox potentials, Eh (NHE), at 2 °C and room temperature	46
7b.	B - Zone: effluent normalized redox potentials, Eh (NHE), at 10 °C and room temperature	47
8a.	B - Zone: effluent electrical conductances, Ec, at 2 °C and room temperature	48
8b.	B - Zone: effluent electrical conductances, Ec, at 10 °C and room temperature	49
9a.	B - Zone: effluent total acidity at 2 °C	50
9b.	B - Zone: effluent total acidity at 10 °C	51
10a.	B - Zone: effluent total alkalinity at 2 °C	52
10b.	B - Zone: effluent total alkalinity at 2 °C	53
11a.	B - Zone: effluent dissolved sulphate concentration at 2 °C	54
11b.	B - Zone: effluent dissolved sulphate concentration at 10 °C	55
12a.	B - Zone: effluent dissolved sulphate loading rate at 2 °C	56
12b.	B - Zone: effluent dissolved sulphate loading rate at 10 °C	57
13a.	B - Zone: effluent percent cumulative total sulphate loading at 2 °C	58
13b.	B - Zone: effluent percent cumulative total sulphate loading at 10 °C	59
14a.	B - Zone: effluent dissolved total iron concentration at 2 °C	60
14b.	B - Zone: effluent dissolved total iron concentration at 10 °C	61

15a. B - Zone: effluent dissolved calcium concentration at 2 °C 62
15b. B - Zone: effluent dissolved calcium concentration at 10 °C 63
16a. B - Zone: effluent dissolved magnesium concentration at 2 °C 64
16b. B - Zone: effluent dissolved magnesium concentration at 10 °C 65
17a. B - Zone: effluent dissolved aluminium concentration at 2 °C 66
17b. B - Zone: effluent dissolved aluminium concentration at 10 °C 67
18a. B - Zone: effluent dissolved manganese concentration at 2 °C 68
18b. B - Zone: effluent dissolved manganese concentration at 10 °C 69
19a. B - Zone: effluent dissolved antimony concentration at 2 °C 70
19b. B - Zone: effluent dissolved antimony concentration at 10 °C 71
20a. B - Zone: effluent dissolved arsenic concentration at 2 °C 72
20b. B - Zone: effluent dissolved arsenic concentration at 10 °C 73
21a. B - Zone: effluent dissolved copper concentration at 2 °C 74
21b. B - Zone: effluent dissolved copper concentration at 10 °C 75
22a. B - Zone: effluent dissolved lead concentration at 2 °C 76
22b. B - Zone: effluent dissolved lead concentration at 10 °C 77
23a. B - Zone: effluent dissolved mercury concentration at 2 °C 78
23b. B - Zone: effluent dissolved mercury concentration at 10 °C 79
24a. B - Zone: effluent dissolved nickel concentration at 2 °C 80
24b. B - Zone: effluent dissolved nickel concentration at 10 °C 81
25a. B - Zone: effluent dissolved silica concentration at 2 °C 82
25b. B - Zone: effluent dissolved silica concentration at 10 °C 83
26a. B - Zone: effluent dissolved zinc concentration at 2 °C 84
26b. B - Zone: effluent dissolved zinc concentration at 10 °C 85
27. B - Zone: effluent dissolved total cyanide concentration at 2 °C 86
28a. B - Zone: total cumulative effluent volume at 2 °C 87
28b. B - Zone: total cumulative effluent volume at 10 °C 88
29. S - Zone: effluent sample temperatures at cold and room conditions 89
30a. S - Zone: effluent pH's at 2 °C and room temperature 90
30b. S - Zone: effluent pH's at 10 °C and room temperature 91

31a. S - Zone: effluent normalized redox potentials, Eh (NHE), at 2 °C and room temperature 92
31b. S - Zone: effluent normalized redox potentials, Eh (NHE), at 10 °C and room temperature 93
32a. S - Zone: effluent electrical conductances, Ec, at 2 °C and room temperature 94
32b. S - Zone: effluent electrical conductances, Ec, at 10 °C and room temperature 95
33a. S - Zone: effluent total acidity at 2 °C 96
33b. S - Zone: effluent total acidity at 10 °C 97
34a. S - Zone: effluent total alkalinity at 2 °C 98
34b. S - Zone: effluent total alkalinity at 2 °C 99
35a. S - Zone: effluent dissolved sulphate concentration at 2 °C 100
35b. S - Zone: effluent dissolved sulphate concentration at 10 °C 101
36a. S - Zone: effluent dissolved sulphate loading rate at 2 °C 102
36b. S - Zone: effluent dissolved sulphate loading rate at 10 °C 103
37a. S - Zone: effluent percent cumulative total sulphate loading at 2 °C 104
37b. S - Zone: effluent percent cumulative total sulphate loading at 10 °C 105
38a. S - Zone: effluent dissolved total iron concentration at 2 °C 106
38b. S - Zone: effluent dissolved total iron concentration at 10 °C 107
39a. S - Zone: effluent dissolved calcium concentration at 2 °C 108
39b. S - Zone: effluent dissolved calcium concentration at 10 °C 109
40a. S - Zone: effluent dissolved magnesium concentration at 2 °C 110
40b. S - Zone: effluent dissolved magnesium concentration at 10 °C 111
41a. S - Zone: effluent dissolved aluminium concentration at 2 °C 112
41b. S - Zone: effluent dissolved aluminium concentration at 10 °C 113
42a. S - Zone: effluent dissolved manganese concentration at 2 °C 114
42b. S - Zone: effluent dissolved manganese concentration at 10 °C 115
43a. S - Zone: effluent dissolved antimony concentration at 2 °C 116
43b. S - Zone: effluent dissolved antimony concentration at 10 °C 117

44a. S - Zone: effluent dissolved arsenic concentration at 2 °C 118

44b. S - Zone: effluent dissolved arsenic concentration at 10 °C 119

45a. S - Zone: effluent dissolved copper concentration at 2 °C 120

45b. S - Zone: effluent dissolved copper concentration at 10 °C 121

46a. S - Zone: effluent dissolved lead concentration at 2 °C 122

46b. S - Zone: effluent dissolved lead concentration at 10 °C 123

47a. S - Zone: effluent dissolved mercury concentration at 2 °C 124

47b. S - Zone: effluent dissolved mercury concentration at 10 °C 125

48a. S - Zone: effluent dissolved nickel concentration at 2 °C 126

48b. S - Zone: effluent dissolved nickel concentration at 10 °C 127

49a. S - Zone: effluent dissolved silica concentration at 2 °C 128

49b. S - Zone: effluent dissolved silica concentration at 10 °C 129

50a. S - Zone: effluent dissolved zinc concentration at 2 °C 130

50b. S - Zone: effluent dissolved zinc concentration at 10 °C 131

51. S - Zone: effluent dissolved total cyanide concentration at 2 °C 132

52a. S - Zone: total cumulative effluent volume at 2 °C 133

52b. S - Zone: total cumulative effluent volume at 10 °C 134

53. Temperature profiles in wasterock and tailings at the Cullaton Lake site, Station 1 135

54. Temperature profiles in wasterock and tailings at the Cullaton Lake site, Station 2 136

55. Temperature profiles in wasterock and tailings at the Cullaton Lake site, Station 3 137

56. Temperature profiles in wasterock and tailings at the Cullaton Lake site, Station 4 138

57. International Kinetic Database: - rate of sulphide oxidation 139

58. International Kinetic Database: - rate of copper leaching 140

59. International Kinetic Database: - rate of zinc leaching 141

List of Tables

Tables		Page
1.	Physical characteristics of B and Shear (S) - Zones tailings	142
2.	Chemical characteristics of B and Shear (S) - Zones tailings	143
3.	Effluent water quality parameters and leaching characteristics of B - Zone tailings at 2 degrees Celsius	144
4.	Effluent water quality parameters and leaching characteristics of B - Zone tailings at 10 degrees Celsius	177
5.	Effluent water quality parameters and leaching characteristics of S - Zone tailings at 2 degrees Celsius	188
6.	Effluent water quality parameters and leaching characteristics of S - Zone tailings at 10 degrees Celsius	218
7.	Temperature distribution in wasterock cover and tailings as a function of time at various monitoring locations at the Cullaton Lake site	228

1.0 INTRODUCTION

1.1 Background to Study

This report describes the column leaching study of the Cullaton Lake mine tailings and compares cold temperature results to those obtained under warm conditions, and is the second in a series of reports that recommends ways of safely decommissioning the tailings and waste management facilities at the site.

The Cullaton Lake Gold Mines Ltd., owned by Homestake Canada Inc., is located in the district of Nunavut and Keewatin sub-district, Northwest Territories, at 61° 16' north latitude and 98° 30' west longitude. The property is located 416 km northwest of Churchill, Manitoba, and 620 km north of Thompson, Manitoba (Fig. 1). The site is at the tree line and in the zone of continuous permafrost.

The Company (Cullaton Lake Gold Mines Ltd.) operated a 300 tonnes per day gold mill at the site from October 1981 to August 1985 and produced about 100,000 ounces of gold. The site has been on care and maintenance since September 1985, and in 1992 the tailings surface was covered with a 1.5 m layer of wasterock and overburden for promoting freezing and permafrost conditions within the tailings.

The ore milled at the site came from two distinct orebodies referred to as the B - and Shear (S) - Zones. A total of 373,000 tonnes of ore was processed at the mill, of which 150,000 tonnes came from the B - Zone, and the balance of 223,000 tonnes from the Shear (S) - Zone. The B - Zone is located at the mill site, and the Shear (S) - Zone is located approximately 5 km to the north (Fig. 2).

The Cullaton Lake B - Zone deposit was a gold-bearing iron formation in a turbiditic sedimentary basin which formed part of the Rankin Inlet - Ennadi Archean greenstone belt in the Keewatin geological district of the Northwest Territories. The belt consisted of

clastic sediments (turbidites), pillow lavas and iron formations. This assemblage was indicative of an eugeosynclinal environment.

The B - Zone iron formation consisted of four distinct facies, namely, carbonate, silicate, oxide and sulphide. The gold mineralization was confined in a strata bound nature to the sulphide facies iron formation. Pyrrhotite and pyrite were the dominant sulphides with lesser amounts of arsenopyrite and chalcopyrite. Gold occurred free in the non-metalliferous gangue and showed no preference for any one sulphide (Page, 1983; Trow, 1991).

The Shear (S) - Zone was located in a discontinuous ridge outcrop of orthoquartzite. Gold occurred in the fractured and sheared orthoquartzite at the Shear (S) - Zone deposit. Mineralization was found in altered shears, breccia zones, pyritic shears, and pyritic sericitic impure quartzite (Chataway and Hanson, 1983; Trow, 1991).

Because of pyrite, pyrrhotite and other reactive sulphide mineralization of the orebodies, the acid rock drainage related issues from tailings and wasterock needed to be addressed. The Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario, was contracted to conduct detailed kinetic leaching tests on Cullaton Lake B- and S - Zone tailings. Results of column leaching tests performed at room temperature and under conditions of batch leaching and rest cycles have been reported previously (Davé, 1992). This report is on work carried out at low (2 °C) and intermediate (10 °C) temperatures.

Previous tests were of a worst case scenario of favourable oxidation and leaching conditions at room temperature (25 °C). In reality, for most of the year at the northern site, ambient temperatures are quite low where both chemical and biological oxidation processes proceed slowly (Knapp, 1987).

Available data and the RATAP model showed that there was considerable decrease in the rate of oxidation as the temperature approached 0 °C. The relative rate of oxidation reduced to about 10% of the relative rate occurring between 25 °C and 30 °C. However, little is know about further decrease in acid generation rate at temperatures below 0 °C (GEOCON, 1993).

Nearly half of Canada is covered by permafrost and there are approximately 190 mines and important mineral deposits in the Yukon and Northwest Territories (Kane and Brown, 1986). Permafrost encapsulation and cold temperature conditions at northern latitudes offer unique management options for reactive tailings and wasterock which are of interest and should be pursued.

Current tests were undertaken at cold temperatures to evaluate differences in leaching characteristics among different temperature regimes. Low temperature leaching studies were designed to simulate conditions similar to those expected within the tailings at the Cullaton Lake site after implementation of a decommissioning plan of covering the tailings with approximately 1.5 m of wasterock and overburden for promoting freezing and permafrost conditions within the tailings. It was anticipated that during the frost free period some of the tailings might thaw to temperatures ranging between 0 °C and 10 °C.

1.2 ARD and its Control

Acid Rock Drainage, or ARD is a term used to define drainage that occurs as a result of oxidation of sulphide minerals exposed to air and water (British Columbia Acid Mine Drainage Task Force Report, 1989). ARD is also referred to as Acid Mine Drainage (AMD). This phenomenon, however, is not confined to mining activities, as it may occur wherever sulphate bearing rock is exposed to water and air.

Reactive sulphide minerals, oxygen and water, in combination cause ARD. The process is accelerated several orders of magnitude by biological activity. In ARD, the biological

oxidation is caused by bacteria such as *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans*. These bacteria are capable of oxidizing iron and sulphur from their environments to obtain energy. Growth of the bacteria is manifested by a decrease in pH and an increase in the concentration of oxidized iron. *Thiobacillus ferrooxidans* are most active in waters with a pH of approximately 3.2.

In the presence of air and water, the sulphide mineral is oxidized, in this instance, the mineral is pyrite:

$$FeS_2 + 7/2\ O_2 + H_2O = Fe^{2+} + 2\ SO_4^{2-} + 2\ H^+$$

An oxidizing environment will further oxidize the ferrous to ferric iron,

$$Fe^{2+} + 1/4\ O_2 + H^+ = Fe^{3+} + 1/2\ H_2O$$

For pH's above 3, the ferric iron is readily hydrolyzed producing ferric hydroxide precipitate and a further decline in pH,

$$Fe^{3+} + 3\ H_2O = Fe(OH)_3 + 3\ H^+$$

The ferric iron not precipitated as ferric hydroxide may oxidize additional pyrite as:

$$FeS_2 + 14\ Fe^{3+} + 8\ H_2O = 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+$$

The result of these reactions is a distinct orange tinge to the host material as well as low pH pore water, capable of leaching heavy metals and other soluble minerals from the host rock. The major environmental impact of this process is felt when such low pH water migrates into the receiving environment, be it lake, river, stream, or other receiver. The

high acidity and metal content of this mobilized water may cause serious damage to plant or animal life in these receiving areas, through acidification and adsorption of these metals.

Through research of the ARD problem, controls have been devised for dealing with ARD. These controls include: the control of the acid generation process, the control of the ARD migration and the collection and treatment of ARD. Control of the acid generation process is the preferred measure. It is preferred because if acid generation is eliminated or reduced to an insignificant level, there is no danger of contaminants entering the environment. The success of this control measure depends on inhibiting the oxidation of the sulphides.

Permafrost encapsulation is believed to be a significant method for abatement of ARD. Factors that affect ARD generation in northern environments include the following:

- low temperature conditions slow chemical and biochemical oxidation of sulphide minerals (Klohn Leonoff, 1992);
- Snow, ground frost and ice cover provide a barrier of limited permeability for oxygen diffusion, thereby limiting the rate of sulphide oxidation;
- bacteria responsible for sulphide oxidation reactions and accelerating the release of acidity have limited activity at temperatures below 5°C; and
- high precipitation events that occur during seasonal snow melt periods can result in detrimental effects on receiving environments by flushing any accumulated oxidation products from the surface of the waste material.

Since pyrite oxidation is an exothermic reaction, and pore water does not freeze entirely below 0°C, the effectiveness of permafrost as an oxidation mitigator is questionable (Morin, 1995).

This study was undertaken to determine the chemical oxidation rate and acid generation potential, including metal release and changes in leachate water chemistry, for Cullaton Lake tailings at low and intermediate temperatures.

1.3 Site Description

Page (1983), and Chataway and Hanson (1983) have studied the geology and mineralogy of the Cullaton Lake area in detail. A brief summary is provided here for background.

The mine property is located within the Churchill Structural Province of the Canadian Shield in what is termed the Kaminak sub-province, a Precambrian greenstone belt which extended from the Saskatchewan border to the Rankin Inlet.

The oldest units were intercalated volcanic and sedimentary rocks of Archean age called the Henik Group. This group consisted of heterogeneous volcanic rocks, predominantly andesite and basalt, intercalated with clastic sediments of greywacke and argillite composition.

The Archean Henik Group was separated from the Lower Proterozoic Montgomery Lake Group by a series of plutonic and associated metamorphic rocks. This sequence was comprised of various bodies of granodiorite and monzonite which had transformed the Henik Group rocks into a variety of gneisses and schists.

The lower Proterozoic Montgomery Lake Group lay unconformably above the Henik Group and the intrusive metamorphosed sequence. This group was comprised of a thick series of boulder-conglomerate, greywacke, quartzite and siltstone.

The Hurwitz Group, Aphebian in age, lay unconformably above the Montgomery Lake Group. It was comprised of a broad assemblage of clastic sedimentary rocks, including conglomerate, orthoquartzite, slate, shale, dolomite, greywacke and arkose.

A sequence of middle Proterozoic intrusive rocks consisting of granite, quartz monzonite, granodiorite, gabbro and diabase dykes intruded the rocks of the above-described groups.

B - Zone

Gold mineralization in the B - Zone was confined to sulphide iron formations in the sedimentary sequence of the Henik group.

Based on dominant mineralogy, the B - Zone iron formation consisted of four distinct facies, namely, carbonate, oxide, silicate, and sulphide. The gold mineralization was confined in a strata bound nature to the sulphide facies iron formation. The carbonate iron formation consisted of layered chert and ankerite; the oxide iron formation consisted of chert, magnetite, and siderite with minor iron sulphides and chlorites; the silicate iron formation consisted of chert, chlorite and minor amounts of stilpnomelane, minnesotaite and siderite; and the sulphide iron formation consisted of chert, pyrrhotite, pyrite, arsenopyrite, magnetite, siderite, minor chalcopyrite and chlorite. The sulphide facies was found within, or bordering the oxide facies and ranged in thickness from 0.6 to 17.5 m.

The gold occurred free in the non-metalliferous gangue and showed no preference to any one sulphide or arsenide mineral.

The trace element content of the B - Zone iron formation was comparable to that of the Algoman type iron formation with the exception of increased amounts of Au and Ag. Au and Ag were enriched in the iron formation in all lithologies, and displayed a positive correlation with As and S. Sr, Y, Rb, Ce, Ba, Ni and Zn form a group of elements which showed a strong positive correlation within the group, and negative correlation with Au, Ag, S and As. Zn, Co, Cu and Sb as in most Algoman type deposits occurred in very low abundances, and their distribution did not correlate with that of any other element. It was assumed that the local concentrations of these elements controlled their abundances.

The veins of the deposit contained low quantities of gold compared to lithologies that they transected.

Approximately twelve iron formations in the Cullaton Lake district occurred along a strike length of 30 km and through a stratigraphic thickness of up to 15 km. The lithological control of gold in the B - Zone orebody might also be found 1.8 km down strike from the deposit in the same iron formation. The same relationship was also found in an iron formation (the A-Zone iron formation) 0.6 km west of the B - Zone. The other iron formations of the district were sampled in outcrop and boulders, and it was demonstrated that the high gold content of sulphide lithology persisted throughout the district.

The association of economic quantities of gold with sulphide iron formation suggested a sedimentary origin for the gold. The wide geographical and stratigraphic distribution of the high-gold sulphide lithology suggested that gold was introduced into the turbiditic basin in hydrothermal solution for the entire history of the basin. The localization of gold with a discrete lithology suggested that the precipitation of gold was controlled by local chemical-sedimentary conditions within the basin, rather than proximity to a discharge site. It was suggested that gold, arsenic and antimony remained in solution as thio complexes. Precipitation of these elements was prompted by the reduction of reduced sulphur species as a consequence of the local precipitation of iron sulphides.

Shear (S) - Zone

The Shear (S) - Zone area was underlain by orthoquartzite and slate, shale and siltstone. The former occurred as a discontinuous ridge of outcrop extending almost the length of the property in a north-south direction.

The orthoquartzite was white with variations of pink to red, fine-grained to glassy, and varied from thin bedded to thick bedded or massive. Typically, the orthoquartzite was composed of 97% or more quartz, with only scattered sericite, feldspar and magnetite. Less pure quartzites occurring in the lower part of the unit were commonly sheared and contained sericite and pyrite.

A greywacke underlay the orthoquartzites with a conformable contact indicating that the greywacke was a part of the Hurwitz Group and not the Henik volcanic. The thinly bedded shale, slate and siltstone unit occurred stratigraphically above the orthoquartzite and the contact area was an interbedded transition zone of siltstone and quartzites with strong hematitic staining.

Gold occurred in the fractured and sheared orthoquartzite in the Shear - Zone orebody. Mineralization was found in: a) altered shears; b) breccia zones; c) pyritic shears; and d) pyritic sericitic impure quartzite.

The altered Shear Zones were extensive and related to the regional structural patterns. Alteration products common to most zones were saponite, limonite, and hematite with occasional chlorite, epidote and sericite. Quartz and tourmaline were present in some zones. Gold occurred as free gold, visibly as sheared flecks or as fine nuggets and as a residue after the transformation of auriferous pyrite to limonite.

A vuggy quartz pyritic quartzite breccia containing gold appeared within an altered Shear Zone having pyrite with milky white quartz matrix.

Unaltered Shear Zones consisting of closely spaced pyrite-filled fractures were also gold bearing. The pyrite occurred as loosely packed filling in the fractures. Generally, these zones were narrow and appeared discontinuous.

A different type of gold mineralization was observed in the impure sheared sericitic quartzite consisting of 5 to 15% pyrite (8% average), disseminated to semi-massive in places. The alteration products of the Shear Zones were not present, but strong sericite and/or epidote was present in the sheared rock, possibly having been introduced post-deformation.

A characteristic feature of the auriferous zones was a pyritic halo extending from 0.5 to 6 m. The pyrite content averaged 2 to 3% but could be as much as 15%. Generally, the pyritic halo had a low gold content.

2.0 EXPERIMENTAL METHODOLOGY
KINETIC LEACHING TESTS

2.1 Experimental Arrangement

Column lysimeter leaching tests were conducted for both B- and Shear (S) - Zones tailings at cold temperatures (2 °C and 10 °C), to determine their oxidation and leaching characteristics at representative field temperature conditions similar to those existing at the site through much of the frost free season.

The equipment consisted of four clear acrylic columns, open at the top but closed at the bottom, with overflow valves near the top of the columns and drainage valves at the bottoms. Attached to the drainage valves were polyethylene hoses. These hoses were included to ease collection of effluent in the collection bottles. Each leaching column consisted of a clear acrylic tube, 80 cm in height and 12.5 cm in diameter, the bottom of which contained 7.5 cm thick layers of clean gravel and sand for bed support and filter purposes (Fig. 3).

A wooden support stand was used to hold the columns upright and to raise the columns off the floor. A representation of the columns and stand is given in Fig. 4.

The columns had been previously used in tailings experiments and, therefore, had to be cleaned. Each column was filled with approximately 10 l of distilled water, acidified with 200 ml of concentrated hydrochloric acid and allowed to sit overnight. The following day, the acid-water mixture was drained from the columns. The columns were then thoroughly

rinsed with cold tap water to remove the last of the acid and other material still remaining in the columns. The columns were then rinsed again with distilled water and replaced in the support stand and left to air dry.

2.2 Sampling Procedures

2.2.1 Tailings Sampling, Loading of Columns and Placement in the Cold Temperature Chamber

The tailings used in the experiment were transported from the Cullaton Lake mine to the Elliot Lake laboratory in four metallic containers. Two of these containers were filled with B - Zone tailings while the other two were filled with S - Zone tailings.

To achieve a representative sample, both B - Zone tailings samples were combined into one sample and the S - Zone tailings combined into another separate sample. Each combination sample was mixed together in a clean dry cement mixer. After thirty minutes of mixing, the sample was removed from the mixer and the columns were charged. Two of the columns were charged with B - Zone tailings and the other two were charged with S - Zone tailings. Each B and S - Zone column contained exactly 9.7 kg of tailings as received (wet).

The support stand with columns was then moved into a refrigerated cold temperature chamber which was maintained at the desired experimental temperatures for the duration of the study.

2.2.2 Inoculation with Bacterial Culture

Since the experiment involved ARD, inoculation of the samples with *Thiobacillus ferrooxidans* was necessary. A mixture of 500 ml of lake water and 100 ml of mine water containing the bacterial culture was placed in the cold chamber so as to reach experimental

temperature before being added to the columns. Upon addition of this mixture of mine and lake water, a compaction of 4.5 cm was noted in the S - Zone columns, while the B - Zone columns exhibited a compaction of 2.4 cm. The columns were then left to acclimatize for a week.

2.2.3 Leaching Scheme

Column leaching at 2 °C was carried out from January 1992 to December 1993 / January 1994. In December 1993, the temperature regulator of the experimental chamber malfunctioned resulting in freezing of test samples. The problem was quickly rectified, the samples were allowed to thaw completely by raising the chamber temperature to approximately 5 °C, and the leaching experiment at 2 °C was continued. The freezing of the tailings, however, had altered sample condition as well as the effluent quality, resulting in the loss of its previously established leaching reference point with respect to the elapsed time. The experiment was continued for another month but in January 1994 when the effluent quality did not re-establish, it was discontinued.

The experimental chamber temperature was then raised to 10 °C and the second leaching condition was established. Before starting the leaching experiment at 10 °C, the test columns were removed temporarily from the cold chamber, the tailings samples homogenized individually, the columns recharged and returned to the experimental chamber. While mixing the samples outside, adequate precautions were taken to keep temperatures close to 10 °C. The experimental columns were allowed to acclimatize for few weeks in the test chamber but were not re-inoculated with the *Thiobacillus ferrooxidans* culture solution. The leaching cycle at 10°C was initiated in February 1994 and continued till February 1995.

The test samples were allowed to weather at the experimental temperatures and rinsed periodically with natural lake water that was added to the columns at the rate of 1 l (litre) per week till October 1992, thereafter the schedule was changed to 1 l every two weeks.

Effluent collection bottles were of an opaque white plastic, with a short handle. The bottles were 26 cm high, of rectangular shape having base dimensions of 10 cm x 10 cm. These were acid-washed prior to sample collection. After filling water to which a small amount of concentrated hydrochloric acid was added, the bottles were set aside, so that the acid could fully combine with the water already in the bottles. After one day, the containers were rinsed thoroughly with cold tap water and then with distilled water, then set aside to air dry. Once dry, the bottles were weighed.

After the first week into the experiment, no water had collected in the effluent bottles. A 500 ml portion of lake water was added to each column and the water was allowed to drain for another week. The following week, drainage effluent had collected in the sample bottles and testing could begin. The amount of sample collected was small, therefore the amount of water added to the columns was increased to 1 l.

2.2.4 Water Sampling, Filtration and Sample Preservation

The sample bottles together with the collected effluent were first weighed to determine the effluent volumes. The samples were sub-divided and initial sample aliquots for pH, redox potential, conductivity and ferrous iron measurements were taken. The remaining samples were filtered to remove all the suspended solids and preserved for other analytical procedures.

The filtration was accomplished using a 1 l filtration flask, a filtration funnel and a 0.45 µm membrane filter. The flask was connected to a vacuum system for filtration.

The sample collected in the effluent containers was poured into the filtration funnel in 250 ml portions until the entire content of the containers was filtered. The filtrate was then poured into three different sample bottles, a 1 l plastic bottle, a 100 ml plastic bottle, and a 100 ml amber glass bottle.

To the 1 l plastic bottle, concentrated hydrochloric acid was added, while concentrated nitric acid was added to the 100 ml plastic bottle. 5N sodium hydroxide was added to the 100 ml amber glass bottle. These two acids and base were added to the samples to preserve them. The three bottles contained water samples that would be used for three different purposes.

The amber bottle was used to hold sample that would be analyzed for cyanide content. The CN^{1-} ion is very reactive and unstable and will react when exposed to sunlight which necessitated the sample preservation in an amber bottle. The 5N sodium hydroxide also inhibited the CN^{1-} ion's reactivity by increasing the pH and hence loss of cyanide as HCN gas. Sodium hydroxide was added until the pH was 12 or greater.

High reactivity of the sample in the 1 l and 100 ml plastic bottles was not the primary reason for the addition of acid. The acid was added because certain cations, such as Al, Cd, Cu. Fe, Pb, Mn, Zn and Ag, were subject to loss by precipitation, adsorption on, or ion exchange with the container walls. Between one to five percent acid by volume of sample was added to preserve the sample at a pH of approximately 2.0. At this pH the ions remained in solution and both the adsorption and ion exchange were minimal.

2.3 Analytical Procedures and Quality Assurance/Quality Control (QA/QC)

2.3.1 Water Samples

The water samples were analyzed for pH, redox potential (Eh), electrical conductance (Ec), total acidity, total alkalinity and dissolved concentrations of SO_4^{2-}, Al, Sb, As, Ca, Cu, ferrous iron (Fe^{2+}), total Fe, Pb, Mg, Mn, Hg, Ni, Si and Zn. The water samples were pre-filtered with 0.45 μm membrane filters and stabilized with dilute nitric acid for dissolved metals and hydrochloric acid for SO_4^{2-} determinations as described above. The acid was added to the sample in the amount of 30 ml per litre.

For most analyses, the Standard Methods for the Examination of Water and Waste Water, American Public Health Association (Greenberg et. al., 1992), were followed. Dissolved metals/elements concentrations were measured using an Inductively Coupled Argon Plasma Atomic Emission Spectrophotometer (ICAP-AES), and SO_4^{2-} concentrations were determined using radiochemical methods as described below.

2.3.1.1 Primary Parameters

pH, Eh, Ec, Total Acidity, Total Alkalinity

The primary parameters were measured in water samples as collected and prior to their filtration for maintaining sample integrity, without loss of dissolved gasses or oxidation of metal ions specially ferrous Fe^{2+}. The pH was measured using a standard glass body combination pH electrode with a saturated Ag / AgCl reference electrode. The redox-potential, Eh, was measured using a platinum and a calomel (Hg / Hg_2Cl_2) reference electrodes. The measured Eh was normalized to standard hydrogen electrode references (NHE) by adding calomel and hydrogen electrodes potential difference of +244 mV. The electrical conductivity, Ec, was measured using a small volume (5 ml) conductivity cell. All these parameters were measured at the cold sample temperature (as received) and normalized to the standard room temperature of 25 °C with an automatic temperature compensator (ATC) or a temperature compensation procedure for Ec measurements.

Total acidity and alkalinity were measured by titrametric methods. The acidity in sample solutions containing hydrolizable metal ions, e.g. Fe^{3+}, Al^{3+}, etc. and polyvalent cations, was measured as a maximum potential acidity by lowering the pH below 4 and oxidizing the reduced ionic species with few drops of 30% H_2O_2,. The sample solution was then titrated with a standard alkalinity (NaOH) solution to pH 8.3 using a potentiometric titration method.

The alkalinity was also measured using a potentiometric titration method. An aliquot of sample solution was titrated with a standard acid (H_2SO_4) solution to pH 4.5. For low alkalinity solutions, additional titrant was carefully added to reduce the pH exactly 0.3 pH units and the total titrant volume was used for alkalinity calculations.

2.3.1.2 Elemental Analysis

Quantitative analysis of dissolved metals and sulphur in solution samples was performed using a Thermo Jarrel Ash Inductively Coupled Argon Plasma - Atomic Emission Spectrophotometer (ICAP-AES), model Polyscan 61E. Elemental concentrations were measured following appropriate wave length calibration, standardization, matrix matching, inter-element and background corrections, and quality control.

Each solution sample was analyzed three times and the analytical results had a typical variance of less than 3%. A quality control (QC) sample, having a similar composition and matrix, was also analyzed every ten samples, and the system stability was checked by the observing variance in the QC sample elemental concentrations. A QC fail command was set at the analyte variance exceeding 5% each element, and upon the detection of the fail command the instrument was automatically re-calibrated and the analyses repeated. Typical detection limits for the ICAP AES were below 0.03 mg/l for most elements.

2.3.1.3 Sulphate Analysis

For solution samples, the sulphate concentrations, in the absence of other soluble sulphur species, were measured using the above described ICAP-AES. In other cases, a radiochemical tracer technique using a gamma emitter Ba-133 radioisotope was used .
The radiometric method consisted of precipitating sulphate as Ba (Ba-133)SO_4 by the addition of a precipitating solution containing a fixed ratio of $BaCl_2$ / (Ba-133)Cl_2 concentrations. The sulphate concentration was determined by measuring the recovery of

Ba-133 radioisotope using a gamma spectroscopy system. The instrument measured the activity of Ba-133 isotope using its 356 keV gamma energy peak with a 10 cm x 10 cm diameter NaI(Tl) detector. By fixing the concentration ratio of $BaCl_2$ (Ba-133)Cl_2, three precipitating solutions, A, B and C were used to measure total sulphate concentrations in the ranges of 10 - 100 mg, 1 - 10 mg and 0 - 1 mg SO_4^{-2}, in sample aliquots, respectively.

This method was preferred over other conventional methods e.g. gravimetric, turbidity etc., for its applicability over a wide concentration range without requiring sample dilution, and ease of operation. The method allowed preparation of samples in large batches, and counting them at a later date and time without affecting results. For very low sulphate concentrations (<10 mg/l) the ICAP-AES method was used.

2.3.1.4 Cyanide Analysis

For both solid and solution samples, total cyanide concentrations were measured, following acid digestion and cyanide distillation, using an automated colourimetric cyanide analyzer. A solution containing cyanide was injected in a distillator and the condensate collected in a cell containing cyanide complexing colouring reagents. The cyanide concentration was then automatically determined by measuring the transmittance (absorbance) of a characteristic wavelength of light.

2.3.1.5 Minimum Detection Limits

For solution samples, the measured instrumental detection limits, defined as 3σ where σ is the standard deviation of the instrumental noise at background concentrations, were on the order of 0.001 to 0.03 mg/l for most metals and SO_4^{-2} for the analytical methods used.

2.3.2 Solid Samples

The tailings solid samples were pulverized to less 40 μm size and analyzed for solid phase elemental compositions following acid digestions and complete dissolutions of the samples. The sample solutions were individually brought to a standard volume and were analyzed using the above described procedures.

The particle size distribution of the dry tailings was determined using the American Standard Testing Method (ASTM) for screen analysis.

2.3.2.1 Sample Digestion

For metal analysis, a pulverized tailings sample (0.5 - 1.0 g) was completely dissolved, first by digesting it with 20 ml of HNO_3 in a 100 ml Teflon beaker and boiling it to dryness, followed by addition of 30 ml of HF and digestion at 100 °C for silica removal. The sample was cooled and digested with 15 ml of a cocktail containing perchloric, nitric and hydrofluoric acids in the ratio of 2:1:7, slowly at 110 °C till dryness, followed by baking at 180 °C till all the white fumes of perchloric acid dissociation were expelled. The sample was cooled again and dissolved completely in 50 ml of 50% HCl, by boiling, if necessary. All sample solutions were stabilized by adding HCl to a final concentration of 10% acid. The final volume of the sample solution was brought to 1 l for most metals, and 100 ml for trace metal analysis, by adding de-ionized water.

For volatile elements, e.g. Pb, the samples were dissolved with nitric acid (following silica destruction) in high pressure Teflon vessels in a microwave digestion oven. The digested samples were then dissolved in 50% HCl as above.

2.3.2.2 Sulphur Speciation

For solid samples, the sulphur species were determined by measuring concentrations of total sulphur, total sulphate sulphur and obtaining the total sulphide sulphur concentration by difference.

The total sulphur concentration was measured using a Leco furnace sulphur analyzer. A measured amount of dry pulverized sample was ignited at a high temperature in an electric spark furnace and the total sulphur concentration was determined by measuring the total quantity of evolved sulphur dioxide gas using gas chromatography. Occasionally, total sulphur concentration was also determined by complete destruction of the silica matrix and oxidation of sulphides to sulphates either by Na_2O_2 fusion or perchloric acid digestion as described before, followed by measurement of total sulphate concentration in the sample solution by gamma spectroscopy or ICAP-AES.

The total sulphate sulphur concentration of the sample was determined by leaching it with distilled water for a period of 24 h to dissolve all water soluble sulphates, and measuring the dissolved sulphate concentration by gamma spectroscopy or ICAP-AES.

2.3.2.3 Quality Assurance / Quality Control (QA/QC)

The QA/QC program consisted of analyzing 15-20% additional sample replicates, sample and reagent blanks, certified reference standards for solid and liquid samples together with an inter-laboratory comparison program of unknown and reference samples.

For quality control, all solid samples were digested in duplicates, together with matrix matched control samples consisting of Canadian Certified Reference Material Standards (CCRMP) for Base Metal Tailings and Ore, and appropriate sample and reagent blanks. All samples were processed concurrently through the analytical procedures. For dissolved metals, instrumental analytical standard deviations were set at the 5% variation

level of a quality control (QC) sample for an automatic QC pass/fail check and re-standardization. The overall precision and accuracy of all measured analytical parameters were between ± 5 to 10% levels depending on the parametric concentration.

3.0 RESULTS

3.1 Solid Phase Comparison

The physical parameters and chemical compositions of both B and Shear (S) - Zones tailings are given, respectively, in Tables 1 and 2.

The B - Zone tailings were characterized by a dark greenish-grey colour, relatively fine texture and particle size distribution diameters, d_{10} and d_{50}, of 35 and 65µm, respectively, for 10% and 50% passing. The tailings had relatively high total sulphur and iron contents of 2.63% (as S) and 20% (Fe) respectively, a total water extractable sulphate concentration of 0.32% (as S), and a negative net neutralization potential (NNP) of -26.8 kg $CaCO_3$/tonne of tailings.

The Shear (S) - Zone tailings were characterized by a brownish-orange colour, slightly coarse texture with particle size distribution parameters, d_{10} and d_{50}, of 45 and 100µm, respectively. The S - Zone tailings had low total sulphur and iron contents of 0.5% (as S) and 3.0% (Fe), respectively, a total water extractable sulphate concentration of 0.09% (as S), and a less negative net neutralization potential (NNP) of -10.5 kg $CaCO_3$/tonne of tailings.

Both tailings were net acid producers, although for the Shear - Zone, both the total sulphur content and total available alkalinity were low (Table 2). The tailings retained appreciable amounts of moisture, ~ 10% by weight, and had very poor drainage

characteristics, as reported by Davé (1992) in the previous room temperature leaching study.

3.2 Column Leaching Results

The column leaching results for 2 °C and 10 °C for B -Zone tailings are given in Tables 3 and 4, respectively. The corresponding results for S - Zone tailings are given in table 5 and 6, respectively.

The effluent water quality parameters and their variations with time are plotted in Figs. 5 to 28 for B - Zone; for sample temperature, pH, Eh(NHE), Ec, total acidity, total alkalinity, dissolved concentration of SO_4^{2-}, effluent SO_4^{2-} loading rate, percent cumulative total SO_4^{2-}loading, and dissolved concentrations of total Fe, Ca, Mg, Al, Mn, Sb, As, Cu, Pb, Hg, Ni, Si, Zn, total CN^{1-} and total cumulative effluent volume, respectively. Results for 2 °C and 10 °C are plotted separately, in figures marked with (a) and (b), respectively. The corresponding S - Zone parameters are given in Figs. 29 to 52.

The cold sample temperatures, shown as laboratory cold temperatures in Figs. 5 and 29, were recorded in the laboratory prior to conducting other measurements at those temperatures. Because of sample handling, the laboratory-measured cold temperatures were 1 to 2 °C higher than the actual experimental cold chamber temperatures.

The collected effluent volumes were measured, as received, at cold sample temperatures, and were later normalized to the laboratory room temperature (25 °C). The effluent pH, Eh, and Ec were measured at both laboratory cold and ambient room (laboratory warm) temperatures, but because of fluctuations in sample temperatures, all these parameters were temperature compensated to a standard room temperature of 25 °C. This was accomplished with automatic temperature compensating (ATC) probes connected to the

instruments. All other parameters were measured after warming the samples to room temperature.

Initially, at the beginning of the experiment, the drainage effluent from both the tailings contained high total dissolved solids (high Ec) and elevated concentrations of calcium and magnesium sulphates which leached rapidly over a short period of 1 to 1.5 months (Figs. 8, 15, 16, 32, 39 and 40). This period represented dissolution and removal of soluble minerals e.g. sulphates of calcium and magnesium from the tailings, present in the tailings as residual minerals from the milling process or accumulated as a result of previous exposure of the tailings to the weathering process leading up to the experimental time. After this initial period, the changes observed in various parameters were characteristic of the weathering and leaching at the experimental temperatures. The detailed results for the two tailings at 2 °C and 10 °C are as follows:

3.2.1 B - Zone Tailings:

pH, Eh, and Ec

The drainage effluent pH, Eh, and Ec profiles for the B - Zone tailings are shown in Figs. 6 to 8 respectively. The pH decreased slowly from the initial 7.0 - 7.5 range to approximately 6.5 - 6.8 over the two-year leaching period at 2°C. With the initiation of leaching at 10°C, the pH gradually decreased to 5.0 - 5.2 range for a period of approximately nine months, and recovered to ~ 7.0 near the end of the experimental period (Fig. 6b).

The normalized redox potential, Eh(NHE), decreased very slowly during leaching at 2 °C from 500 - 550 mV range to ~ 300 - 400 mV. The decrease was more pronounced for redox potentials measured after the sample was warmed to room temperature (Fig. 7a), where the values were approximately 100 - 150 mV lower than at cold sample temperatures. The redox potentials increased gradually during the 10 °C leaching period,

and were in the range of 350 - 500 mV for both sample cold and room temperatures (Fig. 7b).

The effluent electrical conductance, Ec, decreased rapidly, from an initial 14,000 - 14,500 µs/cm range to ~ 250 - 300 µs/cm, during the first two months of leaching and remained constant at ~ 250 µs/cm for the rest of the leaching period at 2 °C (Fig. 8a). At the beginning of the 10 °C leaching, Ec first increased to ~ 380 µs/cm for a short period of time, then decreased slowly to ~ 200 µs/cm (Fig. 8b) for the rest of the leaching period.

In contrast to the room temperature (25°C) leaching of the B - Zone tailings (Davé, 1992), the above results indicated very slow oxidation at 2°C and an initial slight to moderate oxidation at 10 °C. These results are further confirmed by the production of moderate acidity, Fe, and other metals at 10°C, as discussed below.

Total Acidity and Alkalinity

The total acidity and alkalinity profiles for the B - Zone tailings are shown, respectively, in Figs. 9 and 10. The tailings started to produce slightly acidic effluents after a period of approximately 1.5 years at 2 °C when the acidity increased from zero to ~ 300 mg $CaCO_3$/l. During the same period, the effluent alkalinities decreased from approximately 350 mg $CaCO_3$/l to 100 mg $CaCO_3$/l (Fig. 10a).

After the column freeze-up and re-initiation of leaching at 2 °C, the acidities had decreased to near zero (December 1993 - January 1994). With the leaching of columns at 10 °C, the effluent acidities increased rapidly to approximately 900 mg $CaCO_3$/l peak, and decreased to near zero towards the end of the experimental period (Fig. 9b). During the same period, the corresponding effluent alkalinities decreased from ~ 150 mg $CaCO_3$/l to less than 10 mg $CaCO_3$/l (Fig. 10b).

Sulphate and Iron

The B - Zone sulphate and iron concentration profiles are shown in Figs. 11 and 14, respectively. The loading rate as (μg SO_4^{2-} /kg tailings/day) and percent cumulative total loading of sulphate are given in Figs. 12 and 13, respectively.

Similar to Ec, the dissolved sulphate concentration in the effluent decreased very rapidly, from approximately 16,000 mg/l to ~ 1,500 mg/l during the first two months, and increased very slowly to ~ 2,500 mg/l near the end of the leaching period at 2 °C (Fig. 11a). At the beginning of the 10 °C leaching period, the sulphate concentration increased slightly to ~ 3,000 mg/l and then decreased slowly to approximately 2,000 mg/l (Fig. 11b).

The B - Zone sulphate loading rate at 2 °C decreased from an initial high of ~ 215,000 μg SO_4^{2-} /kg tailings/day to ~ 10,000 μg SO_4^{2-} /kg tailings/day and then increased very slowly to ~ 15,000 μg SO_4^{2-} /kg tailings/day near the end of the 2 °C leaching period (Fig. 12a). At 10 °C, the sulphate loading rate remained nearly constant at about 10,000 μg SO_4^{2-} /kg tailings/day (Fig. 12b).

During the 2 °C leaching period, a cumulative total of 21% of the total sulphur contained in the B - Zone tailings was mobilized and removed as total sulphate in the effluent (Fig. 13a). Approximately 10% of the total sulphur was present in the water soluble form, which leached rapidly within two months at the beginning of the experiment. The remaining ~ 11% of the total sulphur was removed as a result of acid generation and neutralization during the balance 1.8 y of leaching at 2 °C. Leaching of the tailings at 10 °C for 1 y, mobilized an additional 5.3% of total sulphur in the effluent (Fig. 13b).

As there was complete acid neutralization in B - Zone tailings during both the leaching periods and the effluent was saturated with respect to gypsum, the effluent sulphate

drainage loading was controlled by gypsum solubility. Thus, further deduction of sulphur oxidation and acid generation rates from the sulphate drainage data was not possible.

The dissolved total iron concentration profiles were similar to those of acidity (Figs. 9 and 14). The dissolved iron concentration increased, from zero to ~ 150 mg/l, near the end of the 2 °C leaching period and peaked at ~ 450 mg/l at the beginning of the 10 °C leaching. Near the end of the 10 °C leaching period, the dissolved iron concentration had returned to near zero (Fig. 14b).

As observed previously, the B - Zone tailings started to produce slightly acidic effluents at 2°C after a period of 1.25 years, and moderate acid generation when leached at 10 °C but only for a short duration of approximately 8 months. The latter observations were similar to those observed at 25 °C leaching, where characteristic acidic effluent peaks were observed for a short period of time. (Davé, 1992).

Calcium and Magnesium

The B - Zone calcium and magnesium profiles are shown in Figs. 15 and 16, respectively. The effluent calcium concentrations initially decreased from ~ 500 mg/l to ~ 400 mg/l during the flushing period of approximately 15 days, thereafter increased to ~ 650 mg/l saturation level of dissolved gypsum. It decreased slowly to ~550 mg/l during the remainder of the 2 °C leaching period and remained constant during leaching at 10°C (Fig. 15b). The results indicated dissolution of the residual gypsum from the tailings, as well as, on going acid generation and limestone neutralization.

The dissolved magnesium and SO_4^{2-} concentrations profiles were also similar (Figs. 11 and 16). The effluent magnesium concentration decreased initially, from a high of ~3,200 mg/l to a low in the range of ~50 - 80 mg/l, during first two months of leaching at 2 °C and remained constant in the low range for another 1.5 years. Near the end of 2 °C leaching and with the beginning of the 10 °C leaching period, Mg concentration increased

gradually to a 200 mg/l peak and decreased slowly to a very low concentration of ~ 8 - 10 mg/l with further leaching at 10 °C (Figs. 16a and b).

Aluminium and Manganese

Figs. 17 and 18 show, respectively, the B - Zone aluminium and manganese leaching profiles. The drainage effluent contained dissolved aluminium on the order of 0.1 - 0.15 mg/l throughout both the leaching periods with no definite trends. The effluent manganese concentration slowly increased from an initial level of ~ 5 - 10 mg/l to ~ 20 mg/l during 2 °C leaching. During the 10 °C leaching period, the manganese profile was similar to that of total iron concentration, peaking at 20 - 25 mg/l and decreasing gradually to a range of 1 - 2 mg/l (Fig. 18b).

Both iron and manganese profiles indicated delayed occurrence of acidic drainage at 2 °C, which increased in magnitude as the temperature was raised from 2 °C to 10 °C. The effluent, at the observed pH and Eh values, contained mostly Fe^{2+} and Mn^{2+} species.

Other Metals:

Sb, As, Cu, Pb, Hg, Ni, Si (dissolved) and Zn

Figs. 19 - 26, show the B - Zone drainage profiles for Sb, As, Cu, Pb, Hg, Ni, Si (dissolved), and Zn, respectively. The results indicated limited drainage of As in the range of 0.1 - 0.2 mg/l, Ni ~ 0.1 - 0.15 mg/l, Pb ~ 0.05 - 0.1 mg/l and dissolved Si ~ 2 - 4 mg/l. Except for Pb, the increased concentrations of these elements were observed during oxidation and leaching at 10 °C. Cu and Zn concentrations were very low to near background concentrations. Dissolved Sb concentrations were also low, ~ 0.02 - 0.05 mg/l, during most of the leaching period and occasionally in the range of ~ 0.1 - 0.25 mg/l. Dissolved Hg concentration was below detection.

Total Dissolved Cyanide

The dissolved CN^{1-} drainage profile for leaching of B - Zone tailings at 2 °C is shown in Fig. 27. Most of the cyanide contained in the tailing porewater, present as a residual milling reagent, was removed within the first 1.5 months of leaching at 2 °C, from an initial 800 µg/l level to ~ 10 µg/l, and the remainder was mobilized in low concentrations, ~ 2 - 10 µg/l, during additional 5 months of leaching. Thereafter, no cyanide was observed in the drainage effluents at both 2 °C and 10 °C leaching.

3.2.2 Shear (S) - Zone Tailings:

pH, Eh, and Ec

The temperature profiles for Shear (S) - Zone leaching regime are shown in Fig. 29, and the drainage effluent pH, Eh, and Ec profiles are shown in Figs. 30 to 32, respectively.

The effluent pH increased initially from 6.2 to 6.8 over a 3 month period and then decreased rapidly to < 4.0 in another 3 months. It declined slowly to 3.0 during the rest of the leaching period at 2 °C (Fig. 30a). No further pH changes were observed during the 10 °C leaching period (Fig. 30b).

The redox potential, Eh(NHE), increased gradually with time, from initial 400 mV to ~ 750 mV, during leaching at 2 °C (Fig. 31a). No further changes in Eh were observed during leaching at 10 °C (Fig. 31b).

The electrical conductance, Ec, decreased very rapidly, from the initial 8,000 µs/cm value to 2,000 µs/cm, during the first 1.5 months and declined further to ~ 500 µs/cm in additional six months of leaching. It increased gradually to 1,200 µs/cm during the rest of the 2 °C leaching period (Fig. 32a). At the beginning of the 10°C leaching period,

Ec peaked at around 3,000 µs/cm and then decreased gradually to 1,000 µs/cm near the end of the leaching (Fig. 32b).

These results are similar to those at 25 °C leaching reported by Davé (1992), indicating oxidation and acidic drainage at all three leaching temperatures. The S - Zone tailings contained less total available alkalinity (~2.0 kg $CaCO_3$/tonne) which resulted in early occurrence of acid drainage at low temperatures compared to B - Zone tailings. This observation is further supplemented by acidity, sulphate, total iron, and other metals results as discussed below.

Total Acidity and Alkalinity

The total acidity and alkalinity profiles for the S - Zone tailings are shown, respectively, in Figs. 33 and 34. After removal of the initial and stored acidity during the first month, the tailings started to produce mildly acidic effluents within 5 months of leaching at 2 °C. The acidity production was rapid and lasted for the balance of the 2°C leaching period, having acidities in the range of 500 - 600 mg $CaCO_3$/l. During 10°C leaching, acidity production peaked at ~ 700 mg $CaCO_3$/l and then decreased rapidly to low acidities on the order of ~ 100 mg $CaCO_3$/l (Fig. 33b). The alkalinity production decreased correspondingly from an initial range of 40 - 45 $CaCO_3$/l to zero during first 10 months of leaching at 2 °C (Fig. 34a).

In comparison to leaching at 25 °C in the earlier study, the acidity production at 2 °C was slightly lower and its occurrence delayed by approximately 2 months. However, similar to the previous study (Davé, 1992), strong acidic drainage only occurred for a limited period indicating a surface activity phenomenon.

Sulphate and Iron

The effluent sulphate and dissolved total iron profiles for Shear (S) - Zone tailings are shown in Figs. 35 and 38, respectively. The loading rate, as (μg SO_4^{2-} /kg tailings/day), and percent cumulative total loading of sulphate are given in Figs. 36 and 37, respectively.

As with the B - Zone tailings, the sulphate and Ec profiles were also similar for the S - Zone tailings. The dissolved sulphate concentration in the effluent decreased from approximately 5,000 mg/l to ~ 1,500 mg/l during the first 1.5 months of leaching and then slowly to the range between 100 - 200 mg/l prior to the onset of acid drainage at 2 °C. During the acidic drainage period at 2 °C, the sulphate concentration increased to 500 mg/l (Fig. 35a). During 10 °C leaching, it first peaked at ~ 2,500 mg/l and then decreased slowly to levels of 100 - 150 mg/l (Fig. 35b).

For S - Zone, the effluent sulphate loading rate at 2 °C decreased from an initial high of ~ 70,000 μg SO_4^{2-} /kg tailings/day at the start of the experiment to a very low rate of ~ 2000 μg SO_4^{2-} /kg tailings/day. With further leaching at 2 °C, it increased slowly to 5000 μg SO_4^{2-} /kg tailings/day (Fig. 36a). Leaching at 10 °C, initially caused an increase in the sulphate loading to a peak rate of ~ 12,000 μg SO_4^{2-} /kg tailings/day, and then a slow decrease to a very low rate of ~ 1200 μg SO_4^{2-} /kg tailings/day (Fig. 36b).

In the absence of sufficient neutralizing buffer, the S - Zone tailings produced acidic effluents which were unsaturated with respect to gypsum. The effluent sulphate loading rate, thus, corresponded directly to total sulphur oxidation and acid generation rates.

The cumulative total sulphate loading of the effluents from S - Zone tailings were relatively high at both the leaching temperatures, where approximately 42% and 13% of the total sulphur contained in the tailings were mobilized and removed, respectively, at 2 °C and 10 °C (Figs. 37a and b). The experimental tailings contained approximately 25%

of the total sulphur in the water soluble form which was quickly removed at the beginning, within first two months of leaching at 2 °C. Further leaching at 2 °C resulted in an additional mobilization and removal of sulphate in the amount equivalent to 17% of the total sulphur contained in the tailings. The three year combined leaching at the two temperatures (2 °C and 10 °C) removed approximately 30% of the total sulphur contained in the S - Zone tailings by further oxidizing them.

The dissolved total iron concentration profile was similar to that of acidity (Figs. 33 and 38). The acidic drainage in S - Zone tailings was accompanied by iron drainage which began at about 6 months during the 2 °C leaching period. Dissolved iron concentrations increased slowly, from zero to ~ 200 mg/l, during leaching at 2 °C and peaked at ~ 250 mg/l with the initiation of the 10 °C leaching. It rapidly decreased to the range of ~ 10 - 20 mg/l with additional leaching at 10 °C (Fig. 38 b).

Similar to observations made for acidity, and in comparison to room temperature leaching (Davé, 1992), iron mobilization and drainage at 2 °C leaching condition was slow and delayed. Also, because the leaching at this temperature was abruptly halted, the total duration of acidic drainage and its continuity at this temperature also ended prematurely. It was, however, clearly evident from the Shear - Zone acidity and dissolved iron profiles that there was no significant reduction in acidic drainage, except delayed occurrence, from these tailings at 2 °C in comparison to room temperature leaching results. The data also defined the acid drainage period when other metals were mobilized.

Calcium and Magnesium

The calcium and magnesium profiles for Shear (S) - Zone tailings are shown in Figs. 39 and 40, respectively. The effluent calcium concentrations increased initially from 400 mg/l to ~ 550 mg/l during the first 3 months of leaching, then decreased rapidly to ~ 50 mg/l with the onset of acid drainage. Because of low available alkalinity, no significant acid neutralization was realized and acidic drainage occurred early in the S - Zone. During the

10°C leaching period, additional drainage of Ca occurred initially at 500 - 550 mg/l and decreased rapidly to low concentrations of 30 -50 mg/l (Fig. 39b).

The dissolved magnesium, Ec, and SO_4^{2-} concentration profiles were also similar, where the effluent magnesium concentration decreased from 700 mg/l to 10 mg/l during the first few months of leaching and remained constant at the low range for the rest of the leaching at 2 °C. For the 10 °C leaching period, a concentration peak at 100 mg/l, similar to Ec and SO_4^{2}, was also observed (Figs 32b, 35b and 40b).

Aluminium and Manganese

Figs. 41 and 42 show, respectively, the aluminium and manganese leaching profiles. Similar to iron, significant aluminium drainage occurred at 20 - 30 mg/l level with the production of acidity while leaching at 2 °C. The drainage decreased rapidly with decreasing acid production during the 10 °C leaching period (Fig. 41b).

The effluent manganese concentration decreased slowly from an initial 170 mg/l level to ~ 10 mg/l during the first three months of leaching at 2 °C, then increased to ~ 30 mg/l with the occurrence of acidic drainage and declined to 5 - 10 mg/l range with further leaching at 2 °C. During 10 °C leaching, manganese levels peaked at ~ 40 mg/l and decreased gradually to < 5 mg/l (Fig. 42b). These observations, similar to Fe, corresponded to oxidation and acidic drainage at 2 °C and 10 °C.

Other Metals:

Sb, As, Cu, Pb, Hg, Ni, Si (dissolved) and Zn

Figs. 43 - 50 show, respectively, the S - Zone leaching profiles for Sb, As, Cu, Pb, Hg, Ni, Si and Zn. With the onset of acidic drainage, significant leaching was observed for As ~ 0.1 - 0.3 mg/l, Cu ~ 0.05 - 1.2 mg/l, Ni ~ 0.5 - 1.5 mg/l, Zn ~ 0.1 - 1.0 mg/l, Pb ~ 0.1 -

2.0 mg/l, and dissolved Si ~ 10 - 50 mg/l at both 2 °C and 10 °C. Similar to B - Zone tailings, effluent concentrations of Sb and Hg were very low, ~ 0.03 mg/l and below detection, respectively.

Total Dissolved Cyanide

The S - Zone cyanide leaching profile for 2 °C is shown in Fig. 51. The dissolved cyanide concentration of the effluent was very low, ranging between 2 - 10 µg/l, and its drainage lasted only for a limited duration at 2 °C. The acid generation in S - Zone caused complete destruction and removal of cyanide during early stages of leaching at 2 °C. No cyanide drainage was observed at 10 °C

4.0 DISCUSSION

It is clearly evident from these results that oxidation and acid generation occurred for both B- and S - Zone tailings at 2 °C and 10 °C. The rate of acid generation was less and the occurrence of acidic drainage was delayed at both 2 °C and 10 °C in comparison to those observed at 25 °C in the earlier study by Davé (1992).

For B - Zone tailings, containing relatively high sulphide (2.31% as S) and total available alkalinity (45.36 kg $CaCO_3$/tonne), the acid generation rate was low enough at 2 °C that a reasonable degree of acid neutralization was achieved and acidic drainage prevented during most of the leaching period except near the end when some acidic drainage occurred. This process continued as the transition was made from 2 °C to 10 °C, where the magnitude of the acid drainage increased, but still the neutralization continued which moderated the effluent pH and acidity. The overall impact of acid drainage was thus low for B - Zone tailings at both leaching temperatures of 2 °C and 10 °C.

For S - Zone tailings, containing low sulphide (0.4% as S) and total available alkalinity (2.0 kg $CaCO_3$/tonne), the acid generation rate was also low at cold temperatures, but because of low available alkalinity there was insufficient acid neutralization and acidic drainage occurred early during the 2 °C leaching period.

Acid drainage continued with additional leaching at 2 °C and its magnitude increased during leaching at 10 °C, but because of the high moisture retention characteristics of these tailings as well, the overall impact of acid drainage was again limited in magnitude and duration. However, for S - Zone tailings, the low temperature acidic drainage was accompanied by release of iron, sulphate, and metals in moderate concentrations.

In comparison to the previous room temperature (25 °C) leaching results (Davé, 1992), there was a significant reduction in acid drainage and metal loading from B - Zone tailings at low temperatures. The contributing factors were low acid generation and high available alkalinity. However, for S - Zone tailings, similar impact at low temperatures was not realized as these tailings contained low available alkalinity.

Although the 2 °C leaching period was terminated prematurely, because of the equipment malfunction and freezing of test samples, sufficient information had been obtained to predict continuation of acidic drainage, perhaps of a weaker strength but for longer duration, from S - Zone tailings at low temperatures. The data should be further analyzed to obtain acid generation and metal loading rates at the three study temperatures.

In addition to reduced acid generation and delayed acidic drainage at low temperatures, the water retention characteristics of the both B- and S - Zones offered the greatest control on overall acidic drainage from these tailings. As noted in the previous study by Davé (1992), both B - and S - Zone tailings retained appreciable amounts of moisture (~ 85 - 100% pore volume saturation) during laboratory leaching, which decreased oxidation and acid generation rates and further reduced the impact of acidic drainage.

It has been clearly demonstrated in the previous and current study that for Cullaton Lake B - and S - Zones tailings, the zone of oxidation and acidification is limited to the uppermost active layer, approximately 10 - 15 cm in thickness. In the field, this thickness may vary depending on site topography, hydrology, and climate. Because of extreme and prolonged low temperatures and relatively dry conditions prevailing in the Nunavut-Keewatin districts, winter drying and desiccation may lead to exposure and oxidation of tailings at greater depths.

Since 1993, the exposed tailings surface has been covered with a 1.5 m layer of wasterock and overburden (Trow Consulting Engineers, 1995). Temperature profiles within the tailings area indicated a cooling trend and upward migration of the permafrost level in the tailings, although this level is increasing slowly as seen from Table 7 and Figs. 53 - 56. The slow upward rise in the permafrost level was attributed to the placement of cover during summer months, probably caused by poor heat dissipation through the wasterock insulating cover and longer cooling period than if the wasterock was placed, for example, during winter months (Homestake Canada Inc., 1994).

Additional field studies are required for site characterization with respect to active zone of freezing, thawing and oxidation; moisture characteristics; and chemical, mineralogical, and microbial compositions of the tailings in assessing their current weathering and oxidation status.

Cullaton Lake data were compared with those of 59 other mines and 385 others kinetic tests from the International Kinetic Database (Morin et al., 1995). The rate of sulphide oxidation in mg/ SO_4/kg/wk at 25 °C (Phase 1 study; Davé, 1992) was shown to be moderate to high. However, leaching rates of copper and zinc from tailings at the site were shown to be low to very low. This indicated that some form of ARD mitigation was occurring within the tailings mass at the site where cold temperatures and freezing conditions are present at least 8 - 10 months a year.

During operations, sodium cyanide consumption for both B - Zone and Shear (S) - Zone ore was at the rate of 2 kg/tonne ore. Cyanide concentrations of tailings porewater at the site ranged between 200 - 300 mg/l (Napier, 1996). Although cyanide concentration decreased with decreasing pH, where it is lost through formation of HCN, the toxicity of tailings seepage water is influenced by the formation of metal complexes in cyanide solutions (Higgs, 1992).

5.0 SUMMARY AND CONCLUSIONS

Cold temperature leaching studies at 2 °C and 10 °C were conducted for Cullaton B - and Shear (S) - Zones tailings to evaluate their oxidation and leaching characteristics at low temperatures.

The results showed that oxidation and acidic drainage occurred in both tailings at these temperatures. The rate of acid generation was less and acidic drainage occurred later at 2 °C than at 10 °C.

The overall impact of acid drainage at cold temperatures was lower for B - Zone tailings than for S - Zone as the former contained higher total available alkalinity.

Both B - and S - Zones tailings also retained appreciable amounts of moisture which limited oxidation and acidification to the well drained upper layer and provided further control on acidic drainage.

6.0 RECOMMENDATIONS

It is recommended that all the available data for the three leaching temperatures, 25 °C (from phase 1), and 10 °C and 2 °C from the present study, should be examined further and analyzed to obtain acid generation and metal loading rates at these temperatures. The tailings management facility at the Cullaton Lake site should also be assessed for its current physical, chemical, mineralogical and biological status by undertaking suitable field studies.

7.0 REFERENCES

Chataway, R. T. and Hanson, W., 1983, Cullaton Lake Gold Mines Ltd. and Royex Sturgex Mining, Shear Lake property, Cullaton Lake, N. W. T.' Summary Report, Cullaton Lake, December 1983.

Davé, N. K., 1991, Column Leaching Characteristics of Cullaton Lake B and Shear Zones Tailings Phase 1 - Room Temperature Leaching, Energy Mines and Resources Canada, Division Report, September 1991.

GEOCON, 1993, Preventing AMD by Disposing of Reactive Tailings in Permafrost. MEND Project 6.1. December 1993.

Greenberg, A. E., Clesceri, L. S. and Eaton, A. D., 1992, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington, DC, 18 th Edition, 1992.

Higgs Associates Ltd., 1992, Technical Guide for the Environmental Management of Cyanide. B. C. Technical and Research Committee on Reclamation, Cyanide Subcommittee.

Homestake Canada Inc., 1994, Cullaton Gold Mine Water Licence NGL3-0940, Annual Licence Report, 1994.

Kane, T. W., and D. D. Brown, 1986, Mines and Important Mineral Deposits of the Yukon and Northwest Territories, 1986. Northern Affairs Program. Mining Resource Section, Mining Administration.

Klohn Leonoff, 1992, Acid Rock Drainage in Northern Environments. Indian and Northern Affairs Publication No. PB 60710102.

Knapp, R. A., 1987, The Bio-geochemistry of Acid Generation in Sulphide Tailings and Wasterock. Proc. Acid Mine Drainage Seminar/Workshop, Halifax, Nova Scotia, March 1987, pp. 47-65.

Morin, K., Agra Earth and Environment, 1995, Towards a Tailings and Wasterock Strategy for Using Permafrost to Manage ARD. Draft MEND report, 1995.

Morin, K., N. Hutt, and K. Ferguson, 1995, Measured Rates of Copper and Zinc Leaching in the International Kinetic Database. Proc. 1995 B. C. Mine reclamation Symposium. Technical and Research Committee on Reclamation.

Napier, W., Homestake Canada Inc., 1996, Personal Communication to V. Clulow.

Page, Charles E., 1983, The Geology of the Cullaton Lake B - Zone Gold Deposit, Northwest Territories. M. Sc. Thesis, University of Waterloo, Ontario, 1983.

Trow Consulting Engineers Ltd., 1991, Abandonment and Restoration Plan, Cullaton Lake Gold Mines Ltd. Trow Consulting Engineers, Thunder Bay, Ontario, April 1991.

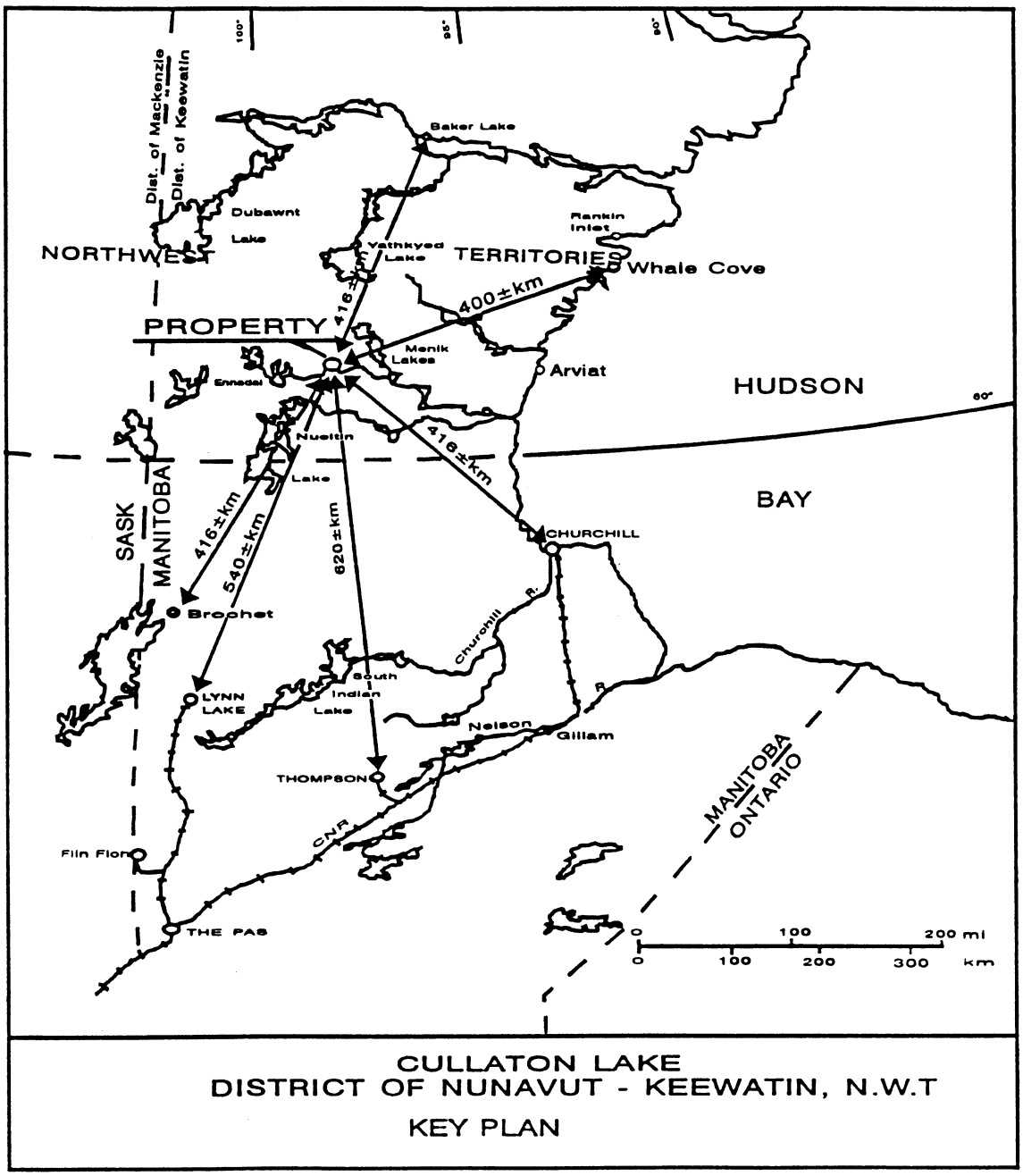


Fig. 1 Location of Cullaton Lake mine, Northwest Territories.

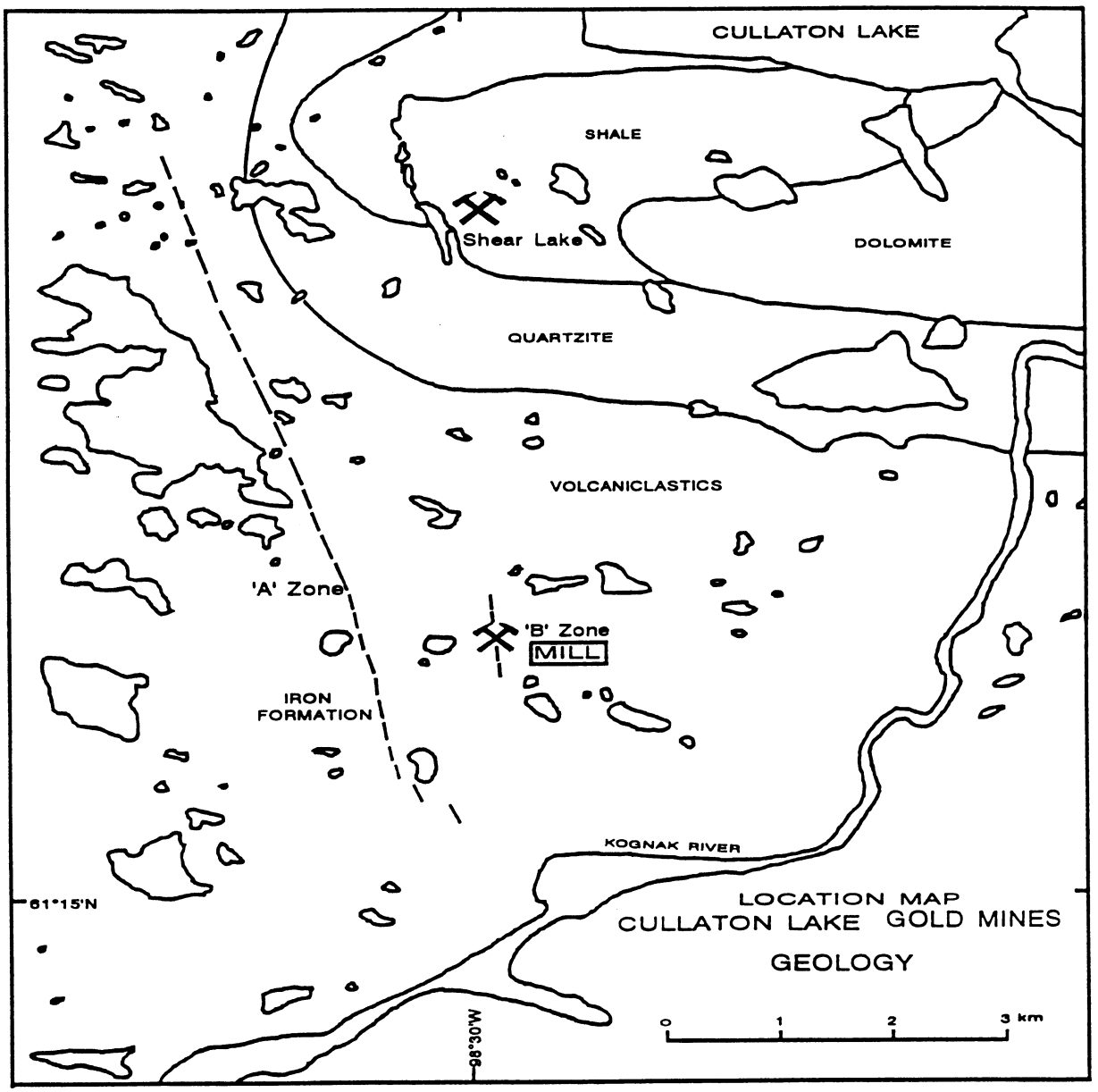
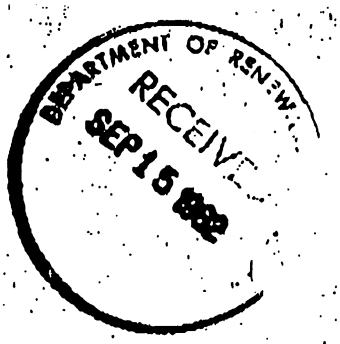


Fig. 2 Location of B- and Shear-Zones at the Cullaton Lake mine property.



Called - 4:50
- Mail

Sep 14 4 54 PM '82

GOVTNWTTRES YK

CNCP SAFT
GUT535 SEP 14 1651 EST

WATER WH WB YK
001 002
RX 03445531 GOVTNTTRES YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SEPTEMBER 14, 1982 3:30 PM

SPILL REPORT NO. 82-80

REPORT DATE — WHEN DATE AND TIME OF SPILL IF KNOWN

A 14-09-82 13-09-82 9:30 A.M.

WHERE LOCATION OR MAP CORDINATES

B KEEWATIN REGION

WHO-PARTY RESPONSIBLE AND/OR OWNER

C CULLATON LAKE GOLD MINES LTD.

WHAT-NATURE OF SPILL-TYPE AND ESTIMATED QUANTITIES

D TAILINGS WATER LEAKAGE UNKNOWN

HOW WAS SPILL CAUSED

E OVERFLOW (SEE H)

IF SPILL TERNIATED OR CONTINUING (IF CONTINUING GIVE VOLUNE AND RATE,

F CONTINUING AT DEMINISHED RATE

NATURE AND EXTENT OF CONTAMINATED AREA

G UNKNOWN

OTHER FACTORS AFFECTING SPILL OR RECOVERY-TEMP, WIND, ETC.

NATURE AND EXTENT OF CONTAMINATED AREA

G UNKNOWN

OTHER FACTORS AFFECTING SPILL OR RECOVERY-TEMP,WIND,ETC.

H CAUSED BY HEAVY RAIN PRIOR TO COMPLETION OF DAM CONSTRUCTION

CONTAINMENT: -A-NATURALLY B-BOOMS,DYKES OR OTHER C-CONTAINMENT

I SEE J

ACTION IF ANY TAKEN OR PROPOSED
CLEAN UP OR TO CONTAIN

J CONSTRUCTION IN PROGRESS TO TERMINATE LEAK

DO YOU REQUIRE ASSISTANCE — IF FOLLOW UP NECESSARY

K NO — NO

ANY HAZARD TO PERSONS OR PROPERY, IE FIRE, DRINKING WATER

L NONE

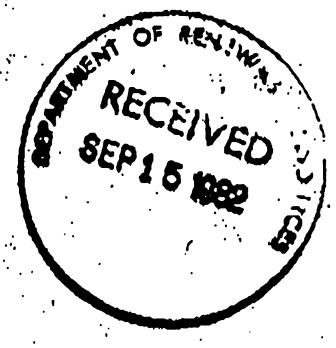
COMMENTS AND/OR RECOMMENDATIONS

M CONSTRUCTION IN PROGRESS USING SIMILAR TECHNIQUES AND MATERIALS SUCCESSFULLY TO CONTAIN LEAK REPORTED JULY14/82.

REPORTED BY M. ARMSTRONG MINE MANAGER 204-677-3270.

86
GOVTNWTTRES YK

BM PA



YTNWTTRES YK Sep 15 11 53 AM '82

CNCP SAFT
GW0134 SEP 15 1235 EST

WATER WN WB YK
001 002
RX 03445531 GOVTNTTRES YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SEPTEMBER 15, 1982

FOLLOW-UP REPORT ON SPILL REPORT 82-80 AT CULLATON LAKE GOLD MINES NEAR KOGNAK RIVER IN THE KEEWATIN DISTRICT OF THE NWT ON SEPTEMBER 13, 1982.

THIS SPILL OF TAILINGS EFFLUENT WAS INVESTIGATED BY THE A/DISTRICT MANAGER FOR THE NAP, DIAND, KEEWATIN DISTRICT.

AN ESTIMATED 5000 GALLONS OF EFFLUENT OVERFLOWED THE LYPALON NER OF THE TAILINGS IMPOUNDMENT DYKE AND LEAKED THROUGH USHED ROCK DEPOSITED ALONG THE CREST OF THE DYKE TO ..ISE THE DYKE 5' IN ELEVATION.

DURING AN ENVIRONMENTAL INSPECTION OF THE SITE ON SEPT 10, 1982 THERE WERE 3 TO 4 FEET OF FREEBOARD IN THE TAILINGS POND. HOWEVER, HEAVY RAINS ON SEPT 10 AND 12 HAD REDUCED FREEBOARD IN THE TAILINGS IMPOUNDMENT AND STRONG WINDS ON SEPT 13, 1982 CAUSED WAVES WHICH WASHED THE EFFLUENT OVER THE HYPALON LINER. THE EFFLUENT LEAKED OVER THE HYPALON LINER ALONG THE NORTH SIDE OF THE TAILINGS IMPOUNDMENT INTO THE RUNOFF DIVERSION DITCH. AS OF 1600 SEPTEMBER 14 LOSS OF EFFLUENT HAD CEASED AND WORK WAS UNDERWAY TO PLACE FINE MATERIAL ALONG THE INSIDE WALL OF THE TAILINGS IMPOUNDMENT AND TO LAY THE HYPALON LINER OVER THE 5' ADDITION TO THE DYKE. WATER SAMPLES HAVE BEEN COLLECTED TO DOCUMENT THE IMPACT OF THE TAILINGS EFFLUENT LEAK.

IF YOU HAVE AN QUESTIONS PLEASE CONTACT D. STENDAHL WATER QUALITY OFFICER AT 920-8248.

BT
GOVTNWTTRES YK

CNCP SAFT
GUI764 MAY 30 1835 EST

;ATER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SPILL REPORT NO: 83-33

-) MAY 30 WHEN - SAME DAY / TIME - 4:30 P.M.

B) CULLATON LAKE NWT

C) CULLATON LAKE GOLD MINES LTD.

D) RUNOFF WATER AND TAILINGS EFFLUANT.

E) DAM LEAKING

) CONTINUING 2000 PLUS GALLONS/HR

G) DOWNSTREAM NUMBER 2 TAILINGS POND.

H) EXTREME SNOW FALL (5-6 FEET THIS YEAR) AND RAIN STORM.

I) (C) NO CONTAINMENT

J) PLUGGING LEAK AT PRESENT

K) NOT YET / NOT YET

L) NO

M) EXTREME RUNOFF CAUSED BY HEAVY SNOWFALL AND RAINFALL.
AT PRESENT AFTER DUMPING 3 LOADS OF MUCK, LEAKAGE IS
REDUCED TO A VERY SMALL TRICKLE.

REPORTED BY: M. ARMSTRONG

POSITION: MINE MANAGER

TELEPHONE: (204) 677-3270

2222

SPILL REPORT SENT OUT AS RECEIVED BY TELEX FROM M. ARMSTRONG,
MINE MANAGER, CULLATON LAKE GOLD MINES LTD.

DIAND/NAP IS FOLLOWING UP ON SPILL.

$
COMM NWTGOV YK

CNCP SAFT
GVP091 MAY 31 1236 EST

ITER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

AS FOLLOWUP TO SPILL REPORT NO: 83-33

MAIN LEAK IS STOPPED THOUGH A SMALL AMOUNT OF LIQUID IS STILL SEEPING THROUGH. EFFORT TO MINIMIZE LEAKAGE CONTINUING. THERE IS MUCH RUNOFF WATER DILUTING SEEPAGE. GEESE, DUCKS AND SEAGULLS USING AREA WHERE LEAKAGE SEEPING AS A RESTING AREA - NO EFFECT NOTICED. OUTFLOW OF LIQUID LASTED FOR APPROX. 6 HOURS MORE OR LESS AT 2000 GALS/HR ESTIMATED. DOWNSTREAM FLOW DILUTED BY NATURAL RUNOFF, DOESN,T MAKE IT POSSIBLE TO PUMP SPILL BACK TO CONTAINMENT AREA. MORE SAMPLES BEING TAKEN AND RESULTS WILL BE FORWARDED AS 'ECEIVED.

THE ACTING DISTRICT MANAGER FOR KEEWATIN IS ON HIS WAY TO THE SITE TO INVESTIGATE.

REPORTED BY: M. ARMSTRONG, MINE MANAGER, CULLATON LAKE GOLD MINES LIMITED

REPORTED TO: D. MILBURN, DIAND/NAP, YELLOWKNIFE, MAY31/83, BY TELEX.

FOLLOWUP TELEX DATE: MAY 31/83

$

&
COMM NWTGOV YK

ICP SAFT
GUJ934 JUN 07 1226 EST

WATER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

JUNE 7 1983

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SPILL REPORT NO: 83-37

A JUNE 7 1983 JUNE 7, 1983
EXACT TIME UNKNOWN

B CULLATON LAKE TAILINGS POND

C CULLATON LAKE GOLD MINES LTD

D TAILINGS POND-EFFLUENT - 10 GAL/HOUR EST.

E LEAK IN TAILINGS DYKE

F CONTINUING

G UNKNOWN LARGE VOLUME OF RUN-OFF - EFFLUENT IS DILUTED

H WARM TEMPETURES CAUSING LARGE VOLUME OF RUN- OFF

I NO CONTAINMENT

J TRYING TO PLUG LEAK ON OUTSIDE OF DYKE

K NO

L NO

M NORTHERN AFFAIRS PROGRAM, DIAND WILL FOLLOW UP

REPORTED BY GLEN SPROUEL, MINE ENGINEER, CULLATON LAKE GOLD MINES LTD. TO A. CULLEN, REGIONAL MANAGER, WATER RESOURCES, NAP DIAND AT PHONE NO. 920-8241

COMM NWTGOV YK

CNCP SAFT
GV0051 JUN 07 1937 EST

WATER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN MR D BILLING
CHIEF, ENVIRONMENTAL SERVICES

THIS IS AN URGENT MESSAGE. PLEASE DELIVER IMMEDIATELY

AS FOLLOWUP TO SPILL REPORT NO: 83-37

TAILINGS DYKE LEAKS

AS PER OUR PHONE CONVERSATION THIS A.M. A NUMBER OF SMALL LEAKS HAVE OCCURED IN THE LAST FEW DAYS ON THE NORTH EAST CORNER OF THE PRIMARY TAILINGS POND DYKE. WE HAVE DUMPED FILL ON THE INSIDE OF THE DYKE IN AN EFFORT TO STOP THE LEAKS TO NO AVAIL. IT WOULD APPEAR THAT THERE IS ICE UNDER THE WATER AND THE LEAK IS UNDER THE ICE. WE ARE NOW ATTEMPTING TO STOP THE LEAK BY PLACING FILL ON THE OUTSIDE OF THE DYKE AND HAVING SOME SUCCESS WITH THIS APPROACH.

I WILL BE TAKING SAMPLES DAILY AND WILL FORWARD THE RESULTS AS I RECEIVE THEM.

REPORTED BY: G. SPROWL, MINE ENG., CULLATON LAKE GOLD MINES LTD (BY TELEX)

REPORTED TO: WATER RESOURCES, DIAND/NAP YELLOWKNIFE,
ATTN: MR. ANDY CULLEN TELEX: 03445623

Spill Reports 33, 37, 39.

Suggestion reports are on file concerning Cullaton Lake Tailing pond seepage

CONFIDENTIAL

MINE SEEPAGE MONITORED

YELLOWKNIFE (June 27, 1983) - Seepage from the tailings pond at the Cullaton Lake gold mine is being monitored by the Water Resources Division of Indian and Northern Affairs Canada (INAC).

The seepage, first detected May 31, is now being contained in a catch basin, while company surveyors are planning construction of another tailings pond which will permanently resolve the problem.

Pumps operating in the catch basin are able to recycle the effluent back into the tailings pond, reported Doug Stendahl, Water Quality Officer, and Peter Kusugak, Assistant Manager of the Rankin Inlet district office.

They reported that no environmental damage had been detected downstream in the Kognak River, after taking samples from several stations.

Mine officials told the inspectors the spills were due to punctures in the tailings dam liner. A more resistant liner will be installed in the new tailings pond.

The mine's immediate response to eliminate seepage is to extend the tailings discharge line, so that tailings can be beached along the inside of the tailings pond. Mine manager Merdy Armstrong said this work and the tailings pond construction would be completed this summer.

Mr. Stendahl said the Division was satisfied with the mine's plans for correcting the situation, but stressed the importance of doing the job quickly because of the critical situation.

Northern Affairs Program staff will continue to make regular inspections of the site over the summer.

Cullaton Lake is located 400 km south-west of Rankin Inlet.

-30

For further information contact:

Doug Stendahl
Water Resources Division
INAC
(403)920-8248

COMM NWTGOV YK

CNCP SAFT
GUJ867 JUN 23 1300 EST

IAND YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN CHIEF, POLLUTION CONTROL GNWT

YK 546
83-06-23

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SPILL REPORT NO: 83-39

A JUNE 21, 1983 JUNE 21/83 1100

B CULLATON LAKE GOLD MINE, NWT
61 DEGREES 16'N , 98 DEGREES 30'W

C CULLATON LAKE GOLD MINES LTD.

D 30-50 GAL. PER HOUR OF TAILING EFFLUENT.

E SEEPAGE THROUGH TAILINGS DAM 4' BELOW AREA OF DAM
NO LINEAR EXISTS AT THIS ELEVATION.

F CONTINUING

G EFFLUENT IS CONTAINED IN CATCH BASIN AT TOW OF TAILINGS
DAM

H NONE

I NATURALLY IN CATCH BASIN

J EFFLUENT BEING RECYCLED INTO TAILINGS POND AND FILL
MATERIAL IS BEING PLACED INSIDE TAILING POND ALONG THE DAM

K NO FORM

L NO

M FREEBOARD IN TAILINGS POND IS 0.5 M.
NAP IS MONITO

COMM NWTGOV YK

CNCP SAFT
GUO867 JUN 23 1317 EST

IAND YK
001 002
TX 03445538 COMM NWTGOV YK

$
COMM NWTGOV YK

CNCP SAFT
GV0097 JUN 10 1704 EST

WATER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN: MR. M. SMITH
CHIEF, POLLUTION CONTROL DIVISION

JUNE 10 1986

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

SPILL REPORT NO. 86-48

A. JUNE 10, 86 3:10 P.M. JUNE 10, 86 9:00 A.M.
B. CULLATON LAKE GOLD MINE
SEEPAGE FROM TAILINGS POND NO. 2 SOUTH END
C. INTERNATIONAL CORONA RESOURCES LIMITED
D. TAILING EFFLUENT 100 GALLONS PER MINUTES
E. DAM SEEPAGE
F. CONTINUING
G. UNKNOWN
H. AVAILABILITY OF MANPOWER
I. NONE
J. PROPOSED ACTION - STARTING JUNE 14, 86 WILL BE DAM REINFORCEMENT
TODAY ACTION - WATER QUALITY SAMPLES TAKEN
K. NO
L. UNKNOWN AT PRESENT
M. CONTACT PETER WHITE AT 204-675-2795 FOR FURTHER DETAILS
NAP LEAD AGENCY

REPORTED BY: PETER WHITE, SENIOR ENGINEER, INTERNATIONAL CORONA RESOURCES, TORONTO 416-862-1342

REPORTED TO: J. NGAI, INLAND WATERS CLERK, WATER RESOURCES DIVISION, YELLOWKNIFE 920-8242

$
COMM NWTGOV YK

1. 86048
2. 06/10/86
3. Cullaton Lake Gold Mine Key
4. Mill tailings WW
5. 0
6. Inter. Corona Resources Mtl
7. Tp
8. Glisson
9. Mcf
10. Y/L

POLLUTION CONTROL JUN 18 1986 INAC/NAP
354
G.N.W.T.

Ken Eulingua - June 18
Bruce Macdonald - June 18

COMM NWTGOV YK

CNCP SAFT
GV0077 JUN 13 1514 EST

WATER WM WB YK
001 002
TX 03445538 COMM NWTGOV YK
ATTN: MR. M. SMITH
CHIEF, POLLUTION CONTROL DIVISION

JUNE 13, 1986

THIS IS AN URGENT MESSAGE PLEASE DELIVER IMMEDIATELY

FOLLOW UP TO SPILL REPORT NO. 86-48

A JUNE 12/86
B CULLATON LAKE GOLD MINE
M WATER SAMPLING TEST SHOWS LIMITS WITHIN WATER QUALITY STANDARDS
- COPPER ..... 0.2 PPM
- LEAD ..... .05 PPM
- ARSENIC ..... .0 PPM
- PH ..... 6.9 PPM
- CYANIDE ..... 2 00.
- SUSPENDED SOLIDS .. 7 MM/LITRE

DAM REPAIR CREW WILL BE ON SITE JUNE 13/86 WEATHER PERMITTING.

ORIGINALLY REPORTED BY: PETER WHITE - (204) 675-2795 -

REPORTED BY: SHERRY HOLDEN - NCNW - YELLOWKNIFE - 873-3953

REPORTED TO: MAXINE VICK - CR - WATER RESOURCES - NAP, YK - 920-8245

BT
COMM NWTGOV YK

Northwest Territories

Hazardous Materials Spill Database

Department of Resources, Wildlife & Economic Development

02 Sep 1998

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
74005	17 Mar 1974	NSL	Giant	Between Tailings Pond & Back Bay	Mine Effluent	22730000	Giant Mine	TP	-
74008	08 Apr 1974	NSL	Giant	Shaft C	Bunker C	3182	Giant Mine	UK	-
74011	05 May 1974	NSL	Con	Kam Lake	Tailings Effluent	0	Cominco Con Operations	TP	-
74018	09 Jun 1974	DEH	Tungsten	Boiler Plant	Fuel Oil #2	0	Canada Tungsten Mining Corp Ltd	PL	INAC/NAP
74031	28 Aug 1974	NSL	Terra	Pipe Between Dock & Tank Farm	Diesel Fuel	1814	Terra Mining Exploration	PL	-
75020		DEH	Tungsten	Retaining Dyke Area	Diesel LOPOR 50	0	Canada Tungsten Mining Corp Ltd	OTH	-
75021	07 Jun 1975	SSL	Pine Point	Pine Point Switch Yard	Diesel Fuel & Sludge	45460	Pine Point Mines	ST>	-
75027	27 Jun 1975	SSL	Pine Point	Pine Point Switch Yard	Diesel Fuel	7273	Cominco	ST>	INAC/NAP
75033		SAH	Port Radium	Power Plant Area	Diesel Fuel	0	Echo Bay Mines Ltd	NS	-
76030		NSL	Con	Con Docks	Bunker C	0	Cominco Con Operations	NS	-
76035	01 Dec 1976	NSL	Giant	Boiler House	Bunker C	909	Giant Yellowknife Mines	UK	INAC/NAP
77003		NSL	Giant	Seepage Pond Below Dam #3D	Tailings	0	Giant Mine	TP	INAC/NAP
77004	25 Jan 1977	NSL	Terra	Main Portal	Diesel Oil	31822	Robinson's Trucking	TRU	INAC/NAP
77014	07 Apr 1977	NSL	Giant	Baker Creek	Arsenic Solution	0	Giant Yellowknife Mines	UK	-
77034	13 Jul 1977	SAH	Port Radium		Unknown	0	Unknown	UK	-
77037	02 Aug 1977	SAH	Port Radium	On Water	Diesel	0	Unknown	UK	-
77050	04 Oct 1977	NSL	Con	Between Lower Pud & Kam Lakes	Tailings	0	Cominco Con Operations	TP	INAC/NAP
77051	06 Oct 1977	NSL	Giant	Tailings Backfill Line Beside Highway	Tailings	0	Giant Yellowknife Mines	TP	INAC/NAP
78008	01 Apr 1978	BAF	Nanisivik	Bank & Bed of Twin Lakes Creek	Mill Tailings	465000	Nanisivik Mines Ltd	PL	-
78011	19 May 1978	NSL	Giant		Bunker C	273	Giant Yellowknife Mines	PL	GNWT
78013	05 Jun 1978	DEH	Tungsten	Pond #4	Tailings	0	Canada Tungsten Mining Corp Ltd	TP	GNWT
78021	29 Jun 1978	SAH	Port Radium		Aviation Fuel	205	Unknown	ST<	INAC/NAP
78029	12 Sep 1978	NSL	Giant	Tailings Pond Outfall	Mill Tailings	22730	Giant Yellowknife Mines	TP	-
79001	02 Jan 1979	NSL	Giant	Tailings Outfall	Tailings	0	Giant Yellowknife Mines	TP	INAC/NAP
79003	22 Dec 1978	NSL	Giant	Baker Creek	Lube Oil	0	Giant Yellowknife Mines	PL	EPS
79006	02 Feb 1979	SSL	Pine Point	Tank Car Area	Diesel P-50	12274	Cominco	OTH	-
79021	27 Apr 1979	SAH	Port Radium	Tank Farm	Diesel Fuel	22730	Echo Bay Mines Ltd	ST>	INAC/NAP
79023	05 May 1979	SSL	Pine Point	Halfway Between Town & Minesite	Gasoline	4546	Heath & Sherwood Drilling	PL	INAC/NAP
79029	18 May 1979	SAH	Port Radium	Tank Farm	Diesel Fuel	0	Echo Bay Mines Ltd	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
79033	30 Jun 1979	NSL	Terra	Tailings Pond Area	Heating Oil P-40	909	Terra Mining Exploration	PL	INAC/NAP
79034	14 Jul 1979	NSL	Con	Tank Farm	Bunker C	6364	Cominco Con Operations	ST>	GNWT
79041	04 Aug 1979	NSL	Giant	Tailings Dam #5	Tailings Water	0	Giant Yellowknife Mines	TP	INAC/NAP
79055	02 Nov 1979	SSL	Pine Point	NCPC Site	Railroad Diesel	9092	NCPC	ST>	-
79056	09 Nov 1979	FTS	Pine Point	NCPC Site	Lube Oil	3410	NCPC	ST>	-
79059	02 Jan 1979	NSL	Giant	In Ditch Opposite Roaster Building	Unknown	2273	Giant Yellowknife Mines	ST>	EPS
79063	08 Dec 1979	KIT	Lupin	Around Tailings Booster Pump Area	Mill Tailings	22730	Echo Bay Mines Ltd	PL	-
80006	21 Feb 1980	SAH	Port Radium	Depression Behind Booster Pumps	Tailings	147745	Echo Bay Mines Ltd	PL	-
80011	10 Mar 1980	NSL	Giant	Dam #5	Tailings	82000	Giant Yellowknife Mines	TP	-
80014	31 Mar 1980	FTS	Pine Point	Bottom of Pit	Diesel	11365	Sedco Drilling	UK	-
80017	17 Apr 1980	NSL	Giant	Dam #5	Tailings	0	Giant Yellowknife Mines	UK	-
80029	28 May 1980	BAF	Polaris	Pipeline	Arctic Diesel	0	Cominco	PL	-
80038	16 Jun 1980	BAF	Polaris	Fuel Storage Area	Diesel Fuel	0	Cominco	PL	-
80058	15 Jul 1980	NSL	Con	Con Docks	Bunker C	23	Cominco Con Operations	OTH	EPS
80113	07 Oct 1980	NSL	Giant	West Side of Highway & Baker Creek	Gasoline	9092	Giant Yellowknife Mines	ST>	-
80119	02 Dec 1980	NSL	Camlaren	Adjacent to Tailings Impoundment Dyke	Mill Tailings	22730	Mining Corporation of Canada	PL	-
81027		NSL	Con	Yellowknife Bay Con Dock	Light Fuel Oil	45	Unknown	UK	INAC/NAP
81035		DEH	Prarie Creek	Tank Farm	Diesel Fuel	45460	Cadillac Explorations Ltd	ST>	INAC/NAP
81037		DEH	Prarie Creek		Capacitor Fluid (PCB)	18	Cadillac Explorations Ltd	OTH	EPS
81043	03 Jul 1981	NSL	Giant	West Side of Mill Building	Floatation Tailings	0	Giant Yellowknife Mines	ST>	INAC/NAP
81052	02 Aug 1981	BAF	Nanisivik	400M & 600M Above Concentrator	Pyrite Tailings/Reclaim Water	0	Nanisivik Mines Ltd	PL	INAC/NAP
82006	24 Jan 1982	FTS	Pine Point	Tank Farm	Diesel P-40	3180	NCPC	PL	GNWT
82011	10 Feb 1982	NSL	Camlaren	Gordon Lake	Diesel P-50	6130	Mining Corporation of Canada	PL	INAC/NAP
82013	24 Feb 1982	NSL	Con	Mill	#2 Oil	230	Cominco Con Operations	PL	GNWT
82017	10 Mar 1982	NSL	Giant	Tailings Dam #4	Clear Effluent	45460	Giant Yellowknife Mines	OTH	INAC/NAP
82018	03 Mar 1982	DEH	Prarie Creek	Tank Farm Area	Fuel Oil	13638	Cadillac Mines	ST>	INAC/NAP
82023		KEE	Cullaton Lake	Tailings Pond	Sewage	0	Cullaton Lake Gold Mines Ltd	TP	INAC/NAP
82025		SAH	Port Radium	Elevated Fuel Storage Area	Diesel Fuel	75009	Echo Bay Mines Ltd	PL	INAC/NAP
82032	11 Apr 1982	KIT	Lupin	Tank Farm	Diesel Fuel	54552	Echo Bay Mines Ltd	PL	INAC/NAP
82033	25 Apr 1982	DEH	Prarie Creek	Tank Farm Area	Diesel Fuel	2725	Cadillac Explorations Ltd	PL	INAC/NAP
82047	10 Jun 1982	KIT	Lupin	Between Tank Farm & Powerhouse	Fuel Oil	2910	Echo Bay Mines Ltd	PL	INAC/NAP
82063	24 Jul 1982	KIT	Lupin		Diesel P-50	4046	Echo Bay Mines Ltd	PL	INAC/NAP
82070	14 Aug 1982	KIT	Lupin	Road Bed Area Around Tank Farm	Gasoline	450	Echo Bay Mines Ltd	ST>	INAC/NAP
82080	13 Sep 1982	KEE	Cullaton Lake	Tailings Dam	Tailings Effluent	22730	Cullaton Lake Gold Mines Ltd	TP	INAC/NAP
82098	22 Nov 1982	BAF	Polaris	Welding Shop	Diesel P-40	68190	Cominco Polaris Mine	PL	INAC/NAP
82102	30 Dec 1982	KIT	Lupin	Tank Area	Diesel P-50	2728	Echo Bay Mines Ltd	ST>	INAC/NAP
83022	20 Mar 1983	DEH	Tungsten		Diesel Fuel	5910	Canada Tungsten Mining Corp Ltd	PL	GNWT
83027	21 Apr 1983	BAF	Polaris	Pumphouse Door & Dump Basin	Tailings Slurry	1136500	Cominco	OTH	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
33033	30 May 1983	KEE	Cullaton Lake	Downstream #2 Tailings Pond	Tailings Effluent	12000	Cullaton Lake Gold Mines Ltd	TP	INAC/NAP
83037	07 Jun 1983	KEE	Cullaton Lake	Tailings Pond	Tailings Pond Effluent	0	Cullaton Lake Gold Mines Ltd	TP	INAC/NAP
83038	15 Jun 1983	DEH	Tungsten	Powerhouse	Lube Oil	295	Canada Tungsten Mining Corp Ltd	ST>	INAC/NAP
83039	21 Jun 1983	KEE	Cullaton Lake	Tailings Dam #4	Tailings Effluent	0	Cullaton Lake Gold Mines Ltd	TP	INAC/NAP
83050	12 Jul 1983	NSL	Con	Robertson Shaft Complex	Diesel P-50	295	Cominco Con Operations	TRU	INAC/NAP
83063	10 Aug 1983	NSL	Con	Between Mosher Island & Con Docks	Bunker C	90	Cominco Con Operations	OTH	INAC/NAP
83065		NSL	Con	Pumphose/Boiler Room	Bunker C	0	Cominco Con Operations	PL	INAC/NAP
83071	27 Aug 1983	BAF	Polaris	Mine Dock Area	Diesel P-60	675	Cominco	PL	INAC/NAP
83074	29 Sep 1983	BAF	Nanisivik	Twin Lakes Creek	Tailings	13500	Nanisivik Mines Ltd	PL	INAC/NAP
83077	29 Oct 1983	BAF	Nanisivik	Twin Lakes Creek Near Mill	Tailings	5000	Nanisivik Mines Ltd	PL	INAC/NAP
84023		NSL	Salmita	Mill Sump & Floor	Tailings & Mill Water	0	Salmita Project	OTH	INAC/NAP
84032	23 Mar 1984	NSL	Con	Tailings Area	Tailings Solution	0	Cominco Con Operations	TP	INAC/NAP
84038	27 Mar 1984	NSL	Salmita	Tank Farm	Diesel Fuel	5000	Salmita Project	ST>	INAC/NAP
84039	02 Apr 1984	NSL	Salmita	Refinery Building	Barren Solution	20000	Salmita Project	ST>	INAC/NAP
84040	02 Apr 1984	NSL	Salmita	Mill	Mill Water	2000	Salmita Project	OTH	INAC/NAP
84042		NSL	Terra	Tank Farm	Diesel Fuel	22700	Terra Mines	PL	INAC/NAP
84044	19 Apr 1984	KIT	Lupin	Storage Tank	Diesel P-50	300	Echo Bay Mines Ltd	ST>	INAC/NAP
84047	08 May 1984	NSL	Giant	South of Mine Entrance	Waste Engine Oil	909	Giant Mine	ST>	INAC/NAP
84049	08 May 1984	DEH	Tungsten	Powerhouse	Lube Oil	18	Canada Tungsten Mining Corp Ltd	PL	INAC/NAP
84050		NSL	Con	Tailings Area Dyke #4	Tailings Effluent	0	Cominco Con Operations	TP	INAC/NAP
84056	28 May 1984	DEH	Tungsten	Tailings Pond #4	Tailings	0	Canada Tungsten Mining Corp Ltd	TP	INAC/NAP
84081	23 Jul 1984	KIT	Lupin	Tailings Pond	Tailings	0	Echo Bay Mines Ltd	TP	INAC/NAP
84099	12 Sep 1984	KEE	Cullaton Lake	Fuel Storage Area	Arctic Diesel	3600	Calm Air	ST>	INAC/NAP
84107	12 Oct 1984	FTS	Pine Point	Railbed	Diesel Fuel	41000	Canadian National Railroad	RT	INAC/NAP
84121	06 Dec 1984	NSL	Salmita	Along Tailings Pipeline	Mill Tailings	10000	Salmita Gold Mines	PL	INAC/NAP
85011	03 Feb 1985	BAF	Nanisivik	200 Yards From 1st Valve Shack	Lead Zinc Tailings	50000	Nanisivik Mines Ltd	PL	INAC/NAP
85014	07 Feb 1985	KIT	Lupin		Diesel Fuel	135	Echo Bay Mines Ltd	ST>	INAC/NAP
85019	18 Feb 1985	BAF	Polaris	Discharge Line Garrow Lake	Tailings	80000000	Cominco	PL	INAC/NAP
85031	25 Mar 1985	DEH	Tungsten	Tank Farm	Diesel Fuel	45400	Canada Tungsten Mining Corp Ltd	ST>	INAC/NAP
85038	26 Apr 1985	NSL	Con	Negus Pond Location	Natent from Arsenic Pit	0	Cominco Con Operations	OTH	INAC/NAP
85041	05 May 1985	KIT	Lupin		Diesel P-40	2270	Echo Bay Mines Ltd	ST>	INAC/NAP
85054		NSL	Camlaren	Gordon Lake	Mill Tailings	0	Camlaren Mines	TP	INAC/NAP
85070	21 Jul 1985	DEH	Tungsten	Backfill Adit By Open Pit	Diesel Fuel	1362	Canada Tungsten Mining Corp Ltd	ST>	INAC/NAP
85072	25 Jul 1985	BAF	Nanisivik	50 Metres From Twin Lakes Creek	Tailings	11250	Nanisivik Mines Ltd	PL	INAC/NAP
85079		NSL	Con	Fuel Farm	Fuel Oil	1135	Cominco Con Operations	ST>	INAC/NAP
85085		NSL	Salmita	Tailings Pond	Tailings	0	Salmita Mines	TP	INAC/NAP
85087	05 Sep 1985	FTS	Pine Point	West of 776 Storage Area	Crankcase Oil	90	Tundra Drilling	TRU	INAC/NAP
85098	28 Sep 1985	NSL	Giant	Baker Creek Near Roaster Building	Mill Tailings	22700	Giant Yellowknife Mines	ST>	INAC/NAP
85111	06 Nov 1985	DEH	Tungsten	Between Mill & Tailings Ponds 1 & 2	Mill Tailings	0	Canada Tungsten Mining Corp Ltd	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
85115	14 Nov 1985	NSL	Salmita	Fuel Line	Diesel P-40	5000	Salmita Mines	PL	INAC/NAP
85118	04 Dec 1985	NSL	Con	Mill Boiler House	Bunker C	500	Cominco Con Operations	ST<	INAC/NAP
86014	21 Feb 1986	NSL	Salmita	Tank Farm	Diesel P-40	4500	Giant Yellowknife Mines	ST>	INAC/NAP
86026	04 Apr 1986	NSL	Giant	Near B Shaft	Arsenic Trioxide	0	FDS Drilling Ltd	OTH	INAC/NAP
86028	08 Apr 1986	FTS	Pine Point	N-81	Diesel Fuel	455	Five Star Water Hauling	ST<	INAC/NAP
86030	12 Apr 1986	BAF	Polaris	100 M From Tailings Thickener	Mill Tailings	32000	Cominco Polaris Mine	PL	INAC/NAP
86034		NSL	Salmita	Tank Farm	Diesel P-40	90000	Giant Yellowknife Mines	ST>	INAC/NAP
86035		DEH	Tungsten	2.2 Km North of Mine	Diesel Fuel	0	Unknown	UK	INAC/NAP
86040	17 May 1986	KIT	Lupin	Tank Farm	Diesel P-40	900	Echo Bay Mines Ltd	ST>	INAC/NAP
86048	10 Jun 1986	KEE	Cullaton Lake	Tailings Pond #2	Mill Tailings	0	International Corona Resources Ltd	TP	INAC/NAP
86049	12 May 1986	NSL	Con	Pud Lake Dam #2	Tailings Effluent	0	Cominco Con Operations	TP	INAC/NAP
86063	03 Jul 1986	DEH	Tungsten	Tank Farm	Propane	900	Canada Tungsten Mining Corp Ltd	ST>	INAC/NAP
86103	16 Sep 1986	NSL	Con	Between Decker Oil Road & Con Mill	Bunker C	900	Cominco Con Operations	PL	INAC/NAP
86107	25 Oct 1986	NSL	Giant	B2 Open Pit	Diesel Fuel	200	Giant Yellowknife Mines	UK	INAC/NAP
87003	03 Jan 1987	NSL	Salmita	Tailings Line	Mill Tailings	0	Giant Salmita Mines	PL	INAC/NAP
87020	20 Feb 1987	NSL	Giant	West of the Mill	Mill Solution	2000	Giant Yellowknife Mines	ST>	INAC/NAP
87023	12 Mar 1987	NSL	Giant	Mill Complex	Arsenic Trioxide Dust	200	Giant Yellowknife Mines	OTH	INAC/NAP
87029		KIT	Lupin	Tank Farm	Diesel P-40	1300	Echo Bay Mines Ltd	PL	INAC/NAP
87030	07 Apr 1987	NSL	Giant	Below Refinery Building	Tailings Effluent	45000	Giant Yellowknife Mines	PL	INAC/NAP
87042	16 May 1987	KIT	Lupin	Pump Station #1	Tailings Effluent	23000	Echo Bay Mines Ltd	PL	INAC/NAP
87046	21 May 1987	KIT	Lupin	Tank Farm	Diesel P-40	325	Echo Bay Mines Ltd	PL	INAC/NAP
87088	21 Aug 1987	NSL	Giant	Baker Creek	Process Water	74000	Giant Yellowknife Mines	PL	INAC/NAP
87100	24 Sep 1987	NSL	Con	Power Substation Enclosure	PCB	5	Nerco Con Mine	OTH	EPS
87121	23 Nov 1987	NSL	Giant	Mine Mill Sump	Tailings Solution	16000	Giant Yellowknife Mines	PL	INAC/NAP
87133	22 Dec 1987	NSL	Giant	Tailings Area Below Dam #11	Tailings	32000	Giant Mine	PL	INAC/NAP
87134	22 Dec 1987	NSL	Giant	Mill West Wall	Tailings	9600	Giant Yellowknife Mines	PL	INAC/NAP
88011	10 Feb 1988	BAF	Polaris	Between Barge & Tailings Thickener	Tailings Slurry	5000	Cominco	PL	INAC/NAP
88014	25 Feb 1988	BAF	Nanisivik	Tailings Dump Pond	Tailings Slurry	10000	Nanisivik Mines Ltd	TP	INAC/NAP
88018	02 Mar 1988	KIT	Lupin	Tank Farm	Diesel P-40	225	Echo Bay Mines Ltd	PL	INAC/NAP
88025	14 Mar 1988	KIT	Lupin	Between Contwoyto Lake & Minesite	Diesel P-40	660	Echo Bay Mines Ltd	TRU	INAC/NAP
88026	14 Mar 1988	KIT	Lupin	Main Tank Farm	Diesel P-40	200	Echo Bay Mines Ltd	PL	INAC/NAP
88041	16 Apr 1988	KIT	Lupin	Tank Farm	Diesel P-40	114	Echo Bay Mines Ltd	ST>	INAC/NAP
88047	02 May 1988	KIT	Lupin	Tank Farm	Fuel	3600	Echo Bay Mines Ltd	ST>	INAC/NAP
88052	09 May 1988	NSL	Giant	West Side of Mill	Tailings	0	Giant Yellowknife Mines	PL	INAC/NAP
88058	22 May 1988	NSL	Giant	Tailings Retreatment Plant Site	Tailings	90000	Giant Yellowknife Mines	PL	INAC/NAP
88065	05 Jun 1988	NSL	Salmita	Old Tundra Tank Farm	Bunker C	40900	Nick Majasik (Superintendent)	ST>	INAC/NAP
88067	07 Jun 1988	NSL	Giant	Behind Arsenic Silo	Arsenic Trioxide	100	Giant Yellowknife Mines	ST>	INAC/NAP
88084	06 Jul 1988	KIT	Lupin	Truck Filling Station	Diesel P-40	90	Echo Bay Mines Ltd	TRU	INAC/NAP
88100	26 Jul 1988	NSL	Giant	Crusher Building	Minewater	109000	Giant Yellowknife Mines	ST<	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
88102	28 Jul 1988	NSL	Giant	Crusher Building	Minewater	1600	Giant Yellowknife Mines	ST<	INAC/NAP
88113	09 Aug 1988	NSL	Con	Line to Mill Boilerhouse	Bunker C	4000	Nerco Con Mine	ST>	INAC/NAP
88122	17 Aug 1988	NSL	Giant	Main Office Road	Water	0	Two Way Enterprises	ST>	GNWT
88166	24 Nov 1988	NSL	Giant	Northwest Side of Dam 22B	Tailings Water	45000	Giant Yellowknife Mines	TP	INAC/NAP
88168	02 Dec 1988	NSL	Giant	Junction of North & South Pond Lines	Tailings	109000	Giant Yellowknife Mines	PL	INAC/NAP
89001	11 Jan 1989	NSL	Giant	500 - 700 Feet From Mill	Minewater	454000	Giant Yellowknife Mines	PL	INAC/NAP
89010	22 Oct 1988	BAF	Polaris	Tailings Pond	Tailings (+123,673,000Kg)	77000000	Cominco Mines	PL	INAC/NAP
89030	21 Mar 1989	KIT	Lupin	Main Fuel Area	Diesel P-40	90	Echo Bay Mines Ltd	OTH	INAC/NAP
89042	09 Apr 1989	KIT	Lupin	Tank Farm	Diesel P-40	450	Echo Bay Mines Ltd	ST>	INAC/NAP
89044	20 Apr 1989	NSL	Giant	Vee Lake Road Turnoff	Tailings	4546	Giant Yellowknife Mines	UK	INAC/NAP
89045	19 Apr 1989	NSL	Con	Arsenic Plant	Arsenic Trioxide Solution	4546	Nerco Con Mine	ST>	INAC/NAP
89050	25 Apr 1989	NSL	Giant	Northwest Tailings Pond	Tailings Solution	250	Giant Yellowknife Mines	PL	INAC/NAP
89053		NSL	Giant	Hill in front of Northwest Tailings Pond	Tailings Solution	205	Giant Yellowknife Mines	TRU	INAC/NAP
89058	08 May 1989	NSL	Giant	Tailings Pipeline	Tailings Water	4546	Giant Yellowknife Mines	TP	INAC/NAP
89074	02 Jun 1989	NSL	Giant	MillOutside South Door	Minewater	4546	Giant Yellowknife Mines	PL	INAC/NAP
89093	30 Jun 1989	NSL	Giant	Tailings Line	Tailings	0	Giant Yellowknife Mines	PL	INAC/NAP
89094	15 Jan 1989	KIT	Lupin	Pipeline in Culvert Under Runway	Fuel Oil P-40	1800	Echo Bay Mines Ltd	PL	INAC/NAP
89119	10 Aug 1989	NSL	Giant	Catchment Pond	Minewater	270000	Giant Yellowknife Mines	PL	INAC/NAP
89136	03 Sep 1989	BAF	Polaris	Between Storage Building & Fuel Tanks	Tailings	10000	Cominco	PL	INAC/NAP
89148	13 Sep 1989	KIT	Lupin	Tailings Area & Fingers Lake	Tailings Water	0	Echo Bay Mines Ltd	PL	INAC/NAP
89154	26 Sep 1989	BAF	Polaris	Tailings Line East of Storage Building	Tailings	2000	Cominco	PL	INAC/NAP
89161	07 Oct 1989	NSL	Giant	Vee Lake Road	Mill Tailings	5000	Giant Yellowknife Mines	PL	INAC/NAP
89162	12 Oct 1989	KIT	Lupin	Between Mill and Carpentry Shop	Mill Tailings	3000	Echo Bay Mines Ltd	OTH	INAC/NAP
89166	17 Oct 1989	NSL	Giant	Mill	Minewater	20450	Giant Yellowknife Mines	PL	INAC/NAP
89167	26 Sep 1989	BAF	Polaris	Tailings Line East of Storage Building	Tailings	3000	Cominco	PL	INAC/NAP
90020	16 Feb 1990	BAF	Polaris	Garrow Lake	Mine Tailings	30000	Cominco	PL	INAC/NAP
90026	28 Feb 1990	NSL	Colomac	Tank Farm	Diesel Fuel	18000	Neptune Resources	ST>	GNWT
90029	02 Mar 1990	NSL	Con	North of Pud Lake near Taylor Road	Mill Tailings Solution	0	Nerco Con Mine	PL	INAC/NAP
90032	09 Mar 1990	NSL	Colomac	Around Fuel Pumps	Diesel P-40	4000	Robinson's Lease Operator	PL	INAC/NAP
90034	13 Mar 1990	NSL	Giant	South of Mill	Condensate Water	900	Giant Yellowknife Mines	PL	INAC/NAP
90039	29 Mar 1990	NSL	Ptarmigan	Water Settling Pond	Minewater	0	Treminco Resources	TP	INAC/NAP
90054		NSL	Giant	Near Mouth of Baker Creek	Tar-like Substance (Unknown)	0	Unknown	UK	INAC/NAP
90059	10 May 1990	NSL	Colomac	Airstrip	Diesel Fuel	450	Neptune Resources	ST<	INAC/NAP
90060	10 May 1990	NSL	Colomac	South Side of Processing Building	Ore Slurry	25000	Neptune Resources	PL	INAC/NAP
90066	11 May 1990	NSL	Colomac	Yard South of Mill Building	Ore Slurry	2700	Neptune Resources	PL	INAC/NAP
90067	14 May 1990	NSL	Colomac	Yard South of Mill Building	Tailings Slurry	20000	Neptune Resources	OTH	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
90076	27 May 1990	NSL	Colomac	North End & West Side of Mill	Tailings Slurry	909	Neptune Resources	PL	INAC/NAP
90080	31 May 1990	NSL	Ptarmigan	Tailings Pond Area	Mine Tailings	35000	Treminco Resources	PL	INAC/NAP
90088	07 Jun 1990	NSL	Colomac	Outside Mill	Leaching Slurry	3000	Neptune Resources	OTH	INAC/NAP
90094	11 Jun 1990	NSL	Colomac	North End of Mill Site	Tailings Slurry	9092	Neptune Resources	OTH	INAC/NAP
90096		NSL	Ptarmigan		Waste Oil	0	Treminco Resources	UK	INAC/NAP
90103	25 Jun 1990	NSL	Con	Machine Shop & Dump	Sulfuric Acid (Dilute)	70	Nerco Con Mine	ST<	INAC/NAP
90114	25 Jun 1990	BAF	Nanisivik	East Adit Catchment Pond	Untreated Run-off Water	50000	Nanisivik Mines Ltd	OTH	INAC/NAP
90115	23 Jun 1990	BAF	Nanisivik	East Adit Retention Pond Dyke	Untreated Run-off Water	0	Nanisivik Mines Ltd	OTH	INAC/NAP
90136	02 Aug 1990	NSL	Giant	Explosives Limited's Plant	Diesel Commercial	150	TC Oil Distributors Esso	TRU	INAC/NAP
90137	06 Aug 1990	NSL	Ptarmigan	Tailings Dam Ditch	Mine Tailings (+140, 000Kg)	318220	Treminco Resources	PL	INAC/NAP
90147	17 Aug 1990	NSL	Colomac	Oil Laydown Area	Hydraulic Oil XD3	205	Northwest Gold Corp	ST<	INAC/NAP
90153	29 Aug 1990	NSL	Colomac	Steeve's Lake East Shore	Diesel Fuel	2273	Neptune Resources	ST>	INAC/NAP
90161	12 Sep 1990	NSL	Colomac	Fuel Tank Farm	Gasoline	0	Northwest Gold Corp	ST>	EPS
90173	30 Sep 1990	NSL	Giant	Dock Site	Gasoline	0	Unknown	UK	INAC/NAP
90205	04 Dec 1990	NSL	Giant	Pit Access Ramp A-2	Diesel	1800	Giant Mine	PL	INAC/NAP
90217	22 Dec 1990	NSL	Colomac	Mill Leach Tank Berm	Gold Ore Slurry	4000	Neptune Resources	PL	INAC/NAP
91004	13 Jan 1991	NSL	Giant	Vee Lake Road Area Beside B138 Portal Area	Tailings	180	Giant Mine	PL	INAC/NAP
91007	25 Jan 1991	KIT	Lupin	Service Tank for Boiler	Diesel P-40	450	Echo Bay Mines Ltd	ST<	INAC/NAP
91010	29 Jan 1991	NSL	Con	Tailings Area, Seepage towards Taylor Road	Tailings Solution	0	Nerco Con Mine	TP	INAC/NAP
91011	04 Feb 1991	NSL	Colomac	Tailings Pumpbox Area	Tailings	100000	Neptune Resources	OTH	INAC/NAP
91017	25 Feb 1991	NSL	Colomac	Pipeline into to Leach Tank #1, Steeves Lake Site	Leach Feed Slurry	60000	Neptune Resources	PL	INAC/NAP
91030	18 Mar 1991	NSL	Con	Upper Pud Lake near Taylor Road	Tailings Solution	225000	Nerco Con Mine	TP	INAC/NAP
91031	15 Mar 1991	NSL	Con	Dam #5	Tailings Solution	4500	Nerco Con Mine	TP	INAC/NAP
91037	05 Apr 1991	NSL	Con	Dam #5	Tailings Solution	100000	Nerco Con Mine	TP	INAC/NAP
91038	06 Apr 1991	NSL	Colomac	Steeves Lake Tailings Line	Tailings	2000	Neptune Resources	PL	INAC/NAP
91049	29 Apr 1991	NSL	Con	Dam #2 Area	Tailings Solution	81720	Nerco Con Mine	TP	INAC/NAP
91050	30 Apr 1991	NSL	Giant	Baker Creek, "A" Shaft Boilerhouse	Bunker C	45	Royal Oak Mines Inc	UK	INAC/NAP
91054	07 May 1991	NSL	Giant	Mill	Roaster Dust Slurry	14000	Giant Mine	PL	INAC/NAP
91058	09 May 1991	NSL	Con	Between Tailings Dams #2 and #3	Tailings Solution	0	Nerco Con Mine	UK	INAC/NAP
91059	09 May 1991	NSL	Giant	Catch Basin #7	Run-off Water from Melting	0	Giant Mine	NS	INAC/NAP
91062	13 Mar 1991	NSL	Giant	Vee Lake Road Area	Reclaim Water	0	Giant Mine	PL	INAC/NAP
91062-B	21 Aug 1991	NSL	Con	Nerco Head Frame	Diesel	12	Nerco Con Mine	ST<	INAC/NAP
91065	15 May 1991	NSL	Giant	Carbon Plant	Fresh Water	0	Giant Mine	UK	INAC/NAP
91078	30 May 1991	BAF	Polaris	South Storage Tank	Tailings Slurry (+4, 550Kg)	4540	Cominco Polaris Mine	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
91080	29 May 1991	NSL	Con	Tailings Line	Tailings Solution	20000	Nerco Con Mine	PL	INAC/NAP
91081	28 May 1991	NSL	Con	Dam #5 Behind Mill	Tailings Solution	0	Nerco Con Mine	TP	INAC/NAP
91089		NSL	Colomac	4 km NE of Mine Site	Drilling Oil	100	Northgate Exploration	OTH	INAC/NAP
91113	28 Jun 1991	NSL	Con	Boiler House Great Slave Lake	Bunker C	15	Nerco Con Mine	OTH	INAC/NAP
91122	05 Jul 1991	NSL	Con	Pumphouse	Bunker C	9	Nerco Con Mine	OTH	INAC/NAP
91123	07 Jul 1991	BAF	Nanisivik	East Adit Catchment Pond	Contaminated Water	120000	Nanisivik Mines Ltd	TP	INAC/NAP
91125	11 Jul 1991	NSL	Con	Pumphouse Area	Bunker C	225	Nerco Con Mine	PL	INAC/NAP
91136	27 Jul 1991	NSL	Giant	Main Tailings Line	Tailings	22000	Royal Oak Mines Inc	PL	INAC/NAP
91146	06 Aug 1991	NSL	Con	Water Treatment Plant	Treated Effluent	0	Nerco Con Mine	UK	INAC/NAP
91153	10 Aug 1991	FTS	Pine Point	Millsite	Sulphuric Acid	0	Cominco	ST>	INAC/NAP
91156	17 Aug 1991	NSL	Giant	Adjacent to Vee Lake Road	Tailings	350000	Royal Oak Mines Inc	PL	INAC/NAP
91162	21 Aug 1991	NSL	Con	Robinson Head Frame Area	Diesel	12	Nerco Con Mine	TRU	INAC/NAP
91164	21 Aug 1991	NSL	Giant	Adjacent to Mill	Tailings	45000	Royal Oak Mines Inc	PL	INAC/NAP
91169	28 Aug 1991	NSL	Giant	Adjacent to Vee Lake Road	Tailings	22500	Royal Oak Mines Inc	PL	INAC/NAP
91200	16 Oct 1991	NSL	Con	Tailings Line Near Crusher Buildings	Tailings/Sludge Solution	6500	Nerco Con Mine	PL	INAC/NAP
91207	06 Nov 1991	NSL	Giant	Adjacent to Dam #4	Mill Tailings	1135	Royal Oak Mines Inc	PL	INAC/NAP
91226	18 Dec 1991	NSL	Giant	Near Dam #8	Tailings	10000	Royal Oak Mines Inc	PL	INAC/NAP
92001	14 Jan 1992	NSL	Con	Behind Mill By Tank Farm	Tailings Solution	20457	Nerco Con Mine	PL	INAC/NAP
92003	25 Jan 1992	NSL	Con	Southeast Corner of Mill Site	Backfill Slurry	25000	Nerco Con Mine	PL	INAC/NAP
92005	29 Jan 1992	NSL	Giant	Boiler House Tank	Bunker C	900	Royal Oak Mines Inc	ST<	INAC/NAP
92022	25 Feb 1992	NSL	Con	Southeast Corner of Mill	Backfill Slurry	27276	Nerco Con Mine	PL	INAC/NAP
92024	26 Feb 1992	KIT	Lupin	Loading Area	10W30 Oil	114	Echo Bay Mines Ltd	ST<	INAC/NAP
92028	04 Apr 1992	NSL	Giant	Fresh Water Intake Line	Water	45460	Royal Oak Mines Inc	PL	INAC/NAP
92042	31 Mar 1992	NSL	Con	Primary Tailings Line Behind Mill	Tailings Solution	909	Nerco Con Mine	PL	INAC/NAP
92043	31 Mar 1992	NSL	Con	Southeast Corner of Mill	Backfill Slurry	27276	Nerco Con Mine	PL	INAC/NAP
92049	14 Apr 1992	NSL	Con	C-1 Backfill Line	Backfill Slurry	27276	Nerco Con Mine	PL	INAC/NAP
92054	26 Apr 1992	NSL	Giant	Old Pit Across from Mill	Diesel Fuel	455	Royal Oak Mines Inc	PL	INAC/NAP
92060	03 May 1992	BAF	Polaris	South of Concentrate Storage Building	Tailings Slurry	2273	Cominco	PL	INAC/NAP
92072	11 May 1992	NSL	Giant	Millsite	Cyanide Solution	100000	Royal Oak Mines Inc	ST>	INAC/NAP
92083	07 May 1992	NSL	Giant	Vee Lake Turnoff	Tailings Solution	250	Royal Oak Mines Inc	TP	INAC/NAP
92085	17 May 1992	KIT	Lupin		10W30 Oil	409	Echo Bay Mines Ltd	ST<	INAC/NAP
92089	23 May 1992	NSL	Giant	Akaitcho Line	Minewater	454	Royal Oak Mines Inc	PL	INAC/NAP
92091	26 May 1992	NSL	Giant	Vee Lake Road	PVC Contamination	0	Picketers on Strike	OTH	INAC/NAP
92094	26 May 1992	NSL	Giant	Tank Farm Along Highway 4	Bunker C	25	Royal Oak Mines Inc	PL	INAC/NAP
92101	30 May 1992	NSL	Giant	Baghouse & Cottrell	Arsenic Trioxide	0	Royal Oak Mines Inc	OTH	GNWT
92105	30 May 1992	KIT	Lupin	Dam 4B Long Lake	Tailings Solution	39000000	Echo Bay Mines Ltd	TP	INAC/NAP
92110	05 Jun 1992	NSL	Giant	Near Gate #6	Tailings Solution	9092	Royal Oak Mines Inc	PL	INAC/NAP
92112	06 Jun 1992	NSL	Giant	Sewage Pumphouse on Lakeshore Corner	Sewage	0	Royal Oak Mines Inc	ST<	INAC/NAP
92122	13 Jun 1992	NSL	Giant	Tailings Line to North Pond	Tailings	0	Royal Oak Mines Inc	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
92123	13 Jun 1992	NSL	Giant	Bag House to Cottrell	Gases Arsenic/SO2	0	Royal Oak Mines Inc	OTH	GNWT
92127	27 May 1992	NSL	Giant	Carbon Plant	Fresh Process Water	2273	Royal Oak Mines Inc	PL	INAC/NAP
92128	14 Jun 1992	NSL	Giant	Feed Line to the EPT	Tailings Water	0	Royal Oak Mines Inc	PL	INAC/NAP
92129		NSL	Giant	Tank Fram Behind Mill	Bunker C	45	Royal Oak Mines Inc	PL	INAC/NAP
92135	24 Jun 1992	BAF	Nanisivik	East Adit Water Treatment Plant	Untreated Run-off Water	660000	Nanisivik Mines Ltd	TP	INAC/NAP
92140	28 Jun 1992	NSL	Giant	Gate #7	Tailings Solution	90	Royal Oak Mines Inc	PL	INAC/NAP
92147	01 Jul 1992	NSL	Giant	Gate #7	Tailings Water	0	Royal Oak Mines Inc	PL	INAC/NAP
92149	02 Jul 1992	NSL	Giant	Supercrest	Unknown	1818	Royal Oak Mines Inc	PL	INAC/NAP
92162	14 Jul 1992	KIT	Lupin	Adjacent to Plant Steel Yard	Cleaning Solvent	45	Echo Bay Mines Ltd	ST<	INAC/NAP
92190	28 Aug 1992	NSL	Con	Adjacent to Autoclave Building	Tailings Solution	20450	Nerco Con Mine	ST>	INAC/NAP
92202	13 Sep 1992	NSL	Giant	Adjacent to Mill	Barren/Pregnant Solution	200	Royal Oak Mines Inc	ST<	INAC/NAP
92205	15 Sep 1992	NSL	Con	Adjacent to Autoclave Building	Tailings Slurry	18185	Nerco Con Mine	OTH	INAC/NAP
92215	28 Sep 1992	NSL	Giant	Mill Area	Floatation Concentrate	9092	Royal Oak Mines Inc	OTH	INAC/NAP
92216	23 Sep 1992	NSL	Giant	Baker Creek	Oil	0	Royal Oak Mines Inc	PL	INAC/NAP
92226	20 Oct 1992	NSL	Ptarmigan	Southeast of Ingraham Trail	Tailings	70000	Treminco Resources	PL	INAC/NAP
92228	23 Oct 1992	NSL	Giant	Vee Lake Road and Adjacent Mill	Tailings	0	Royal Oak Mines Inc	TP	INAC/NAP
92229	23 Oct 1992	NSL	Giant	Tailings Line Adjacent to Mill	Tailings Mine Water	450000	Royal Oak Mines Inc	PL	INAC/NAP
92233		BAF	Polaris	South of Concentrate Storage Building	Tailings Slurry (+20, 000Kg)	62500	Cominco	PL	INAC/NAP
92234	05 Nov 1992	NSL	Con	Adjacent to Autoclave Tank	Tailings Slurry (+10, 000Kg)	39000	Nerco Con Mine	PL	INAC/NAP
93001		NSL	Ptarmigan	Ingraham Trail	Minewater	70000	Treminco Resources	PL	INAC/NAP
93010	27 Jan 1993	BAF	Nanisivik	Underground Compressor Room	Askarel Oil (PCB)	2	Nanisivik Mines Ltd	OTH	INAC/NAP
93012	31 Jan 1993	NSL	Giant	Roaster Building South Door	Water/Mill Solution	2500	Royal Oak Mines Inc	ST>	INAC/NAP
93026	14 Mar 1993	NSL	Giant	Catch Basin 226 Vee Lake Road	Tailings Liquid Effluent	0	Royal Oak Mines Inc	TP	INAC/NAP
93027	18 Mar 1993	NSL		Lac De Gras Area 64 34N 110 28W	Diesel P-50	0	Robinson's Trucking	TRU	INAC/NAP
93036	26 Mar 1993	NSL	Giant	Adjacent to Pit 138	Mill Tailings	500	Royal Oak Mines Inc	PL	INAC/NAP
93044		NSL	Giant	Roaster Building	Untreated Roaster Gas	0	Royal Oak Mines Inc	OTH	GNWT
93060	10 May 1993	NSL	Giant	Refinery Catchment Basin South of Mill	Mill Tailings & Run-Off Water	1350	Royal Oak Mines Inc	TP	INAC/NAP
93062	14 May 1993	NSL	Giant	Tailings Line Adjacent Road	Mill Tailings	22000	Royal Oak Mines Inc	PL	INAC/NAP
93063	15 May 1993	NSL	Giant	Adjacent to Vee Lake Road	Mill Tailings	45000	Royal Oak Mines Inc	PL	INAC/NAP
93065	18 May 1993	NSL	Giant	Day Tank Northeast of Mill	Diesel Fuel	6800	Royal Oak Mines Inc	ST>	INAC/NAP
93076	03 Jun 1993	KIT	Lupin	Dump Pond #1	Tailings Solution/Run-off	4500	Echo Bay Mines Ltd	TP	INAC/NAP
93078	04 Jun 1993	KIT	Lupin	Tailings Line Adjacent to Dump Station #1	Tailings Solution/Run-off	2250	Echo Bay Mines Ltd	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
93082	08 Jun 1993	NSL	Giant	Carbon Tanks	High Ammonia Tailings	0	Royal Oak Mines Inc	TP	INAC/NAP
93090	26 Jun 1993	NSL	Giant	Vee Lake Road Area	Mill Tailings	90000	Royal Oak Mines Inc	PL	INAC/NAP
93102	02 Jul 1993	NSL	Giant	Vee Lake Road Area	Mill Tailings Solution	100000	Royal Oak Mines Inc	PL	INAC/NAP
93103	03 Jul 1993	NSL	Giant	Vee Lake Road Area	Mill Tailings	25000	Royal Oak Mines Inc	PL	INAC/NAP
93110	16 Jul 1993	NSL	Giant	Barge Loading Area	Bunker C	45	Royal Oak Mines Inc	PL	INAC/NAP
93155	15 Aug 1993	NSL	Con	Adjacent to the Mill	Mill Slurry	2000	Nerco Con Mine	ST>	INAC/NAP
93156	16 Aug 1993	NSL	Giant	Northwest Pond Area	Mill Tailings	22000	Royal Oak Mines Inc	PL	INAC/NAP
93167	08 Oct 1993	BAF	Nanisivik	Concentrator Building	Mill Tailings	10000	Nanisivik Mines Ltd	PL	INAC/NAP
93170	03 Oct 1993	NSL	Giant	150 Metres Past Pinch Valves	Mill Tailings	15000	Royal Oak Mines Inc	PL	INAC/NAP
93172	24 Oct 1993	NSL	Giant	Corner of Ingraham Trail & Vee Lake Road	Tailings	205	Royal Oak Mines Inc	PL	INAC/NAP
93174	01 Nov 1993	NSL	Giant	Near Catch Basin at Point 138	Mill Tailings	30000	Royal Oak Mines Inc	PL	INAC/NAP
93176		NSL	Con	Dam #1, Upper pud lake	Cyanide/Copper Tailings	10000	Miramar Con Mine Ltd	TP	INAC/NAP
93178	28 Oct 1993	NSL	Giant	Tailings Reclamation Plant	Propane	50000	Royal Oak Mines Inc	ST>	INAC/NAP
93183	04 Dec 1993	NSL	Giant	Roaster Building Area	Concentrate Thickener	7000	Royal Oak Mines Inc	PL	INAC/NAP
93184	06 Dec 1993	NSL	Giant	By Refinery Building	Mill Tailings	20000	Royal Oak Mines Inc	TP	INAC/NAP
93186	09 Dec 1993	NSL	Con	Adjacent to Autoclave Building	Tailings	13600	Miramar Con Mine Ltd	TP	INAC/NAP
93192	30 Dec 1993	NSL	Giant	Carbon Plant Catchment Pond	Fresh Water	0	Royal Oak Mines Inc	OTH	INAC/NAP
94005	13 Jan 1994	NSL	Giant	Tailings Line Near Catch Basin	Mill Tailings	100000	Royal Oak Mines Inc	PL	INAC/NAP
94008	18 Jan 1994	BAF	Nanisivik	300 Metres Beyond Duck Pond	Tailings Solution	0	Nanisivik Mines Ltd	PL	INAC/NAP
94009	13 Jan 1994	NSL	Giant		Mill Tailings	20000	Royal Oak Mines Inc	PL	INAC/NAP
94012	19 Jan 1994	NSL	Colomac	Tank Farm Area	Diesel Fuel	500	Royal Oak Mines Inc	TRU	INAC/NAP
94013	19 Jan 1994	NSL	Giant	B-138 on Northwest Tailings Line	Mill Tailings	15000	Royal Oak Mines Inc	PL	INAC/NAP
94014	21 Jan 1994	NSL	Giant	Northwest Line Vee Lake Road	Mill Tailings	100000	Royal Oak Mines Inc	PL	INAC/NAP
94015	24 Jan 1994	NSL	Con	Southside Door From Mill	Tailings Solution	10000	Miramar Con Mine Ltd	PL	INAC/NAP
94017	25 Jan 1994	NSL	Giant	Adjacent to Refinery	Pregnant Solution & Tailings	20000	Royal Oak Mines Inc	OTH	INAC/NAP
94019	27 Jan 1994	NSL	Con	Boneyard South of Mill	Tailings Solution	30000	Miramar Con Mine Ltd	PL	INAC/NAP
94047	27 Mar 1994	NSL	Colomac	Mill Yard Area	Fresh Water	5000000	Royal Oak Mines Inc	OTH	INAC/NAP
94048	26 Mar 1994	NSL	Colomac	Tank Farm	Diesel P-40	900	Royal Oak Mines Inc	ST>	INAC/NAP
94050	29 Mar 1994	NSL	Con	Adjacent To Mill	Tailings Solution	0	Miramar Con Mine Ltd	PL	INAC/NAP
94074	05 May 1994	BAF	Nanisivik	Tailings Line Near Duck Lake	Mill Tailings	10000	Nanisivik Mines Ltd	PL	INAC/NAP
94075	05 May 1994	BAF	Nanisivik	Concentrator Building	Reclaim Water	150000	Nanisivik Mines Ltd	OTH	INAC/NAP
94078	27 May 1994	DEH	Tungsten	Mine Site	Gasoline	4000	Canada Tungsten Mining Corp Ltd	ST>	INAC/NAP
94081	21 May 1994	NSL	Colomac	Bunkhouse #8	Diesel Fuel	909	Royal Oak Mines Inc	ST<	INAC/NAP
94089	02 May 1994	BAF	Nanisivik	Ship Loading Area	Calcium Hydroxide	1000	Nanisivik Mines Ltd	OTH	INAC/NAP
94110	20 Jun 1994	NSL	Con	Water Treatment Plant	Treated Tailings Effluent	3300000	Miramar Con Mine Ltd	OTH	INAC/NAP
94113	28 Jun 1994	NSL	Giant	Tailings Line Next to North Tailings Pond	Tailings	30000	Royal Oak Mines Inc	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
94114	28 Jun 1994	NSL	Giant	Tailings Line Next to North Tailings Pond	Mill Tailings	2273	Royal Oak Mines Inc	PL	INAC/NAP
94118	03 Jul 1994	NSL	Giant	Pipebox Between Mill & AC Roaster	Concentrator Process Water	2200	Royal Oak Mines Inc	PL	INAC/NAP
94126	18 Jul 1994	DEH	Prarie Creek	At Generator	Diesel Fuel	760	San Andreas Resources Corp	TRU	INAC/NAP
94130	24 Jul 1994	NSL	Colomac	Mine Site Steeves Lake	Tailings Solution	10	Royal Oak Mines Inc	PL	INAC/NAP
94138	04 Aug 1994	NSL	Colomac	Tailings Line Road	Mill Tailings	7000	Royal Oak Mines Inc	OTH	INAC/NAP
94161	28 Aug 1994	NSL	Ptarmigan	Adjacent to Mill	Mine Tailings	16500	Treminco Resources	PL	INAC/NAP
94174	16 Sep 1994	NSL	Colomac	Mill	Tailings Slurry	3000	Royal Oak Mines Inc	OTH	INAC/NAP
94192	12 Oct 1994	NSL	Ptarmigan	Both Sides of Ingraham Trail	Mine Tailings	375000	Treminco Resources	PL	INAC/NAP
94200	04 Nov 1994	NSL	Colomac	Mill #2 Conveyor Trail Pulley Sump	Mill Floor Water	0	Royal Oak Mines Inc	PL	INAC/NAP
94206	15 Nov 1994	NSL	Colomac	Mill	Tailings	10000	Royal Oak Mines Inc	PL	INAC/NAP
95006	22 Jan 1995	NSL	Con	Adjacent to Mill/Fine Ore Tank	Tailings Solution	2000	Miramar Con Mine Ltd	PL	INAC/NAP
95007	22 Jan 1995	NSL	Con	Tailings Line South Side of Mill	Tailings Solution	0	Miramar Con Mine Ltd	PL	INAC/NAP
95008	22 Jan 1995	NSL	Con	Tailings Line Adjacent to Ore Stockpiles	Tailings Solution	100000	Miramar Con Mine Ltd	PL	INAC/NAP
95010	21 Jan 1995	NSL	Ptarmigan	Tailings Pond Area	Tailings Effluent	100000	Treminco Resources	PL	INAC/NAP
95017	08 Feb 1995	NSL	Colomac	North of Crushed Ore Stock Pile	Reclaim Water	175000	Royal Oak Mines Inc	PL	INAC/NAP
95024	17 Feb 1995	KIT	Lupin	Fuel Tank Farm	Diesel	50	Echo Bay Mines Ltd	TRU	INAC/NAP
95028	20 Mar 1995	NSL	Colomac	Leach Tank #5	Tailings	50000	Royal Oak Mines Inc	ST>	INAC/NAP
95030	24 Mar 1995	KIT	Lupin	Main Tank Farm #1 Tank	Diesel Fuel	682	Echo Bay Mines Ltd	ST>	INAC/NAP
95031	27 Mar 1995	NSL	Giant	Pinch Valves East of Mill	Mill Tailings	2000	Royal Oak Mines Inc	TP	INAC/NAP
95035	03 Apr 1995	NSL	Giant	Base of Dam #21A	Tailings Slurry	10000	Royal Oak Mines Inc	TP	INAC/NAP
95039	13 Apr 1995	KIT	Lupin	On hill on Corner Near Dam 3	Tailings	0	Echo Bay Mines Ltd	UK	INAC/NAP
95040	09 Apr 1995	KIT	Lupin	Main Roadway to Tails Beside Tank Farm	Diesel P-40	91	Echo Bay Mines Ltd	ST<	INAC/NAP
95051	29 Apr 1995	NSL	Giant	#138 Catch Basin	Mill Tailings	10000	Royal Oak Mines Inc	PL	INAC/NAP
95077	03 Jun 1995	BAF	Nanisivik	Gas & Adit Treatment Plant	Run-off Water	86400	Nanisivik Mines Ltd	TP	INAC/NAP
95078	04 Jun 1995	NSL	Giant	Ingraham Trail Area North of Lower Access Road	Mill Tailings	120000	Royal Oak Mines Inc	PL	INAC/NAP
95114	19 Jul 1995	KIT	Lupin	NW Corner Outside Paste Backfill Plant	Tailings (80%) & Cement (3%)	8000	Echo Bay Mines Ltd	PL	INAC/NAP
95133	20 Aug 1995	KIT	Lupin	30 Metres from Mill Building	Tailings Solids and Solution	1000	Echo Bay Mines Ltd	PL	INAC/NAP
95144	28 Aug 1995	DEH	Prarie Creek	On Road Beside Mill	Transmission Oil	5	San Andreas Resources Corp	TRU	INAC/NAP
95148	04 Sep 1995	NSL	Giant	East Side of Mill Near Refinery Catch Basin	Mill Tailings	20000	Royal Oak Mines Inc	PL	INAC/NAP
95152	12 Sep 1995	NSL	Giant	Tailings Pipe at Crossing of Ingraham Trail	Tailings Solution	50	Royal Oak Mines Inc	PL	INAC/NAP
95160	29 Sep 1995	BAF	Nanisivik	Along Tailings Line	Mill Tailings	10000	Nanisivik Mines Ltd	PL	INAC/NAP
95165	04 Oct 1995	NSL	Con	Behind Mill at Door #9	Tailings Solution	8000	Miramar Con Mine Ltd	PL	INAC/NAP
95169		NSL	Colomac	Southside of Mill Beside Powerhouse	Diesel	0	Royal Oak Mines Inc	UK	INAC/NAP
95174	30 Oct 1995	NSL	Giant	#10 Fuel Storage Tank Across From Boilerhouse	Diesel P-40	0	Royal Oak Mines Inc	ST>	INAC/NAP
95182	10 Nov 1995	NSL	Giant	North Side of Cottrell Plant	Arsenic Trioxide Dust	13	Royal Oak Mines Inc	PL	EPS
95189	28 Nov 1995	NSL	Colomac	Adjacent to Mill & Admin. Building	Mill Tailings Slurry	20000	Royal Oak Mines Inc	PL	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
95190	25 Nov 1995	NSL	Giant	Mill Area	Minewater & Solution	1364	Royal Oak Mines Inc	PL	INAC/NAP
95193	02 Dec 1995	NSL	Colomac	Along Tailings Line Near Fuscum Lake	Tailings Slurry	5000	Royal Oak Mines Inc	PL	INAC/NAP
95195	04 Dec 1995	NSL	Colomac	Adjacent to Leach Tank Containment Area	Leach Slurry	6000	Royal Oak Mines Inc	PL	INAC/NAP
95203	27 Dec 1995	NSL	Giant	Winch Building	Oil/Water Residue	1	Royal Oak Mines Inc	OTH2	INAC/NAP
96007	24 Jan 1996	NSL	Colomac	Adjacent to Heavy Equipment Shop	Diesel Fuel	1000	Royal Oak Mines Inc	TRU	INAC/NAP
96014	30 Jan 1996	NSL	Colomac	Tank #7	Diesel Fuel	750	Royal Oak Mines Inc	ST>	INAC/NAP
96016	10 Feb 1996	NSL	Giant	Dam 22-B Northwest Tailings Pond	Tailings Effluent	15000	Royal Oak Mines Inc	TP	INAC/NAP
96021	13 Feb 1996	NSL	Giant	Tailings Line to North Pond	Tailings	60000	Royal Oak Mines Inc	PL	INAC/NAP
96022	13 Feb 1996	NSL	Giant	Refinery Catch Basin West Side of Mill	Mill Tailings Water	20000	Royal Oak Mines Inc	OTH2	INAC/NAP
96046	26 Mar 1996	NSL	Con	Water Treatment Plant	Hydrogen Peroxide	1000	Miramar Con Mine Ltd	PL	INAC/NAP
96056	17 Apr 1996	NSL	Colomac	Reclaim Road Near Crusher Pile	Reclaim Water	30000	Royal Oak Mines Inc	PL	INAC/NAP
96058	21 Apr 1996	NSL	Con	Water Treatment Plant	Treated Effluent	9020000	Miramar Con Mine Ltd	UK	INAC/NAP
96064	29 Apr 1996	NSL	Ptarmigan	Ptarmigan Mine	Tailings	40640	Treminco Resources	PL	INAC/NAP
96066	05 May 1996	NSL	Colomac	Adjacent to and underneath Heavy Equipment Sh	Gasoline		Royal Oak Mines Inc	UK	INAC/NAP
96084	31 May 1996	KIT	Lupin	Tailings Line Near Sewage Lakes	Mill Tailings	500	Echo Bay Mines Ltd	PL	INAC/NAP
96089	24 Jan 1996	NSL	Colomac	Northside of Warehouse	Diesel	2000	Royal Oak Mines Inc	TRU	INAC/NAP
96112	26 Jun 1996	NSL	Colomac	Colomac Mine	Mill Tailings Slurry	20000	Royal Oak Mines Inc	PL	INAC/NAP
96114	27 Jun 1996	NSL	Colomac	Beside Tailings Road 1 Km from Mill	Mill Tailings Slurry	40000	Royal Oak Mines Inc	PL	INAC/NAP
96120	02 Jul 1996	NSL	Giant	SE Side of NW Tailings Pond	Tailings Solution	70000	Royal Oak Mines Inc	PL	INAC/NAP
96121	02 Jul 1996	NSL	Giant	South Door of Roaster Building	Process Water	500	Royal Oak Mines Inc	ST>	INAC/NAP
96122	02 Jul 1996	NSL	Giant	Southwest Corner of Mill	Leach Solution	500	Royal Oak Mines Inc	PL	INAC/NAP
96128	03 Jul 1996	BAF	Nanisivik	East Adit Water Treatment Plant	Mine Drainage Water	1015000	Nanisivik Mines Ltd	TP	INAC/NAP
96132	13 Jul 1996	KIT	Lupin	Tailings Line Along Road South of Mill	Mill Tailings	250	Echo Bay Mines Ltd	PL	INAC/NAP
96142	25 Jul 1996	KIT	Lupin		30W Oil	341	Echo Bay Mines Ltd	UK	INAC/NAP
96144	28 Jul 1996	NSL	Giant	Back Road Between Hill & North Road	Mill Tailings	2000	Royal Oak Mines Inc	PL	INAC/NAP
96145	30 Jul 1996	BAF	Nanisivik	East Adit Water Treatment Plant	Mine Drainage Water	685300	Nanisivik Mines Ltd	TP	INAC/NAP
96159	23 Aug 1996	KIT	Lupin	Paste Backfill Line	Mill Tailings Paste Backfill	4064	Echo Bay Mines Ltd	PL	INAC/NAP
96164	27 Aug 1996	NSL	Giant	Near B8 Portal Adjacent to Ingraham Trail	Tailings Solution	70000	Royal Oak Mines Inc	PL	INAC/NAP
96166	29 Aug 1996	NSL	Giant	NW Side of Leach Berm Adjacent to Mill	Leach Slurry	45000	Royal Oak Mines Inc	ST>	INAC/NAP
96169	29 Aug 1996	NSL	Giant	Road to NW Pond Adjacent to Ingraham Trail	Tailings Solution	2000	Royal Oak Mines Inc	PL	INAC/NAP
96170	29 Aug 1996	NSL	Giant	Road to NW Pond Adjacent to Ingraham Trail	Tailings Solution	8000	Royal Oak Mines Inc	PL	INAC/NAP
96182	11 Sep 1996	BAF	Nanisivik	Mill Building	Tailings Water	10000	Nanisivik Mines Ltd	PL	INAC/NAP
96189	17 Sep 1996	KIT	Lupin	Tailings Dam 3	Clear Solution		Echo Bay Mines Ltd	TP	INAC/NAP
96197	25 Sep 1996	KIT	Lupin	Bypass Tailings Line Past Old Airstrip	Mill Tailings		Echo Bay Mines Ltd	PL	INAC/NAP
96205	01 Oct 1996	KIT	Lupin	Bypass Line Past Old Airstrip	Mill Tailings	186	Echo Bay Mines Ltd	PL	INAC/NAP
96210	04 Oct 1996	BAF	Nanisivik	Tailings Line near Water Tower	Tailings	3000	Nanisivik Mines Ltd	PL	INAC/NAP
96215	10 Oct 1996	NSL	Colomac	Behind Dam #1	Tailings Water	80000	Royal Oak Mines Inc	TP	INAC/NAP
96216	10 Oct 1996	NSL	Colomac	SW Corner of Vehicle Maintenance Shop	Diesel Fuel	100	Royal Oak Mines Inc	TRU	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
96222	17 Oct 1996	NSL	Giant	B-138 Pit NE Corner	Diesel Fuel	1591	Royal Oak Mines Inc	ST<	INAC/NAP
96229	22 Oct 1996	NSL	Giant	Effluent Dicharge to Baker Creek	Treated Effluent (Copper Exceeded)		Royal Oak Mines Inc	TP	INAC/NAP
96239	21 Nov 1996	NSL	Con	South Side of Oxygen Plant	Mine Tailings	200000	Miramar Con Mine Ltd	PL	INAC/NAP
96240	22 Nov 1996	NSL	Giant	East Side of Mill	Mine Tailings	6000	Royal Oak Mines Inc	PL	INAC/NAP
97003	21 Jan 1997	NSL	Con	Boneyard Between Mill Area & Con Pond	Fresh Water with Elevated Arsenic		Miramar Con Mine Ltd	PL	INAC/NAP
97014	12 Feb 1997	NSL	Con	East Side of Rycon Trailer Court	Sewage		Miramar Con Mine Ltd	PL	INAC/NAP
97016	13 Feb 1997	NSL	Koala	20 Yds West of Nuna Shop	Hydraulic Fluid	54	Nuna Logistics	UK	INAC/NAP
97017	13 Feb 1997	NSL	Koala	Culvert Camp	Diesel	30	RTL Trucking (BHP)	ST<	INAC/NAP
97019	15 Feb 1997	NSL	Koala	Top Shelf - BHP Diamond Site	Hydraulic Oil	91	Clark Builders - BHP Diamonds	OTH	INAC/NAP
97020	17 Feb 1997	NSL	Koala	Koala Camp Tank Farm	Diesel	1363	RTL/BHP Diamonds Inc.	ST>	INAC/NAP
97021	18 Feb 1997	NSL	Koala	Koala Camp Mechanic Shop	Engine Oil	400	BHP Diamonds Inc	ST<	INAC/NAP
97024	22 Feb 1997	NSL	Colomac	Fuel Farm - Tank #4	P-40 Diesel Fuel	27276	Royal Oak Mines Inc	ST>	INAC/NAP
97027	04 Mar 1997	NSL	Koala	Tank Farm - Koala Camp	Diesel Fuel	100	RTL/BHP Diamonds	TRU	INAC/NAP
97034	13 Mar 1997	KIT	Lupin	North Turnaround on Airstrip	P-40 Diesel Fuel	600	Echo Bay Mines Ltd	TRU	INAC/NAP
97039	13 Mar 1997	NSL	Koala	Permanent Emulsion Plant	Diesel	20	Nuna Logistics	DRUM	INAC/NAP
97040	18 Mar 1997	NSL	Colomac	North Side of Power Plant	Diesel Fuel	682	Royal Oak Mines Inc	ST>	INAC/NAP
97043	25 Mar 1997	NSL	Koala	Panda Pit (Blast 460-19)	Diesel Fuel	800	BHP	OTH	INAC/NAP
97045	04 Jan 1997	NSL	Koala	Level 2 Koala Minesite Facility	Diesel Fuel	8	Clark Builders - BHP Diamonds	UK	INAC/NAP
97048	04 Feb 1997	NSL	Koala	Panda Pit 460 Elevation	Hydraulic Oil	30	Nuna Logistics - BHP Diamonds	PL	INAC/NAP
97050	06 Apr 1997	NSL	Koala	Permanent Accommodation Building Area	Ethylene Glycol	40	H.A. Simons (BHP)	ST<	INAC/NAP
97051	09 Apr 1997	NSL	Koala	Top Level - Permanent Site	Diesel	50	BHP	ST>	INAC/NAP
97053	08 Apr 1997	NSL	Koala	Nuna Shop - BHP Koala	Diesel	10	Nuna (BHP)	TRU	INAC/NAP
97059	06 Apr 1997	NSL	Koala	Koala Camp Laydown Area	Powertrain Oil	30	Finning Canada - BHP Diamonds	OTH2	INAC/NAP
97065	17 Apr 1997	NSL	Giant	NW End of 'C' Dry Building	Thermal Oil	170	Royal Oak Mines Inc	PL	INAC/NAP
97072	27 Apr 1997	NSL	Koala	Main Tank Farm Fuelling Location	Diesel Fuel	50	BHP	TRU	INAC/NAP
97075	04 May 1997	NSL	Koala	Intersection of Nuna Road and Main Road	Hydraulic Oil	20	Nuna Logistics	OTH2	INAC/NAP
97077	03 May 1997	NSL	Koala	Accomodations Complex Dorm E	Glycol	1600	Travco Industrial Housing Ltd.	PL	INAC/NAP
97080	08 May 1997	NSL	Koala	Warming Shed - Top Bench	Diesel	10	Clark Builders	OTH2	INAC/NAP
97084	12 May 1997	NSL	Colomac	Tails Line 500 m South of Reclaim Barge	Tailings Water	1000	Royal Oak Mines Inc	PL	INAC/NAP
97085	14 May 1997	KIT	Lupin	Ulu Exploration Site - Near Generator Building	Used Engine Antifreeze	113	Echo Bay Mines Ltd	DRUM	INAC/NAP
97089	19 May 1997	NSL	Koala	Panda Pit, West Side, 2nd Bench	Diesel Fuel	113	BHP Diamonds Inc	OTH2	INAC/NAP
97090		KIT	Lupin	Near Boat Dock	Jet B fuel	30	Echo Bay Mines Ltd	DRUM	INAC/NAP
97095	25 May 1997	NSL	Koala	Generator Building, 2nd Bench, Main Camp	Petroleum Product	4	BHP Diamonds Inc	UK	INAC/NAP
97097		NSL	Koala	East Side of Maintance Shop Koala Camp	Used Oil	2	BHP Diamonds Inc	ST<	INAC/NAP
97104		NSL	Koala	SE Corner of Process Building	Engine Oil	1	Ledcor Industries (BHP)	OTH	INAC/NAP
97108	02 Jun 1997	KIT	Lupin	East End of Cold Storage #2	Calcium Hydroxide	1000	Echo Bay Mines Ltd	OTH2	INAC/NAP
97116	09 Jun 1997	NSL	Koala	Fuel Dispersing Module Permanent Camp	Diesel	45	Nuna	TRU	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
97119	10 Jun 1997	NSL	Colomac	E Side of Road Adjacent to Leach Berm	Tailings	150000	Royal Oak Mines Inc	PL	INAC/NAP
97122	13 Jun 1997	NSL	Koala	Middle Bench Area Permanent Plant Site	Diesel	250	RTL/BHP	TRU	INAC/NAP
97123	14 Jun 1997	NSL	Giant	Adjacent to Main Mill Building	Mill Tailings	25000	Royal Oak Mines Inc	PL	INAC/NAP
97127	15 Jun 1997	NSL	Giant	SE Side of Northwest Tailings Pond	Water/Dilute Tailings	10000	Royal Oak Mines Inc	PL	INAC/NAP
97133	17 Jun 1997	NSL	Con	WT Plant to Meg/Peg/Keg Lake System	Treated Effluent	9150000	Miramar Con Mine Ltd	TP	INAC/NAP
97134	20 Jun 1997	NSL	Koala	East Side of H.A. Simons Office - 2nd Bench	Oil or Diesel		BHP Diamonds Inc	UK	INAC/NAP
97135		NSL	Koala	Waste Oil Cube Storage Area, Old Camp	Waste Oil	20	BHP Diamonds Inc	ST<	INAC/NAP
97137	28 Jun 1997	NSL	Koala	2nd Bench N End Power House, Main Camp	Hydraulic Oil	20	Clark Builders - BHP Equipment	UK	INAC/NAP
97138	29 Jun 1997	NSL	Koala	South of Skirt Wall Process Plant	Hydraulic Oil	5	Ledcor Industries & Associates Inc.	UK	INAC/NAP
97140	29 Jun 1997	NSL	Colomac	Tails Line Between Dams 1 & 2 at Crest Hill	Tailings	1000	Royal Oak Mines Inc	PL	INAC/NAP
97141	30 Jun 1997	NSL	Colomac	North of Warehouse by Diesel Refill Pumps	Diesel	500	Royal Oak Mines Inc	PL	INAC/NAP
97144	02 Jul 1997	NSL	Giant	Storage Tank Near Assay Lab, SE of Access Rd.	Mixed Waste Oils	75	Royal Oak Mines Inc	DRUM	INAC/NAP
97148	06 Jul 1997	NSL	Koala	Ammonia Nitrate Site	Hydraulic Oil	4	Ledcor Industries & Associates Inc.	OTH	INAC/NAP
97149	07 Jul 1997	NSL	Koala	Panda Pit Drill Pattern 450-24	Tellus T22 Hydraulic Oil	60	BHP Mining Division	OTH2	INAC/NAP
97150	08 Jul 1997	NSL	Colomac	South of Mill & Powerhouse/Access Road	Mill Process Water	20000	Royal Oak Mines Inc	ST>	INAC/NAP
97152	04 Jun 1997	NSL	Koala	South End of Panda Pit	Hydraulic Oil	2	BHP Diamonds Inc	UK	INAC/NAP
97158	16 Jul 1997	NSL	Koala	Midbench-South Side of Process Plant	30W Oil	4	Ledcor Industries (BHP)	OTH2	INAC/NAP
97161	11 Jul 1997	NSL	Con	WT Plant to Meg/Keg/Peg Lakes	Treated Effluent (Cu Conc.)	17209000	Miramar Con Mine Ltd	TP	INAC/NAP
97162	17 Jul 1997	BAF	Nanisivik	Mill/Mine Perimeter road	Tailings	300	Nanisivik Mines Ltd	TRU	INAC/NAP
97163	20 Jul 1997	KIT	Lupin	Tailings Line Dump Pond #2	Runoff Water	230	Echo Bay Mines Ltd	TP	INAC/NAP
97170	25 Jul 1997	NSL	Koala	SW Side, H.A. Simons Office - Middle Bench	Hydraulic Oil	132	Ledcor Industries & Associates	UK	INAC/NAP
97178	02 Aug 1997	NSL	Koala	Water Pump Stand Area Near Koala Lake	Hydraulic Oil	22	Nuna Logistics (BHP)	TRU	INAC/NAP
97186	13 Aug 1997	NSL	Colomac	Southwest of Powerhouse & Mill	Mill Process Water	25000	Royal Oak Mines Inc	OTH	INAC/NAP
97190	14 Aug 1997	NSL	Koala	Bulk Oil Storage Facility	Waste Oil	100	Nuna/Finning	ST<	INAC/NAP
97195	18 Aug 1997	NSL	Giant	NE Corner of Mill Bldg.	Mill Tailings	5000	Royal Oak Mines Inc	PL	INAC/NAP
97197		SAH	Other	Octan/Terra Mines, Camsell River	Waste Oil	455	Octan Resources Inc.	DRUM	INAC/NAP
97200	22 Aug 1997	NSL	Giant	North Corner of 'C' Dry Building	Diesel Fuel	15	Royal Oak Mines Inc/Imperial Oil	TRU	INAC/NAP
97204	23 Aug 1997	BAF	Nanisivik	East Adit Treatment Facility	Runoff Water		Nanisivik Mines Ltd	OTH2	INAC/NAP
97205	27 Aug 1997	BAF	Nanisivik	Southern Exit from the Mill Building	Runoff Water (1000 L) & Motor Oil (15 L)	1015	Nanisivik Mines Ltd	TRU	INAC/NAP
97209	28 Jul 1997	NSL	Con	Con Camp Distribution Pipe Box	Sewage/Fresh Water		Miramar Con Mine Ltd	PL	INAC/NAP
97211	04 Sep 1997	NSL	Koala	Ammonium Nitrate Site	Hydraulic Oil	113	Ledcor Industires/BHP	OTH	INAC/NAP
97218	14 Sep 1997	NSL	Con	Sewage Main Line Backup (Opposite Trailer #23)	Sewage/Fresh Water	250	Miramar Con Mine Ltd	PL	INAC/NAP
97220	16 Sep 1997	NSL	Giant	Storage Tank Berm Area near Assay Lab	Used Oil	54700	Royal Oak Mines Inc	ST>	INAC/NAP
97223	19 Sep 1997	NSL	Colomac	NW of Tank Farm	Diesel Fuel		Royal Oak Mines Inc	ST>	INAC/NAP
97225	21 Sep 1997	KIT	Lupin	Occurence #8 Pit	Hydraulic Oil	440	Nuna Logistics (Echo Bay)	OTH	INAC/NAP
97231	26 Sep 1997	DEH	Tungsten		Diesel Fuel	10000	Tungsten Mine	UK	INAC/NAP
97237	06 Oct 1997	BAF	Nanisivik	Base of Mt. Fuji, Outside of West Twin	Mill Tailings		Nanisivik Mines Ltd	TP	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
97238	08 Oct 1997	NSL	Koala	Middle of Intersection, West of Nuna Shop	Engine Oil	23	RTL	OTH	INAC/NAP
97240	09 Oct 1997	NSL	Giant	Adjacent to 'A' Boiler Bldg. near Townsite	Oily Water	70	Royal Oak Mines Inc	OTH	INAC/NAP
97241	12 Oct 1997	NSL	Ekati (Koala)	On Road b/w Old & New Camp	Hydraulic Oil	113	Nuna Logistics	TRU	INAC/NAP
97243	18 Oct 1997	NSL	Colomac	Access Road to Tails Facility	Tailings	20000	Royal Oak Mines Inc	PL	INAC/NAP
97244	22 Oct 1997	NSL	Colomac	Near Sewage Lagoon, Duck Lake	Tailings Slurry	400000	Royal Oak Mines Inc	TP	INAC/NAP
97249	31 Oct 1997	NSL	Ekati (Koala)	NE of Service Building	Glycol/Water	100	Adco North	UK	INAC/NAP
97250	21 Oct 1997	NSL	Ekati (Koala)	Main Tank Farm	Diesel	1000	BHP Diamonds Inc	PL	INAC/NAP
97254	17 Nov 1997	NSL	Colomac	S. of Mill, Powerhouse	Mill Process Water	10000	Royal Oak Mines Inc	ST>	INAC/NAP
97272	19 Dec 1997	NSL	Ekati (Koala)	H.A. Simons Office	Transmission Fluid	10	H.A. Simons (BHP)	TRU	INAC/NAP
97273	20 Dec 1997	NSL	Ekati (Koala)	Till Dump Entrance (1st)	Hydraulic Oil	100	Nuna Logistics (BHP)	TRU	INAC/NAP
97275	27 Dec 1997	NSL	Ekati (Koala)	Truckshop Top Bench	Glycol	1000	BHP Diamonds Inc.	PL	INAC/NAP
98003	13 Jan 1998	NSL	Ekati (Koala)	Taxiway @ Airstrip	Diesel	100	RTL Robinson Trucking	PL	INAC/NAP
98010	23 Jan 1998	NSL	Ekati (Koala)	RTL Shop - 2nd Bench	Waste Oil	100	RTL/BHP Diamonds Inc.	PL	INAC/NAP
98016	11 Feb 1998	NSL	Ekati (Koala)	Diamond Drill Pad, Edge of Koala Lake	Hydraulic Oil	130	Nuna Logistics	OTH	INAC/NAP
98017		NSL	Ekati (Koala)	HA Simons office crawl space	Raw Sewage		RTL/HA Simons	PL	INAC/NAP
98018	14 Feb 1998	NSL	Ekati (Koala)	East Fuel Unloading Module	Diesel Fuel	2000	BHP Diamonds Inc	PL	INAC/NAP
98020	17 Feb 1998	NSL	Ekati (Koala)	Paul Lake Bridge	Oil and Diesel	6	Ledcor	OTH	INAC/NAP
98026	24 Feb 1998	NSL	Ekati (Koala)	East Fuel Module	Diesel Fuel	15	BHP Diamonds	ST>	INAC/NAP
98027	28 Feb 1998	NSL	Ekati (Koala)	Beside Road b/w Airstrip Quarry & Koala Camp	Diesel Fuel and Antifreeze	425	RTL/BHP Diamonds Inc.	TRU	INAC/NAP
98056	23 Apr 1998	NSL	Ekati (Koala)	Truck Drop Area - 3rd Bench	Hydraulic Oil	40	BHP Diamonds Inc.	TRU	INAC/NAP
98057	22 Apr 1998	NSL	Ekati (Koala)	40 Metres NE of Truckstop	Antifreeze	60	Finning	TRU	INAC/NAP
98059	25 Apr 1998	NSL	Ekati (Koala)	Outlet of the Diversion Channel into Kodiak Lake	Hydraulic Oil	20	NWT Rock/BHP Diamonds	OTH	INAC/NAP
98064	03 May 1998	NSL	Ekati (Koala)	Long Lake Outlet Dam	Diesel Fuel	100	BHP Diamonds Inc.	ST<	INAC/NAP
98065		NSL	Ekati (Koala)	76A3W . 436000 754600E- Patch Lake Fuel Cac	Diesel &Jet B	250	BHP Minerals Canada Ltd.	TRU	INAC/NAP
98069	26 Apr 1998	NSL	Nanisivik	Saddle of Ridge, Outside West Twin Disposal Ar	Suspected Mill Tailings and local area shale dust		Mill and Material Services	TP	INAC/NAP
98073	16 May 1998	NSL	Ekati (Koala)	Nuna Chrusher Site N of Panda Pit	Diesel Fuel	200	Nuna Logistics (BHP)	ST<	INAC/NAP
98078	20 May 1998	NSL	Ekati (Koala)	Fuel Distribution Line Within Tank Farm	Diesel	100	BHP Diamonds Inc	ST>	INAC/NAP
98079	19 May 1998	NSL	Ekati (Koala)	Process Plant North Side	60/40 Glycol	55000	Ledcor/H.A. Simons/BHP Diamonds Inc.	ST>	INAC/NAP
98082		NSL	Ekati (Koala)	Top Bench Laydown Area	Dry Flocculent	100	BHP Diamonds Inc.	OTH2	INAC/NAP
98090	06 Jun 1998	BAF	Nanisivik	Nanisivik Dock Storage Area	Ammonium Nitrate	50	Mill and Material Services	OTH	INAC/NAP
98091	08 Jun 1998	NSL	Ekati (Koala)	Nuna Laydown Area Adjacent to Panda Pit Haul R	Diesel Fuel	300	Nuna Logistics	ST<	INAC/NAP
98092		NSL		BHP Boston Camp Atop a Crushed Pad in Camp	Lubricating Oil	90	BHP Minerals Ltd.	ST<	INAC/NAP
98095	11 Jun 1998	NSL	Ekati (Koala)	Main Haul Road	Hydraulic Oil	21	BHP Diamonds Inc	TRU	INAC/NAP
98100	16 Jun 1998	NSL	Giant		Treated Effluent with Arsenic		Royal Oak Mines Inc.	TP	INAC/NAP

Search Criteria: Mine Spills in the Northwest Territories

Spill #	Spill Date	Region	Mine	Description	Commodity	Quantity (L or Kg)	Party	Source	Agency
98104	30 Jun 1998	KIT	Lupin	South Side of Powerhouse	P-40 Diesel Fuel	2364	Echo Bay Mines	ST>	INAC/NAP
98106	28 Jun 1998	NSL	Ekati (Koala)	Southend of Truckshop Wall	Waste Oil	20	BHP	ST<	INAC/NAP
98117	19 Jul 1998	NSL	Ekati (Koala)	Sewage Treatment Plant Ramp	Sewage effluent	450	Robinsons Trucking Ltd/BHP	TRU	INAC/NAP
98122	25 Jul 1998	NSL	Ekati (Koala)	Panda Pit	Hydraulic Oil	360	BHP Diamonds Inc	OTH	INAC/NAP

This report contains information regarding spills that were ***reported*** to the 24 Hour Spill Line. The absence of information on any particular location in no way guarantees that contamination has not occurred at that location.

Hazardous Material Spill Database

ALL ENTRIES ARE TO BE MADE USING CAPITAL LETTERS ONLY

Database Title - SPILLS
Table Title - SPILLREP (Appendix A)

1. Spill Number: Assigned by INAC/NAP at the time the spill is reported (example: 87051 means 1987, spill number 51) (a number with - entered in every column indicates no report was received).

2. Spill Date: MM/DD/YY - date spill occurred, not report date

3. Spill Location:

   Locality: Enter as reported on fax message (municipality, kilometre post on highway, mine, etc.....).

   Government of the N.W.T. Administrative Districts include:

FTSM	Ft. Smith	INU	Inuvik	NSL - North Slave
FTSI	Ft. Simpson	NW	Norman Wells	SSL - South Slave
YK	Yellowknife			SAH - Sahtu

   enter "-" if not in a district (Kitikmeot, Keewatin or Baffin Regions). DEH - Deh Cho

4. Nature of Spilled Hazardous Material:

   Commodity: enter as reported on fax message.

   Commodity Category includes:

PET-GAS	- Petroleum - gasoline
PET-FO	- Petroleum - fuel oil (jet, diesel, turbo, heating, aviation)
PET-CO	- Petroleum - crude oil
PET-LO	- Petroleum - lubricating oil (lube, hydraulic)
PET-WO	- Petroleum - waste oil (slops, sludge)
PET-OTH	- Petroleum - other (bunker, asphalt, propane)
PET-UK	- Petroleum - unknown
CHEM	- Chemicals (including transformer oils)
WW	- Wastewater (sewage, mine tailings)
DMUD	- Drilling mude
OTH	- Other
UK	- Unknown
MIXED	- Mixed load

5. Spill Volume/Quantity:

   enter liquids in litres under VOLUME and solids or dry quantities in kilograms under QUANTITY - if there is liquid only, enter "-0-" in QUANTITY column and if solid only enter "-0-" in VOLUME column

   enter unknowns as "0"

6. Party Responsible:

   Identification

   enter as reported on telex message
   communities entered as City of, Town of, Hamlet of, etc.
   some abbreviations used: NTCL, NCPC, DPW&H, MOT, POL, DND, NAP/INAC, CANMAR

   Party Category includes:

PET	- Petroleum (bulk fuel storage, exploration and refining companies)
TRANS	- Transportation (any of the transportation sectors or companies whose major activity relates to transportation)
GOV-FED	- Federal Government departments
GOV-TER	- Territorial government departments (includes POL contractors)
GOV-MUN	- Municipal governments
GOV-CC	- Federal government crown corporations
TGOV-CC	- Territorial government crown corporations
MIN	- Mining companies
CON	- Construction companies
PI	- Private individuals
OTH	- Other (not directly related contractors, hotels, co-ops, housing associations)
UK	- unknown

7. Source of Spill includes:

ST>	- Storage tank > 4,000 litres (bulk storage, tank farms, etc.)
ST<	- Storage tank < 4,000 litres (day tanks)
TRU	- Truck (any truck, including trailers and also includes spills from drums or barrels transported by trucks)
MV	- Marine Vessels (any marine vessel - barges, ships, etc. and also includes spills from drums or barrels transported by marine vessels)
AIR	- Aircraft (any aircraft - helicopters, planes, etc. and also includes pills from drums or barrels transported by aircraft)
RT	- Rail Train (and also includes spills from drums or barrels transported by rail)
OTT	- Other Transportation (tractors, cats, etc. and also includes drums, barrels or trailers pulled by transportation other than trucks)
NS	- Natural Seepage
PL	- Pipe or Line (any pipeline, pipe, line, hose, etc.)
TP	- Tailings Pond (and also includes drilling fluid sumps)
SL	- Sewage Lagoon
OTH	- Other (wells, wet wells, flaring booms)
UK	- Unknown

8. Cause of Spill includes:

OF	- Overflow (from storage tanks, any kind of vehicle, sewage lagoon, tailings pond, etc.)
TL	- Tank Leak (leaks from storage tanks or leaks from tank trucks, other vehicles, marine vessels or aircraft, not caused by overturns, collisions, sinking, deliberate discharge)
PL	- Pipe Leak (leaks from pipelines, pipes, lines, hoses, etc., and also leaks from pipes on trucks, other vehicles, etc., not caused by overturns, collisions, sinking, etc.)
FL	- Fitting Leak (leaks at valves, couplings, fuel filters and pumps on tanks, pipes, trucks, other vehicles, etc., not caused by overturns, collisions, sinking and also includes leaks at valves that are not completely closed)
VO	- Vehicle Overturn
COL	- Collision/Crash (any collisions)
SK	- Sinking (marine vessels)
GD	- Grounding (marine vessels)
DD	- Deliberate Discharge (any spill caused deliberately)
DF	- Dyke Failure
WB	- Well Blowout (includes almost any spill with a well as its source, along with typical blowouts)
OTH	- Other (vehicle breaking through ice; and also includes leaks from transportation not caused by overturns, collisions, sinking, grounding and not in the category of tank, pipe or fitting leaks)
UK	- Unknown

9. Reason for Spill includes:

HE	- Human Error
MEF	- Material or Equipment
CF	- Climatic factors (icy roads or muddy roads due to rain, high temperatures causing expansion of fuel in tanks, frozen pipes, etc.)
INT	- Intentional (product is spilled intentionally but not for destructive purposes (usually the cause is deliberate discharge)
VAN	- Vandalism (product is spilled intentionally and for destructive purposes)
OTH	- Other (tanks fallen over, lines or tanks hit by a vehicle causing them to rupture, hole/punctures in barges or trucks not due to material/equipment failure, power failures)
UK	- Unknown

10. Entered Water includes:

YM	- Yes, Marine Waters (also includes spills onto ice)
YF	- Yes, Fresh Waters (also includes spills onto ice)
N	- No
UK	- Unknown (if it is not known whether spill has yet entered water or if it is not known whether there is a spill)

11. Responding Government Agency:

    enter as reported on telex messages.
    assigned according to Working Agreement on Government Response to Spills and includes:

GNWT	- Government of the Northwest Territories (Renewable Resources)
INAC/NAP	- Indian and Northern Affairs, Northern Affairs Program
EPS	- Conservation and Protection, Environment Canada
CCG	- Canadian Coast Guard
RCMP	- Royal Canadian Mounted Police
HWC	- Health and Welfare Canada
AECB	- Atomic Energy Control Board
NEB	- National Energy Board
ILA	- Inuvialuit Lands Administration
"-"	- No follow-up undertaken or necessary

12. Spill Significance Designation:

    assigned according to Working Agreement on Government Response to Spills (includes MAJOR or MINOR)
    enter as reported on fax message

APPENDIX A

DATA TABLE

NAME	TYPE	LENGTH
SPILL-#	INTEGER	1 value(s)
SPILL-DT	TEXT	8 characters
LOCATION	TEXT	28 characters
REGION	TEXT	3 characters
COMMOD	TEXT	27 characters
COM-CAT	TEXT	7 characters
VOLUME	INTEGER	1 value(s)
PARTY	TEXT	30 characters
PAR-CAT	TEXT	7 characters
SOURCE	TEXT	3 characters
CAUSE	TEXT	3 characters
REASON	TEXT	3 characters
WATER	TEXT	2 characters
AGENCY	TEXT	8 characters
DISTRICT	TEXT	4 characters
QUANTITY	INTEGER	1 value(s)
DESIG	TEXT	5 characters

APPENDIX 4

SACATON MINE

ERROL L. MONTGOMERY & ASSOCIATES, INC.
CONSULTANTS IN HYDROGEOLOGY
1075 EAST FORT LOWELL ROAD, SUITE B
TUCSON, ARIZONA 85719 (602) 881-4912
TELEX: 165597 MONTE TUC

ERROL L. MONTGOMERY, P.G.
JOHN W. HARSHBARGER, P.G., P.E.
DONALD K. GREENE, P.E.
WILLIAM R. VICTOR, P.G.
EDWARD W. PEACOCK, P.G.
RONALD H. DEWITT

RECEIVED
JUL 1987
WATER PERMITS
UNIT

July 30, 1987

Mr. Rob B. Larson
Water Permits Unit
Arizona Department of Environmental Quality
Central Palm Plaza Building
2005 North Central Avenue
Phoenix, Arizona 85004

RE: ASARCO Sacaton Open Pit Mine
Groundwater Quality Protection Permit File No. 86-142

Dear Mr. Larson:

In response to your request of March 20, 1987 regarding justification of proposed monitor well design (large perforated interval versus more conventional interval of 30 feet for monitor wells), and use of the existing exploration borehole, vent shaft, and well 6 for monitor wells, we offer the following comments:

1. General Comment The open pit mine is a hydrologic sink and drains groundwater from the surrounding conglomerate and mineralized igneous plutonic rocks at a rate we estimate to be in the range from two to 32 gallons per minute. Because the leachate collection system will operate during and after landfill operations, the open pit will continue to function as a hydrologic sink. Under these conditions we believe that the primary function of the monitoring system is to demonstrate, through continued measurement of water levels, that the hydraulic gradient in the rocks penetrated by the open pit remains toward the pit. We do propose however, that water samples for laboratory chemical analyses be collected from the monitor wells and well 6 at three-month intervals. We also believe that the most important water sample collection point would be from the leachate pump-back system.

2. Large Perforated Interval For Monitor Wells Permeability of the conglomerate and the mineralized igneous plutonic rocks exposed in the pit walls is very small. Two airlift pumping tests for

these rock units indicate discharges of 0.6 and 6.5 gallons per minute and specific capacities of 0.002 and 0.02 gallons per minute per foot of drawdown. We are concerned that, with only 30 feet of perforations, groundwater yield from the monitor wells may not be sufficient for obtaining groundwater samples. It also seems desirable to monitor the entire hydrogeologic section penetrated by the open pit as the pit is being filled. As you mention, if problems develop, identification and isolation of the problem would be difficult. In the event a contamination problem did develop, depth specific monitor wells may be required. As long as the leachate pump-back system is functioning properly we believe the potential for a problem is extremely remote.

3. Vent Shaft The vent shaft was constructed to a depth of 1,070 feet, about the same depth as the open pit, and penetrates the same rock units as the open pit. The vent shaft provides an additional control point for monitoring the hydraulic gradient in the conglomerate and mineralized igneous plutonic rocks in the vicinity of the open pit. Groundwater samples could be obtained from the vent shaft for laboratory chemical analyses if required. However, because the vent shaft is 14 feet in diameter, and contains about 800,000 gallons of groundwater, pumping of three to five borehole volumes of groundwater before sampling would not be practical.

4. Existing Exploration Borehole We are recommending a third new monitor well to replace existing exploration borehole (D-5-5)26ddal[S-54]. This monitor well would be located approximately 200 feet west, toward the open pit, from the existing exploration borehole and is identified as (D-5-5)26dda2[M-3]. Proposed construction is the same as for monitor wells (D-5-5)26cca[M-1] and (D-5-5)35bda[M-2] as described on pages 32 and 33 in our preliminary report of November 21, 1986.

5. Well 6 Well 6 was drilled to a total depth of 2,118 feet and penetrated the basement fault at 1,270 feet. Ten-inch casing was set in this well to a depth of 2,090 feet. The upper 1,290 feet of ten-inch casing is blank and two cement baskets were installed on the casing just above the top of the perforated section. This well would serve as a monitor point for the confined aquifer in the fractured rocks below the basement fault.

In response to concerns expressed during our meeting of July 15, 1987, we propose possible future construction of monitor wells to monitor groundwater soley in the conglomerate unit. It is planned to drill the three initial new monitor wells using a down-hole hammer and the air rotary drilling method. Using this drilling method, estimates can be made of groundwater yield versus depth of penetration during drilling. After completion of drilling, casing, and testing for the three monitor wells, we

propose to meet with personnel from your office to discuss feasibility of construction of two additional monitor wells completed in the conglomerate unit adjacent to monitor wells (D-5-5)26cca[M-1] and (D-5-5)35bda[M-2]. Feasibility of these additional conglomerate monitor wells will depend on depth to the contact between the conglomerate unit and mineralized igneous plutonic rocks and on groundwater yield from the conglomerate unit. We expect that the third monitor well, (D-5-5)26dda2[M-3], will bottom in the conglomerate unit at total planned depth of 1,050 feet, and an additional conglomerate monitor well at this site would not be recommended.

If you have questions or require further discussion, please contact us.

Very truly yours,

ERROL L. MONTGOMERY & ASSOCIATES, INC.

Dr. Errol L. Montgomery

cc: V. Martz

ERROL L. MONTGOMERY & ASSOCIATES, INC.
CONSULTANTS IN HYDROGEOLOGY
1075 EAST FORT LOWELL ROAD, SUITE B
TUCSON, ARIZONA 85719

TUCSON, AZ
PM
30 JUL
1987

MAIL EARLY
ISN'T
TOO SOO
USA
22

Mr. Rob Larson
Water Permits Unit
Arizona Department of Environmental Quality
Central Palm Plaza Building
2005 North Central Avenue
Phoenix, Arizona 85004

ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

November 24, 1986



Mr. A. O. Hellerud
Office of Waste and Water Quality Management
Division of Environmental Health Services
Arizona Department of Health Services
2005 N. Central Avenue
Phoenix, Arizona 85004

Dear Sir:

SACATON SANITARY LANDFILL
Notice of Disposal File No. 86-142

Enclosed please find two (2) copies of the report prepared by Erroll L. Montgomery and Associates, Inc., entitled:

Hydrogeologic Conditions
Asarco Sacaton Open - Pit Mine
Pinal County, Arizona

This hydrogeologic report is submitted as partial fulfillment of Arizona Department of Health Services requirements for a Groundwater Quality Protection Permit Application for operations at a proposed sanitary landfill at the completed Asarco Sacaton open pit mine. A plan of operations for the facility is being developed and will be submitted upon completion.

Upon your approval, this preliminary report can be finalized.

Very truly yours,

T. E. Scartaccini

T. E. Scartaccini

TES/VCM/kh

Encls.

cc: VCMartz
ELMontgomery & Assoc.

Water Permi

P. O. Box 5747 Tucson, Az 85703-0747

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-4)14acc	(D-5-4)14ccb2	(D-5-4)35ccb	(D-5-4)35ccb	(D-5-4)35ccb	(D-5-5)26dcb [Pit water]	(D-5-5)26dda [S-54]
DATE SAMPLED	09-19-72	09-19-72	09-23-41	09-14-49	08-23-50	04-03-86	09-13-68
LABORATORY[a]	BC	BC	USGS	USGS	USGS	BC	BC
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	40	60	38	110	130	637	62
Magnesium	4	8	12	21	26	212	29
Sodium	132	162	--	--	--	1,510	641
Potassium	4	4	--	--	--	58	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	0	0
Bicarbonate	120	123	150	160	150	0	146
Chloride	106	149	57	200	240	2,124	788
Sulfate	140	178	92	130	150	3,200	420
Nitrate	17	59	2.5	28	38	48.7	--
Fluoride	2.8	1.7	0.8	0.5	0.5	6.2	--
Total Dissolved Solids (mg/l)	553	772	350	700	800	8,400	2,086
pH	7.8	7.8	--	--	--	4.1	--
Temperature (degrees C)	--	--	--	--	--	22.0	30
Specific Conductance[c]	810	1,090	604	1,200	1,360	10,300	3,800

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-5)34bcc [TM-1]	(D-5-5)34bcc [TM-1]	(D-5-5)34bcc [TM-1]	(D-5-5)35aba1 [Well 5]	(D-5-5)35aba2 [Well 6]	(D-5-5)35aba2 [Well 6]	(D-5-5)35aba3 [P. Shaft]
DATE SAMPLED	08-22-73	08-05-80	03-15-85	07-10-79	07-10-79	11-30-82	07-10-79
LABORATORY[a]	BC	BC	BC	BC	BC	BC	BC
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	28.0	19.9	111	4.0	3.8	6.5	4.5
Magnesium	11.3	3.6	20	3.1	0.09	0.08	0.04
Sodium	1,140	710.0	1,470	191	205	192	223
Potassium	14.5	0.7	1.4	2.0	1.7	2.7	21
Anions (mg/l)							
Carbonate	0	0	5.1	15.3	15.3	6.8	53.7
Bicarbonate	553.3	145.5	170.0	78.8	62.4	64.1	0
Chloride	633.7	303.4	630.0	116.8	117.9	112.2	130.6
Sulfate	1,213	1,025	2,350	170	200	197	204.0
Nitrate	18.6	31.0	68.2	4.4	7.1	2.2	5.3
Fluoride	10.0	15.0	9.2	11.2	12.0	12.2	15.8
Total Dissolved Solids (mg/l)	3,080	2,083	4,950	567	587	550	777
pH	7.7	8.1	8.2	8.4	8.4	8.8	10.0
Temperature (degrees C)	--	--	20.8	36.7	39.2	33.3	33
Specific Conductance[c]	5,200	3,400	6,700	890	910	940	1,120

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-6)19acb	(D-5-6)27ada	(D-5-6)27ada	(D-5-6)28aac [Well 1]	(D-5-6)28aac [Well 1]	(D-5-6)28daa [Well 2]	(D-5-6)28daa [Well 2]
DATE SAMPLED	08-21-72	02-06-57	08-31-82	08-21-72	11-30-82	09-19-72	11-30-82
LABORATORY[a]	ADHS	USGS	USGS	ADHS	BC	BC	BC
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	13	4.8	7.4	26	11	16	20
Magnesium	9	0	0.4	5	1.2	0.5	0.37
Sodium	206	102	120	222	260	148	178
Potassium	--	0.4	1.0	--	10	4	7.4
Anions (mg/l)							
Carbonate	4	6	--	0	0	0	2.6
Bicarbonate	68	128	--	94	166.3	71	68.4
Chloride	208	22	40	156	129.6	71	96.3
Sulfate	100	63	93	270	293	185	225
Nitrate	42	0.7	--	2	5.8	<0.5	5.3
Fluoride	1.7	9.0	5.1	6.8	6.6	6.5	6.9
Total Dissolved Solids (mg/l)	450	296	350	525	833	520	603
pH	8.6	8.5	8.5	8.3	8.1	8.3	8.5
Temperature (degrees C)	--	--	25.5	--	--	--	24.4
Specific Conductance[c]	--	496	608	1,200	1,300	710	950

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-6)29ddc	(D-5-6)33aaa [Well 3]	(D-5-6)33aaa [Well 3]	(D-5-6)33add [Well 4]	(D-6-4)1ddd	(D-6-4)3ddc	(D-6-4)3ddc
DATE SAMPLED	10-25-72	09-19-72	11-30-82	09-19-72	06-19-41	08-27-76	07-13-84
LABORATORY[a]	BC	BC	BC	BC	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	20	22	8	610	--	220	180
Magnesium	6.8	0.5	0.23	0	130	--	38
Sodium	620	196	210	170	--	--	180
Potassium	10.4	7	8	4	--	--	3.7
Anions (mg/l)							
Carbonate	0	0	1.7	22	0	--	--
Bicarbonate	548	66	90.1	29	110	--	--
Chloride	269	117	131.3	99	1,300	--	390
Sulfate	585	248	250.0	180	1,000	--	380
Nitrate	5.0	9.3	8.9	1.9	240	--	--
Fluoride	12.0	4.7	5.8	6.2	0.5	0.8	0.3
Total Dissolved Solids (mg/l)	2,145	733	720	565	3,900	--	1,300
pH	7.8	8.3	8.4	8.6	--	--	7.3
Temperature (degrees C)	--	--	25.5	--	--	28.0	25.0
Specific Conductance[c]	3,200	980	1,125	800	5,860	2,100	2,130

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-4)11ddc	(D-6-4)11ddd	(D-6-4)13add	(D-6-4)13add	(D-6-4)13add	(D-6-4)13add	(D-6-4)24bad
DATE SAMPLED	08-25-82	08-27-76	09-15-41	09-14-49	08-23-50	07-16-51	11-06-57
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	19	--	64	160	--	--	68
Magnesium	35	--	13	28	--	--	17
Sodium	220	--	--	--	--	--	90
Potassium	3.0	--	--	--	--	--	2
Anions (mg/l)							
Carbonate	--	--	0	0	0	0	0
Bicarbonate	--	--	140	160	160	160	154
Chloride	310	--	120	280	260	290	110
Sulfate	420	--	130	230	--	--	135
Nitrate	--	--	--	34	--	--	11
Fluoride	1.0	1.0	0.7	0.9	--	--	0.5
Total Dissolved Solids (mg/l)	1,300	--	500	980	--	--	547
pH	--	--	--	--	--	--	7.6
Temperature (degrees C)	--	27.5	25.0	25.5	26.0	--	24.5
Specific Conductance[c]	--	2,930	868	1,610	1,550	1,630	883

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-4)25cdd	(D-6-4)27cddl	(D-6-4)27cddl	(D-6-4)27cddl	(D-6-4)34ddd	(D-6-4)34ddd	(D-6-4)36add
DATE SAMPLED	09-15-41	09-23-41	09-14-49	03-20-51	02-17-58	09-09-76	09-15-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	36	40	--	30	--	40
Magnesium	--	10	8.6	3.9	--	9	--
Sodium	--	52	--	--	69	--	55
Potassium	--	--	--	--	1.8	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	--	0
Bicarbonate	170	168	180	170	160	--	174
Chloride	25	24	31	32	29	--	23
Sulfate	--	66	64	--	62	--	76
Nitrate	--	2.5	9.6	--	6.2	--	3.6
Fluoride	--	0.7	0.6	--	0.8	0.4	--
Total Dissolved Solids (mg/l)	--	274	342	--	320	--	292
pH	--	--	--	--	8.0	--	--
Temperature (degrees C)	24.5	--	25.0	24.5	28.0	29.0	--
Specific Conductance[c]	494	472	523	546	476	487	496

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-4)36ddd	(D-6-4)36ddd	(D-6-5)7bcc	(D-6-5)8cad	(D-6-5)8cdd	(D-6-5)9dcc	(D-6-5)12ccb
DATE SAMPLED	09-15-41	07-16-51	09-19-72	06-19-41	06-19-41	06-19-41	09-19-72
LABORATORY[a]	USGS	USGS	BC	USGS	USGS	USGS	BC
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	--	88	680	650	248	190
Magnesium	--	--	17	140	140	93	44
Sodium	--	--	190	--	--	759	1,050
Potassium	--	--	5	--	--	--	10
Anions (mg/l)							
Carbonate	0	0	0	0	0	0	0
Bicarbonate	170	170	135	200	180	57	462
Chloride	27	26	209	1,400	1,500	994	1,430
Sulfate	--	--	275	1,300	1,300	1,110	719
Nitrate	--	--	16	170	200	5	95
Fluoride	--	--	2.0	2.2	2.6	0.4	4.5
Total Dissolved Solids (mg/l)	--	--	1,028	4,500	4,600	3,240	4,514
pH	--	--	8.1	--	--	--	7.9
Temperature (degrees C)	25.0	25.0	--	25.5	24.5	--	--
Specific Conductance[c]	490	504	1,420	6,560	6,560	5,080	5,900

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)12dad	(D-6-5)12dad	(D-6-5)16add	(D-6-5)16bdd	(D-6-5)16dcd	(D-6-5)17aad	(D-6-5)17add
DATE SAMPLED	07-16-51	03-19-51	06-20-41	06-20-41	06-20-41	06-20-41	06-20-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	24	220	340	480	390	720	548
Magnesium	5.5	42	110	110	94	140	108
Sodium	155	463	--	--	--	--	771
Potassium	--	--	--	--	--	--	--
Anions (mg/l)							
Carbonate	16	0	0	0	0	0	0
Bicarbonate	153	250	260	180	200	230	253
Chloride	163	470	1,100	1,100	930	1,500	1,290
Sulfate	63	830	1,500	1,300	1,200	1,500	1,270
Nitrate	5.6	--	42	130	120	220	175
Fluoride	1.8	1.0	1.5	1.1	0.5	1.1	0.9
Total Dissolved Solids (mg/l)	509	2,200	4,200	3,900	3,500	4,900	4,280
pH	--	--	--	--	--	--	--
Temperature (degrees C)	27.0	26.5	--	24.0	24.0	25.0	24.5
Specific Conductance[c]	828	3,310	6,060	5,520	5,440	7,060	6,190

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)17add	(D-6-5)17add	(D-6-5)19adc	(D-6-5)20ddd	(D-6-5)21add1	(D-6-5)21add1	(D-6-5)21add2
DATE SAMPLED	06-21-49	04-09-51	09-19-72	01-18-58	06-20-41	06-21-49	08-14-52
LABORATORY[a]	USGS	USGS	BC	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	422	307	125	440	382	376	--
Magnesium	95	52	27	68	84	84	--
Sodium	896	814	202	320	719	781	802
Potassium	--	--	8	3.4	254	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	0	0
Bicarbonate	293	355	167	150	254	352	351
Chloride	1,030	830	308	730	940	910	750
Sulfate	1,580	1200	275	750	1,210	1,310	1,180
Nitrate	65	45	10.5	75	84	55	39
Fluoride	0.6	1.2	0.8	0.4	1.8	0.8	--
Total Dissolved Solids (mg/l)	4,300	3,480	1,225	2,500	3,540	3,730	--
pH	--	--	7.9	7.7	--	--	--
Temperature (degrees C)	23.5	24.0	--	25.5	24.5	24.0	24.5
Specific Conductance[c]	6,040	5,000	1,850	3,700	5,150	5,310	4,800

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)21add2	(D-6-5)21add2	(D-6-5)21add2	(D-6-5)21add2	(D-6-5)21add2	(D-6-5)21add2	(D-6-5)21add2
DATE SAMPLED	08-10-54	08-09-55	05-21-56	05-09-57	05-26-58	08-25-59	06-21-60
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	260	--	--	--	--	--
Magnesium	--	65	--	--	--	--	--
Sodium	--	701	--	--	--	--	--
Potassium	--	--	--	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	--	--
Bicarbonate	350	370	380	380	370	360	380
Chloride	780	710	710	640	640	600	540
Sulfate	--	1,070	--	--	--	850	820
Nitrate	44	39	--	--	--	--	--
Fluoride	1.4	1.0	--	--	--	--	--
Total Dissolved Solids (mg/l)	--	3,100	--	--	--	--	--
pH	--	7.2	7.3	7.3	7.8	7.2	7.4
Temperature (degrees C)	28.0	23.0	23.5	24.0	23.5	24.0	23.5
Specific Conductance[c]	4,710	4,400	4,430	4,120	4,040	3,900	3,740

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)22bcd	(D-6-5)22dbb1	(D-6-5)22dbc	(D-6-5)23add	(D-6-5)23cda	(D-6-5)25bbb	(D-6-5)25bbb
DATE SAMPLED	09-09-72	07-12-41	06-20-41	03-30-61	04- -60	06-19-41	06-21-49
LABORATORY[a]	BC	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	113	270	280	--	--	304	263
Magnesium	23	70	1.0	--	--	96	61
Sodium	510	--	--	--	--	511	587
Potassium	6	--	--	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	6.9	0
Bicarbonate	325	200	310	320	196	81	363
Chloride	428	800	860	180	420	700	600
Sulfate	550	1,100	1,300	240	--	1,130	970
Nitrate	50	40	30	--	--	23	33
Fluoride	1.8	0.7	220	--	--	1.3	1.6
Total Dissolved Solids (mg/l)	2,222	3,100	3,600	--	--	2,810	2,760
pH	8.0	--	--	7.4	--	--	--
Temperature (degrees C)	--	23.5	23.5	20.5	--	23.5	23.5
Specific Conductance[c]	3,000	4,620	5,170	1,570	2,770	4,120	3,990

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)25bbb	(D-6-5)25ccc	(D-6-5)27aaa	(D-6-5)27aaa	(D-6-5)27aaa	(D-6-5)27aaa	(D-6-5)27aad
DATE SAMPLED	08-23-50	09-25-41	06-19-41	09-19-72	09-10-76	07-24-84	07-12-41
LABORATORY[a]	USGS	USGS	USGS	BC	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	270	350	103	96	85	480
Magnesium	--	58	7,200	20	18	18	89
Sodium	--	--	--	500	440	460	--
Potassium	--	--	--	7	3.2	2.7	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	--	0
Bicarbonate	410	290	340	322	340	--	350
Chloride	490	740	1,000	407	370	390	1,100
Sulfate	--	1,200	1,400	510	390	440	1,400
Nitrate	30	--	44	59	--	--	80
Fluoride	--	--	4.4	3.2	3.5	4.4	0.7
Total Dissolved Solids (mg/l)	--	3,200	4,100	2,159	1,500	1,500	4,100
pH	--	--	--	8.0	7.7	7.5	--
Temperature (degrees C)	23.5	23.5	23.5	--	23.0	23.0	24.0
Specific Conductance[c]	3,400	4,660	5,920	2,900	2,530	2,600	5,790

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)27aad	(D-6-5)30ddd	(D-6-5)31add1	(D-6-5)31add1	(D-6-5)31add2	(D-6-5)36aaa	(D-6-6)5aaa
DATE SAMPLED	09-10-76	08-27-82	09-12-41	07-16-51	09-09-76	09-25-41	09-19-72
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	BC
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	99	42	--	--	370	13
Magnesium	--	26	9.8	--	--	110	0.5
Sodium	--	130	--	--	--	--	210
Potassium	--	2.5	--	--	--	--	3
Anions (mg/l)							
Carbonate	--	--	0	0	--	0	16
Bicarbonate	--	--	170	180	--	370	34
Chloride	--	240	30	38	--	960	124
Sulfate	--	200	91	--	--	1,700	250
Nitrate	--	--	3.9	--	--	25	1.9
Fluoride	1.6	0.4	0.7	--	0.5	4.9	7.3
Total Dissolved Solids (mg/l)	--	780	330	--	--	4,300	766
pH	--	--	--	--	--	--	8.7
Temperature (degrees C)	24.0	--	25	25.5	28.5	23.5	--
Specific Conductance[c]	2,750	--	522	578	728	5,830	990

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)7aaa2	(D-6-6)7aaa2	(D-6-6)7aaa2	(D-6-6)7dbc2	(D-6-6)7ddd2	(D-6-6)9dad	(D-6-6)13cdd1
DATE SAMPLED	08-30-62	09-19-72	07-13-84	09-10-76	09-10-76	08-26-82	06-18-41
LABORATORY[a]	USGS	BC	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	4	4.4	--	--	55	49
Magnesium	--	(-)0.1	0.2	--	--	9.8	20
Sodium	--	141	150	--	--	170	70
Potassium	--	2	1.1	--	--	2.3	--
Anions (mg/l)							
Carbonate	4	18	--	--	--	--	11
Bicarbonate	90	64	83	--	--	--	95
Chloride	84	53	67	--	--	210	64
Sulfate	170	153	130	--	--	100	159
Nitrate	--	(-)0.5	--	--	--	--	2.0
Fluoride	4.8	5.9	6.5	0.8	0.7	1.1	0.8
Total Dissolved Solids (mg/l)	--	486	420	--	--	680	422
pH	8.5	8.7	8.8	--	--	--	--
Temperature (degrees C)	28.0	--	30.5	31.5	29.0	--	24.5
Specific Conductance[c]	804	650	1,000	3,520	2,450	--	712

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)14aad	(D-6-6)15ddd	(D-6-6)15ddd	(D-6-6)16ddd	(D-6-6)17ddd1	(D-6-6)20dca	(D-6-6)20ddd
DATE SAMPLED	02-18-58	06-21-49	08-26-82	06-16-41	08-27-41	09-25-41	06-16-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	91	350	140	28	246	130	183
Magnesium	16	78	32	8.3	52	280	39
Sodium	110	--	170	62	128	--	157
Potassium	5.0	--	3.6	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	--	13	0	0	0
Bicarbonate	150	220	--	125	152	190	190
Chloride	180	440	240	24	342	200	270
Sulfate	150	800	370	72	418	240	375
Nitrate	6.6	110	--	4.4	7.7	--	37
Fluoride	1.0	0.6	0.5	0.8	1.1	--	0.8
Total Dissolved Solids (mg/l)	680	2,200	1,000	274	1,340	800	1,160
pH	7.4	--	--	--	--	--	--
Temperature (degrees C)	28.0	24.0	--	--	--	24.5	24.0
Specific Conductance[c]	1,060	3,050	--	448	2,070	1,350	1,850

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)21bbb	(D-6-6)21bbb	(D-6-6)21bbb	(D-6-6)21cdd	(D-6-6)21ddd	(D-6-6)22cdd1	(D-6-6)22cdd1
DATE SAMPLED	11-20-65	09-07-72	09-19-72	06-06-41	09-16-41	06-17-41	09-16-49
LABORATORY[a]	ATL	ADHS	BC	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	16	98	30	170	--	110	240
Magnesium	2	12	5	35	--	30	57
Sodium	--	134	150	--	--	--	--
Potassium	--	--	3	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	0	0
Bicarbonate	88	100	88	180	180	130	220
Chloride	78	180	110	21	380	150	330
Sulfate	180	190	170	320	--	260	460
Nitrate	--	31	25	25	--	20	31
Fluoride	2.1	0.8	1.2	1.0	--	1.0	0.6
Total Dissolved Solids (mg/l)	531	650	644	960	--	730	1,400
pH	8.4	7.8	8.1	--	--	--	--
Temperature (degrees C)	--	--	--	23.5	24.0	24.0	24.0
Specific Conductance[c]	--	900	850	1,520	2,490	1,200	2,210

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)22cdd1	(D-6-6)22cdd2	(D-6-6)22ddd	(D-6-6)23ddd1	(D-6-6)24ddd1	(D-6-6)25bdd	(D-6-6)26cdb
DATE SAMPLED	08-17-50	07-16-51	09-16-41	06-16-41	06-18-41	08-27-41	08-02-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	--	--	65	53	170	34
Magnesium	--	--	--	15	13	34	10
Sodium	--	--	--	71	59	--	--
Potassium	--	--	--	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	0	170
Bicarbonate	190	150	190	174	153	160	--
Chloride	260	150	42	61	62	300	23
Sulfate	--	--	--	134	84	280	63
Nitrate	--	--	--	8.4	16	--	2.5
Fluoride	--	--	--	1.0	0.2	0.6	1.1
Total Dissolved Solids (mg/l)	--	--	--	441	363	900	270
pH	--	--	--	--	-	--	--
Temperature (degrees C)	24.5	26.5	24.0	24.0	24.5	24.0	25.0
Specific Conductance[c]	1,820	1,880	613	727	618	1,450	400

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)28cbal	(D-6-6)28cbal	(D-6-6)28ddd	(D-6-6)30add	(D-6-6)30dcc	(D-6-6)30dcc	(D-6-6)31dcc
DATE SAMPLED	09-25-41	07-16-51	09-25-41	03-20-51	04-20-83	07-24-84	09-25-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	200	98	250	--	54	90	267
Magnesium	44	20	53	--	12	18	57
Sodium	--	--	--	--	440	520	864
Potassium	--	--	--	--	2.1	3.0	--
Anions (mg/l)							
Carbonate	0	0	0	0	--	--	0
Bicarbonate	200	160	170	310	--	--	398
Chloride	350	160	390	530	320	410	1010
Sulfate	470	250	710	--	350	440	988
Nitrate	32	14	--	--	--	--	--
Fluoride	1.4	1.6	--	--	3.0	3.9	--
Total Dissolved Solids (mg/l)	1,400	810	1,700	--	1,400	1700	3,380
pH	--	--	--	--	7.6	7.5	--
Temperature (degrees C)	25.0	26.0	26.0	24.0	22.5	23.0	--
Specific Conductance[c]	2,210	1,250	2,630	3,500	2,240	2,710	5,130

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)31dcc	(D-6-6)34cbb	(D-6-6)34cbb	(D-6-6)34cbb	(D-6-6)34cbb	(D-6-6)34cbb	(D-6-6)34cbb
DATE SAMPLED	05-03-51	09-25-41	06-21-49	08-17-50	07-16-51	05-10-60	07-26-76
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	232	190	240	--	480	--	--
Magnesium	40	37	43	--	80	--	--
Sodium	640	--	--	--	--	--	--
Potassium	--	--	--	--	--	--	--
Anions (mg/l)							
Carbonate	0	0	0	0	0	--	--
Bicarbonate	390	210	250	270	380	130	--
Chloride	675	300	350	510	680	600	--
Sulfate	776	580	610	--	1,200	--	--
Nitrate	60	12	28	--	41	--	--
Fluoride	2.3	2.1	1.1	--	0.2	--	0.8
Total Dissolved Solids (mg/l)	2,660	1,500	1,700	--	3,200	--	--
pH	--	--	--	--	--	7.9	--
Temperature (degrees C)	--	27.0	27.0	27.0	25.5	--	32.0
Specific Conductance[c]	4,000	2,220	2,530	2,830	4,320	3,220	1,720

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)36add	(D-7-4)W1dad	(D-7-4)W1dad	(D-7-5)5ddd1	(D-7-5)5ddd1	(D-7-6)1cca	(D-7-6)1ccc
DATE SAMPLED	09-11-41	07-11-84	08-05-85	09-12-41	07-16-51	02-17-58	08-06-84
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	210	6.2	7.9	44	--	50	180
Magnesium	9	1.9	2.1	12	--	6.3	25
Sodium	--	100	100	--	--	120	170
Potassium	--	1.2	1.2	--	--	2.2	5.0
Anions (mg/l)							
Carbonate	0	0	--	0	0	0	--
Bicarbonate	170	--	--	180	170	110	--
Chloride	23	24	30	26	36	100	310
Sulfate	76	60	60	84	--	160	310
Nitrate	3.6	--	--	3.7	--	--	--
Fluoride	--	1.6	1.4	--	--	1.8	0.5
Total Dissolved Solids (mg/l)	290	290	310	310	--	530	1100
pH	--	8.3	8.4	--	--	8.1	7.4
Temperature (degrees C)	25.0	31.5	31.5	--	--	29.5	27.0
Specific Conductance[c]	1,980	485	501	525	571	854	1,850

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-7-6)1cdc	(D-7-6)1cdd	(D-7-6)1ddb	(D-7-6)2cda	(D-7-6)3daa	(D-7-6)6dcd	(D-7-6)6dda1
DATE SAMPLED	08-16-48	08-16-48	08-01-58	03-30-61	09-25-41	01-18-57	09-25-41
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS	USGS	USGS
CONSTITUENT							
Cations (mg/l)[b]							
Calcium	--	--	--	--	190	220	69
Magnesium	--	--	--	--	36	16	14
Sodium	--	--	--	--	--	120	--
Potassium	--	--	--	--	--	1.8	--
Anions (mg/l)							
Carbonate	0	0	--	0	0	0	0
Bicarbonate	150	150	160	300	310	170	290
Chloride	140	75	43	260	300	140	130
Sulfate	--	--	--	440	480	500	310
Nitrate	--	--	--	--	--	8.9	12
Fluoride	--	--	--	--	--	1.7	--
Total Dissolved Solids (mg/l)	--	--	--	--	1,400	1,100	920
pH	--	--	7.1	6.9	--	7.5	--
Temperature (degrees C)	--	26.0	--	24.0	25.5	26.5	24.5
Specific Conductance[c]	1,010	709	530	2,010	2,190	1,590	1,470

TABLE 2. SUMMARY OF ROUTINE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-7-6)6ddd	(D-7-6)6ddd	(D-7-6)11acd
DATE SAMPLED	02-18-58	01-12-77	08-16-48
LABORATORY[a]	USGS	USGS	USGS
CONSTITUENT			
Cations (mg/l)[b]			
Calcium	340	--	--
Magnesium	51	--	--
Sodium	360	--	--
Potassium	3.6	--	--
Anions (mg/l)			
Carbonate	0	--	0
Bicarbonate	210	--	180
Chloride	530	--	67
Sulfate	840	--	--
Nitrate	--	--	--
Fluoride	1.0	1.3	--
Total Dissolved Solids (mg/l)	2,300	--	--
pH	7.3	--	--
Temperature (degrees C)	26.5	24.0	28.0
Specific Conductance[c]	3,180	2,800	873

[a] BC - BC Laboratories
USGS - U.S. Geological Survey
ADHS - Arizona Department of Health Services
ATL - Arizona Testing Lab

[b] mg/l - milligrams per liter

[c] micrombos per centimeter

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-4)14acc	(D-5-4)14ccb2	(D-5-5)34bcc [TM-1]	(D-5-5)34bcc [TM-1]	(D-5-5)34ccb [TM-1]	(D-5-5)35aba [Well 5]	(D-5-5)35aba [Well 5]
DATE SAMPLED	09-19-72	09-19-72	08-22-73	07-15-77	01-05-83	06-28-79	07-10-79
LABORATORY[a]	BC	BC	BC	BC	BC	BC	BC
TRACE CONSTITUENT (milligrams per liter)							
Iron	--	--	0.07	1.1	(-)0.05	0.1	--
Mangenese	--	--	0.08	0.04	(-)0.01	--	--
Arsenic	(-)0.01	(-)0.01	0.02	0.03	0.03	--	--
Copper	--	--	(-)0.01	(-)0.01	0.01	0.01	--
Zinc	--	--	0.11	0.31	0.54	--	--
Barium	--	--	--	(-)1.0	--	--	--
Cadmium	--	--	--	0.008	--	--	--
Chromium (total)	--	--	0.08	--	--	--	--
Lead	--	--	(-)0.05	0.004	(-)0.01	--	--
Mercury	--	--	--	(-)0.0002	--	--	--
Selenium	--	--	(-)0.01	(-)0.01	(-)0.01	--	--
Silver	--	--	--	(-)0.01	--	--	--
Antimony	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--
Nickel	--	--	--	(-)0.05	--	--	--
Thallium	--	--	--	--	--	--	--
Boron	0.09	0.10	3.0	1.3	--	--	0.35
Silica	--	--	--	--	21	--	--
Molybdenum	--	--	0.01	--	--	--	--
Strontium	--	--	--	(-)0.1	--	--	--

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-5)35aba [Well 6]	(D-5-5)35aba [P. Shaft]	(D-5-5)35aba [P. Shaft]	(D-5-6)19acb	(D-5-6)27ada [Well 1]	(D-5-6)28aac [Well 2]	(D-5-6)28daa
DATE SAMPLED	11-30-82	06-05-79	07-10-79	08-21-72	08-31-82	11-30-82	11-30-82
LABORATORY[a]	BC	BC	BC	ADHS	USGS	BC	BC
TRACE CONSTITUENT (milligrams per liter)							
Iron	(-)0.05	(-)0.1	--	--	.004	(-)0.05	(-)0.05
Mangenese	0.01	--	--	--	(-)0.001	0.01	(-)0.01
Arsenic	0.10	--	--	(-)0.01	--	0.1	0.07
Copper	(-)0.01	0.01	--	--	--	(-)0.01	(-)0.01
Zinc	(-)0.01	--	--	--	--	0.01	0.01
Barium	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--
Chromium (total)	(-)0.01	--	--	--	--	0.02	0.01
Lead	(-)0.01	--	--	--	--	(-)0.01	(-)0.01
Mercury	--	--	--	--	--	--	--
Selenium	--	--	--	--	--	--	--
Silver	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--
Nickel	--	--	--	--	--	--	--
Thallium	--	--	--	--	--	--	--
Boron	--	--	0.42	--	0.4	--	--
Silica	17	--	--	--	24	48	32
Molybdenum	--	--	--	--	--	--	--
Strontium	--	--	--	--	--	--	--

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-5-6)29ddc	(D-5-6)33aaa [Well 3]	(D-5-6)33add [Well 4]	(D-6-4)11ddc	(D-6-5)7bcc	(D-6-5)12ccb	(D-6-5)19adc
DATE SAMPLED	10-25-72	11-30-82	09-19-72	08-25-82	09-19-72	09-19-72	09-19-72
LABORATORY[a]	BC	BC	BC	USGS	BC	BC	BC
TRACE CONSTITUENT (milligrams per liter)							
Iron	--	(-)0.05	--	0.050	--	--	--
Mangenese	--	(-)0.01	--	0.010	--	--	--
Arsenic	(-)0.01	0.05	(-)0.01	0.021	(-)0.01	(-)0.01	(-)0.01
Copper	--	(-)0.01	--	0.001	--	--	--
Zinc	--	(-)0.01	--	0.030	--	--	--
Barium	--	--	--	--	--	--	--
Cadmium	--	--	--	(-)0.001	--	--	--
Chromium (total)	--	0.01	--	0.010	--	--	--
Lead	--	(-)0.01	--	0.003	--	--	--
Mercury	--	--	--	0.0001	--	--	--
Selenium	--	--	--	0.004	--	--	--
Silver	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Beryllium	--	--	--	(-)0.01	--	--	--
Nickel	--	--	--	(-)0.004	--	--	--
Thallium	--	--	--	--	--	--	--
Boron	2.4	--	0.06	0.910	0.08	0.11	0.33
Silica	--	59	--	45	--	--	--
Molybdenum	--	--	--	--	--	--	--
Strontium	--	--	--	--	--	--	--

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-5)20ddd	(D-6-5)22bcd	(D-6-5)22cab	(D-6-5)27aaa	(D-6-5)27aaa	(D-6-5)30ddd	(D-6-6)5aaa
DATE SAMPLED	01-18-58	09-19-72	08-27-82	09-19-72	07-24-84	08-27-82	09-19-72
LABORATORY[a]	USGS	BC	USGS	BC	USGS	USGS	BC
TRACE CONSTITUENT (milligrams per liter)							
Iron	0	--	0.02	--	0.009	0.005	--
Mangenese	0	--	(-)0.01	--	(-)0.001	(-)0.001	--
Arsenic	--	(-)0.01	--	(-)0.01	0.022	--	(-)0.01
Copper	--	--	--	--	(-)0.01	--	--
Zinc	--	--	--	--	0.008	--	--
Barium	--	--	--	--	0.030	--	--
Cadmium	--	--	--	--	(-)0.001	--	--
Chromium (total)	--	--	--	--	--	--	--
Lead	--	--	--	--	(-)0.010	--	--
Mercury	--	--	--	--	--	--	--
Selenium	--	--	--	--	--	--	--
Silver	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Beryllium	--	--	--	--	(-)0.001	--	--
Nickel	--	--	--	--	--	--	--
Thallium	--	--	--	--	--	--	--
Boron	--	0.07	1.4	0.08	1.50	0.38	0.07
Silica	47	--	61	--	52	32	--
Molybdenum	--	--	--	--	0.040	--	--
Strontium	--	--	--	--	1.10	--	--

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)7aaa2	(D-6-6)7aaa2	(D-6-6)7dad	(D-6-6)7dad	(D-6-6)9dad	(D-6-6)15ddd	(D-6-6)21bbb
DATE SAMPLED	09-19-72	07-13-84	09-19-72	08-25-82	08-26-82	08-26-82	09-19-72
LABORATORY[a]	BC	USGS	BC	USGS	USGS	USGS	BC
TRACE CONSTITUENT (milligrams per liter)							
Iron	--	0.024	--	0.06	0.008	0.007	--
Mangenese	--	0.003	--	0.02	0.002	0.002	--
Arsenic	0.05	0.057	(-)0.01	--	0.016	--	(-)0.01
Copper	--	(-)0.010	--	--	0.004	--	--
Zinc	--	0.032	--	--	0.003	--	--
Barium	--	0.006	--	--	--	--	--
Cadmium	--	(-)0.001	--	--	(-)0.001	--	--
Chromium (total)	--	--	--	--	0.010	--	--
Lead	--	(-)0.010	--	--	(-)0.001	--	--
Mercury	--	--	--	--	0.0001	--	--
Selenium	--	--	--	--	0.003	--	--
Silver	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Beryllium	--	(-)0.001	--	--	0.001	--	--
Nickel	--	--	--	--	0.001	--	--
Thallium	--	--	--	--	--	--	--
Boron	0.09	0.33	0.08	0.99	0.60	0.74	0.09
Silica	--	19	--	38	39	37	--
Molybdenum	--	0.010	--	--	--	--	--
Strontium	--	0.051	--	--	--	--	--

TABLE 3. SUMMARY OF TRACE CHEMICAL CONSTITUENTS IN GROUNDWATER SAMPLES FROM SELECTED WELLS, MINERAL EXPLORATION BOREHOLES, AND SHAFTS, ASARCO SACATON PROJECT AND VICINITY, PINAL COUNTY, ARIZONA

WELL NUMBER	(D-6-6)30dcc	(D-7-4)W1dad	(D-7-6)1ccc	(D-7-6)6dcd	(D-7-6)6ddd
DATE SAMPLED	07-24-84	07-11-84	08-06-84	01-18-57	02-18-58
LABORATORY[a]	USGS	USGS	USGS	USGS	USGS
TRACE CONSTITUENT (milligrams per liter)					
Iron	0.012	0.010	0.015	0	0
Mangenese	0.003	0.002	(-)0.001	--	0
Arsenic	0.011	0.031	0.003	--	--
Copper	0.020	0.020	(-)0.010	--	--
Zinc	0.010	0.013	0.006	--	--
Barium	0.036	0.012	0.091	--	--
Cadmium	(-)0.001	0.002	(-)0.001	--	--
Chromium (total)	--	--	--	--	--
Lead	(-)0.010	(-)0.010	(-)0.010	--	--
Mercury	--	--	--	--	--
Selenium	--	--	--	--	--
Silver	--	--	--	--	--
Antimony	--	--	--	--	--
Beryllium	(-)0.001	(-)0.001	(-)0.001	--	--
Nickel	--	--	--	--	--
Thallium	--	--	--	--	--
Boron	1.30	0.20	0.23	--	--
Silica	52	25	33	--	42
Molybdenum	0.050	0.010	(-)0.010	--	--
Strontium	1.20	--	3.8	--	--

[a]BC - BC Laboratories
USGS - U.S. Geological Survey
ADHS - Arizona Department of Health Services

(-) less than

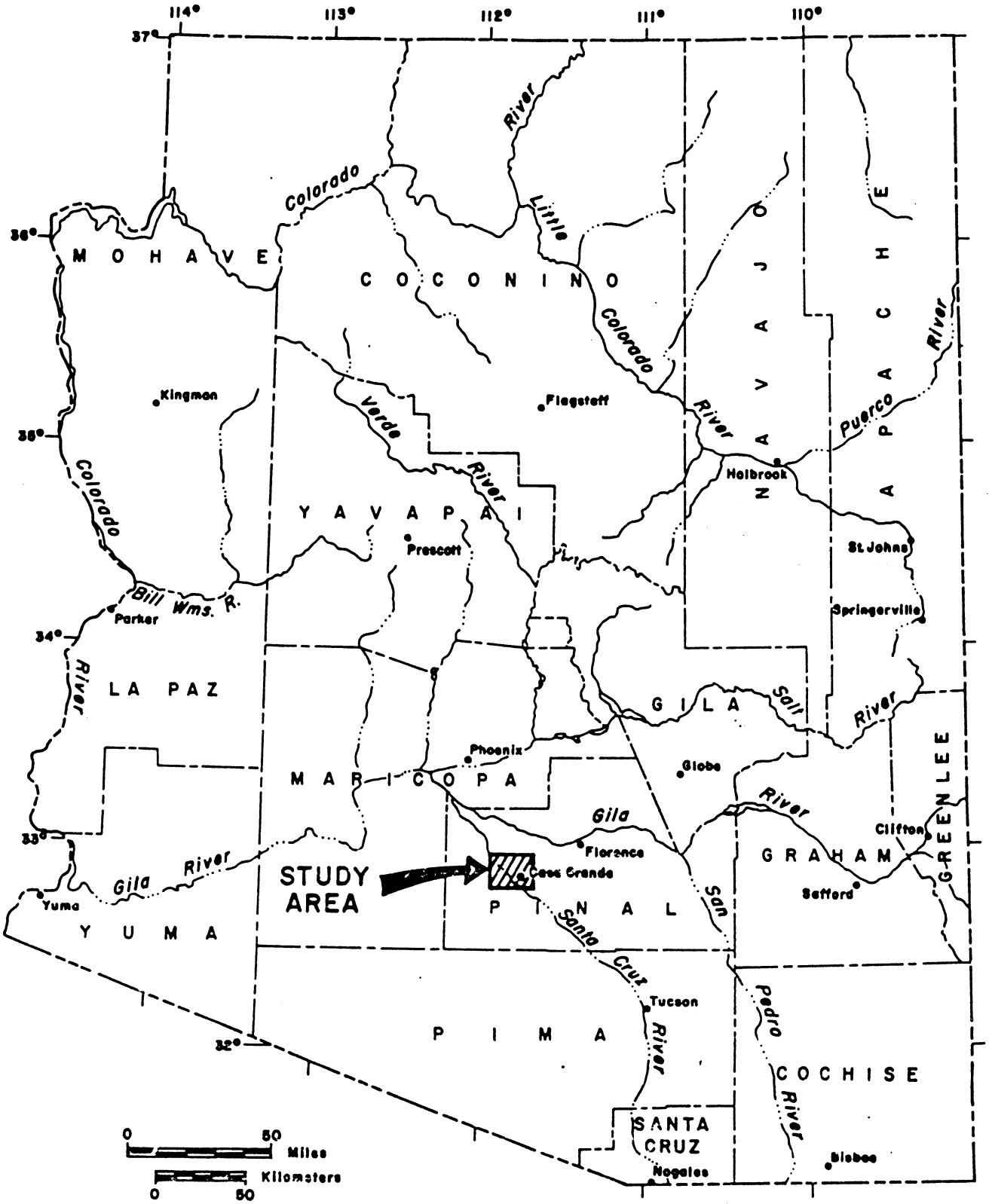


FIGURE I. LOCATION MAP

ERROL L. MONTGOMERY & ASSOCIATES, INC.
TUCSON, ARIZONA

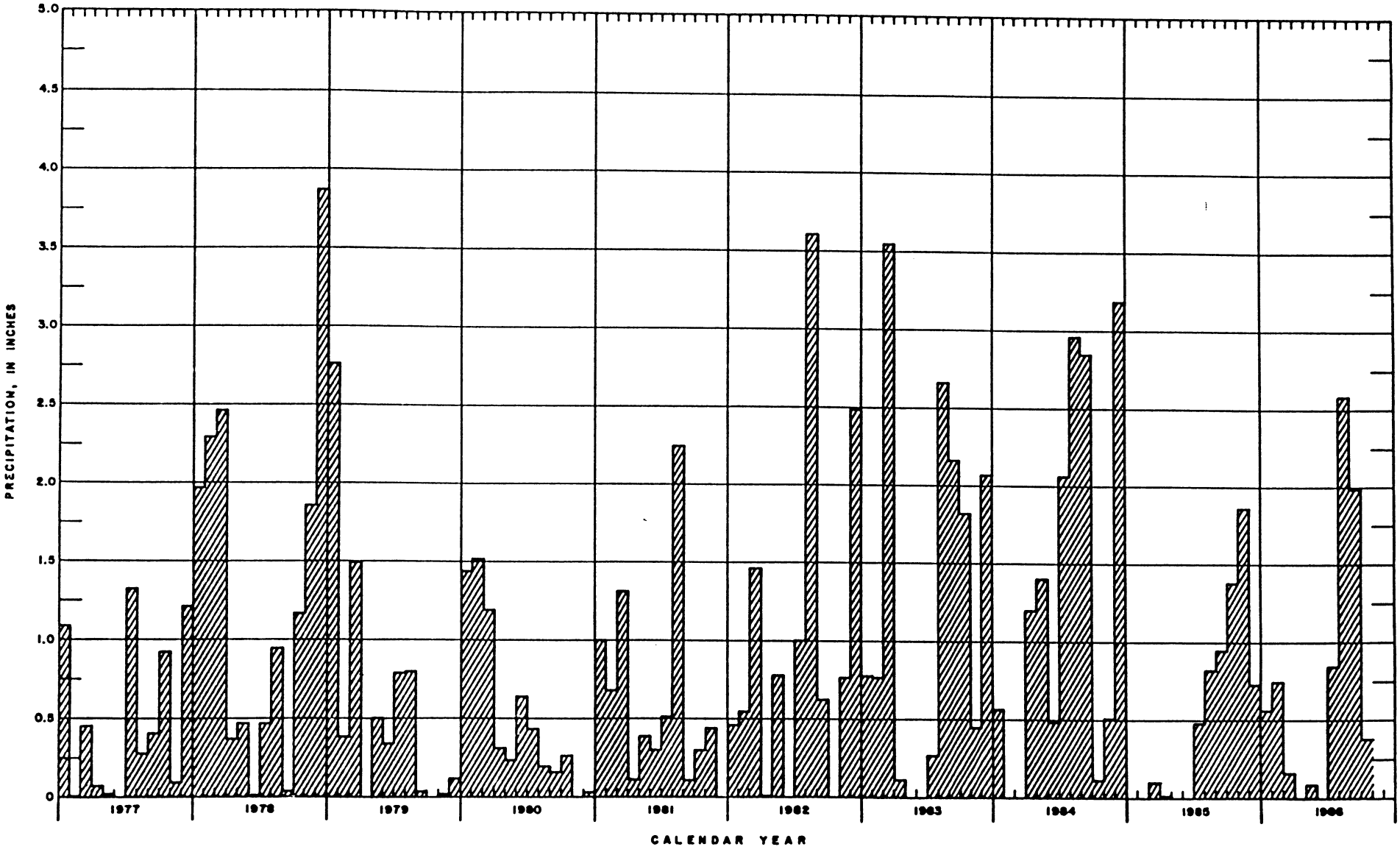


FIGURE 3. MONTHLY PRECIPITATION AT THE ASARCO SACATON OPEN-PIT MINE, 1977–1986

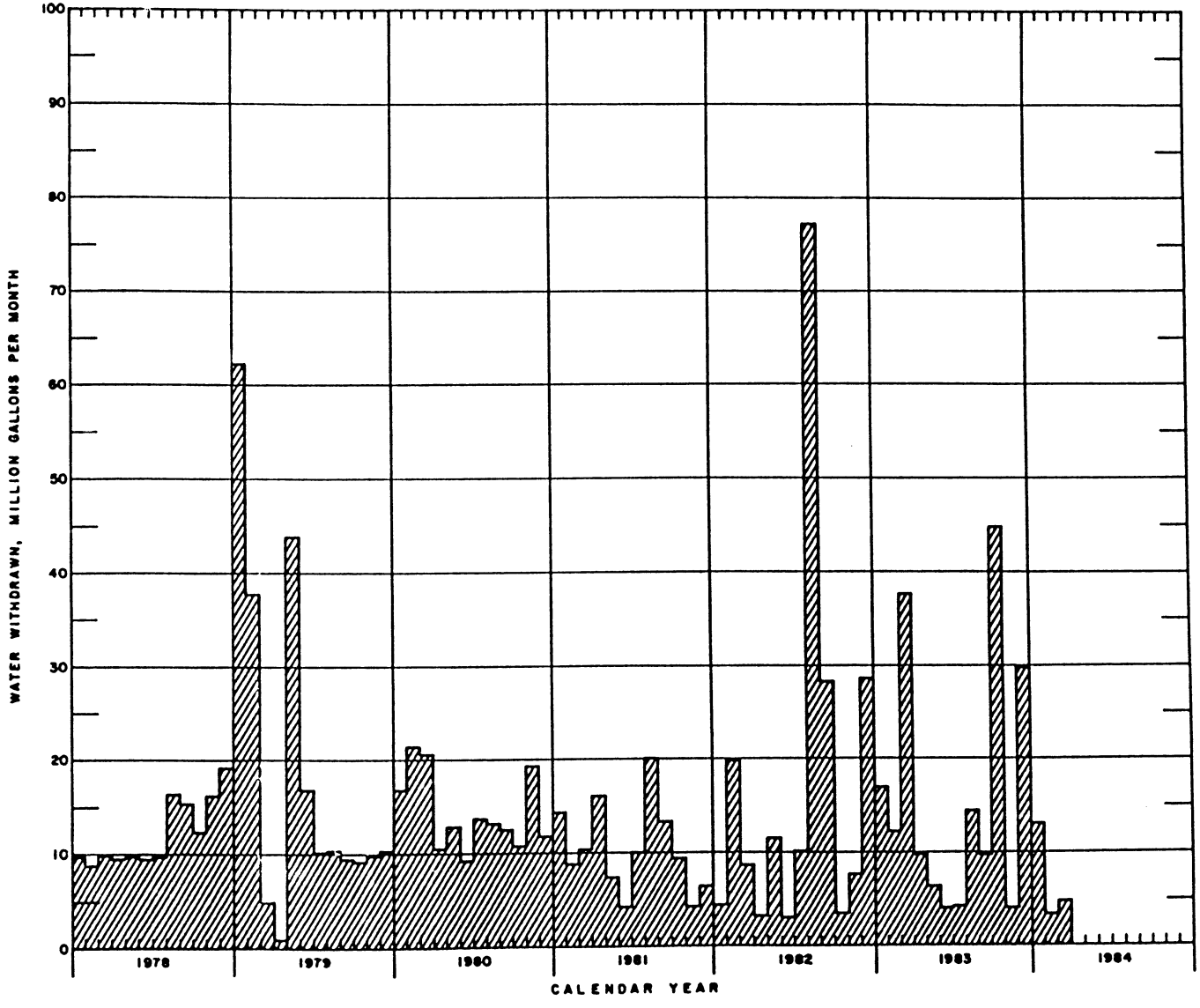


FIGURE 6. WATER WITHDRAWN FROM THE ASARCO INC. SACATON OPEN-PIT MINE, 1978 TO 1984

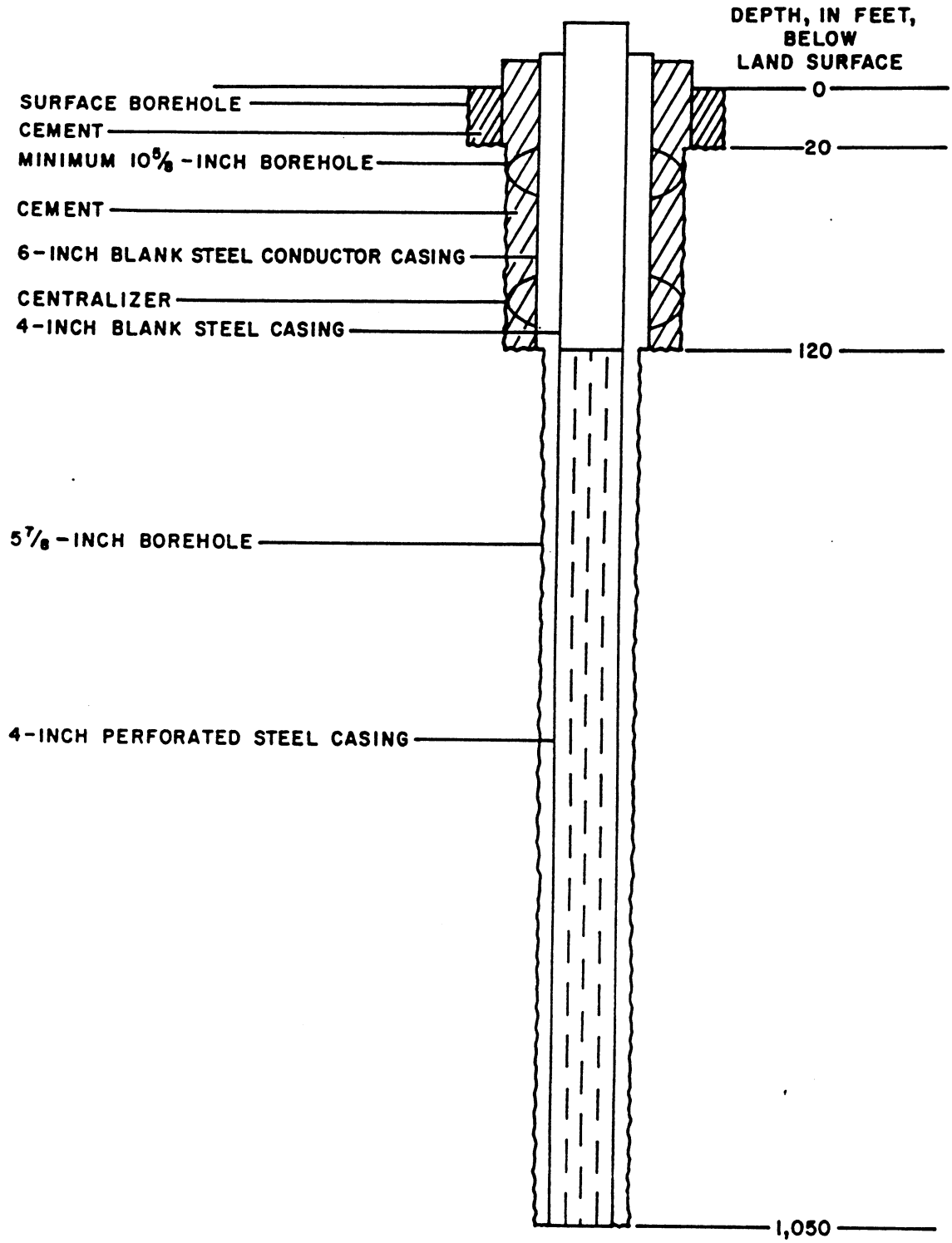


FIGURE 8. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR PROPOSED MONITOR WELLS

APPENDIX A

WELL NUMBERING SYSTEM

The well numbers used in this study are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the state into four quadrants. These quadrants are designated, counter-clockwise, by the capital letters A, B, C, and D. All land north and east of the point of origin is in quadrant A; all land north and west of the point of the origin is in quadrant B; all land south and west is in quadrant C; and all land south and east is in quadrant D. The first digit of a well number indicates the township; the second digit the range; and the third digit the section in which the well is located. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract or quarter section; the second letter denotes the 40-acre tract or quarter-quarter section; and the third letter denotes the 10-acre tract or quarter-quarter-quarter section. These letters are also assigned in a counter-clockwise direction, beginning in the northeast quarter. As Figure A-1 shows, well number (D-6-4)26bdd designates the well as being in the Southeast ¼, Southeast ¼, Northwest ¼, Section 26, Township 6 South, Range 4 East. Where more than one well is within a 10-acre tract, consecutive numbers, beginning with "1" are added as suffixes.

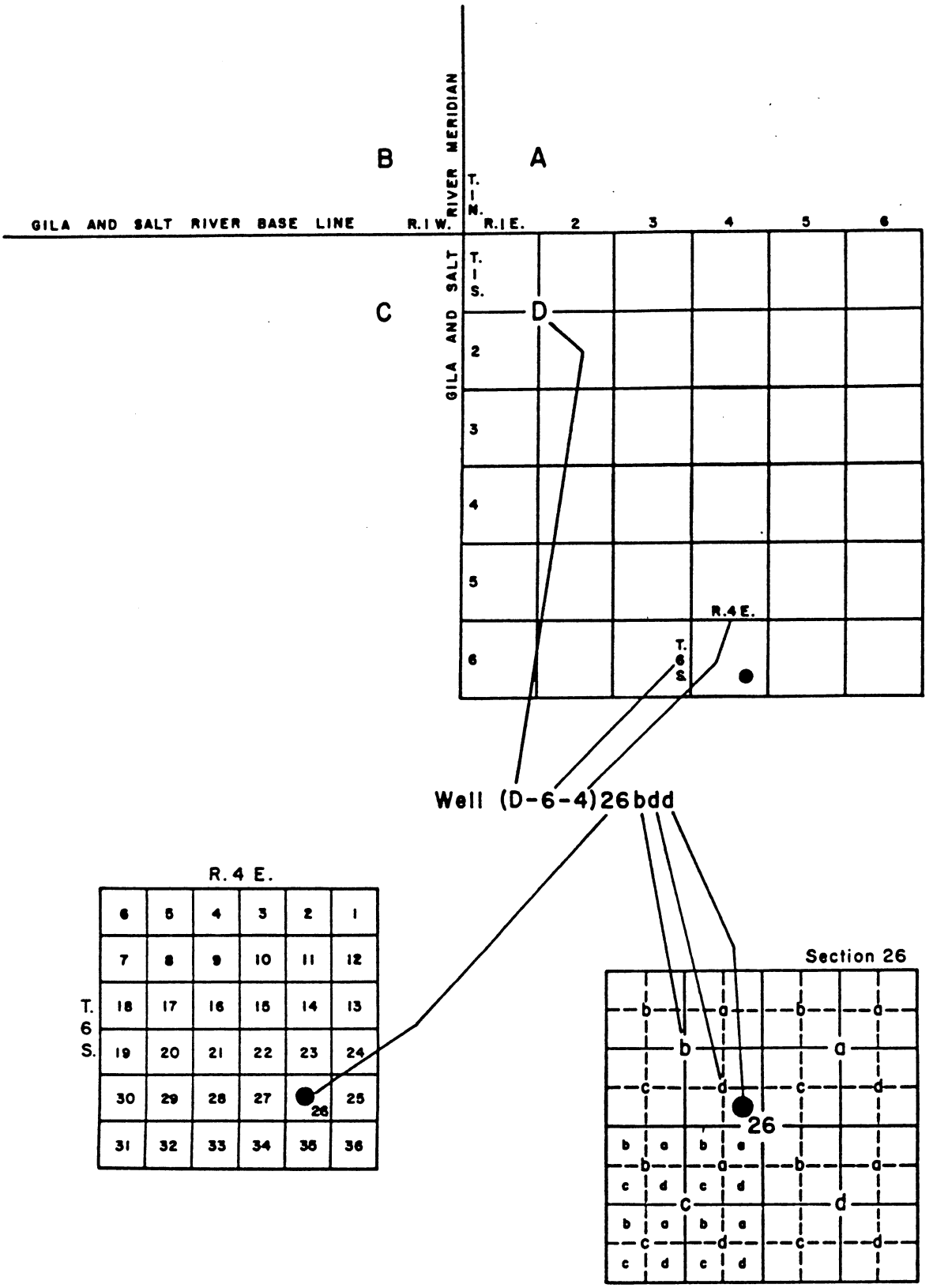
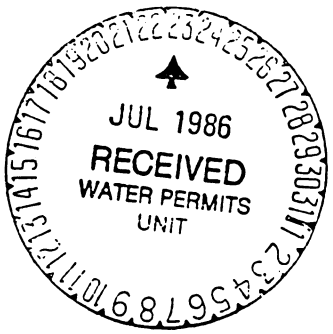


FIGURE A-1. WELL NUMBERING DIAGRAM

ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

July 23, 1986



Mr. A. O. Hellerud
Office of Waste and Water Quality Management
Division of Environmental Health Services
Arizona Department of Health Services
2005 N. Central Avenue
Phoenix, AZ 85004

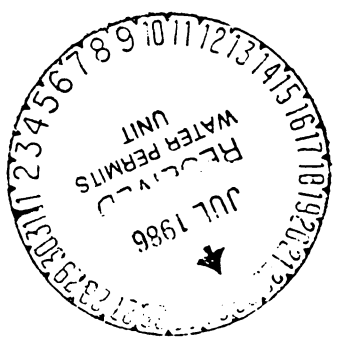
Dear Sir:

ASARCO Incorporated, Southwestern Mining Department, was made aware of a need for a regional landfill. Use of our mined-out open pit at Asarco's Sacaton Unit was suggested as a site. There has been an interest shown by the City of Phoenix and other municipalities in the area. Asarco made the decision to eventually operate the site as a landfill and obtain a permit preparatory to operations. Discussions were held with you and others of your staff and included a site tour. We have retained Errol L. Montgomery and Associates to make a hydrogeologic study of the area and site.

Attached is a Notice of Disposal to open the file on this proposed facility plus a preliminary proposal from Montgomery and Associates. The Montgomery proposal outlines the extent of the hydrogeologic study that will be submitted to Asarco and ADHS. Please review the Montgomery proposal and inform us if the proposed hydrogeologic report is adequate or if it should be expanded beyond the proposal by Montgomery to satisfy your requirements.

Very truly yours,

T. E. Scartaccini



VCM/mck
attachs.

cc: SLBurrill
VCMartz
ELMontgomery & Assoc.

NOTICE OF DISPOSAL FORM

1.) a. Facility name Sacaton Unit

b. Facility Owner ASARCO Incorporated

c. Name, title, address, and telephone number of contact person for facility.

Name: Clarence Skinner

Title: Mechanical Superintendent

Mailing address: ASARCO Incorporated
P O Box V
Casa Grande, AZ Zip Code 85222

Telephone number: (602) 836 2171
(Area Code)

d. Address and telephone number of facility:

Mailing address: P. O. Box V
Casa Grande, AZ
Zip Code 85222

Telephone number: 602-836 2171
(Area Code)

e. Facility location information:



6 miles northwest of Casa Grande off the Maricopa Road

Zip Code

Pinal County, Arizona

Township 5 south

Range 5 east

Sections 26 S-1/2; 35 N-1/2

¼ ¼

ADHS/BWWQM-218 (1/84)
Revised 7/84

f. Describe access to facility via Casa Grande - Maricopa Road, 4 miles NW of Casa Grande, thence two miles north on Bianco Road

g. Landowner of facility site ASARCO Incorporated

h. Type of Permit you are applying for:

area permit _____ individual facility permit X

i. Type of facility requesting permit:

new X existing _____

2.) a. Attach a topographic map (preferably a 7.5 minute quadrangle base), showing the geographic location of the facility(s) and all disposal locations. In addition, show the location of any existing groundwater withdrawal wells within the approximate vicinity (¼ mile radius) of the disposal area and identify the use of each well (i.e. industrial wells, drinking water supply wells, etc.). (If applying for an area permit as described in R9-20-211, indicate on the map the location of each facility and disposal location in the proposed permitted area).

b. List Latitude/Longitude of all disposal locations indicated on the attached map

N 32°57'09" Lat, W 111°50'12" longitude

3.) a. Type of Facility(s) Sanitary landfill

b. Nature of Activity conducted at facility(s) This open pit copper mine is considered an excellent site for a sanitary landfill and conversion to a sanitary landfill is proposed.

c. List applicable U.S. Department of Commerce Standard Industrial Classification (SIC) Codes for above activities

SIC 4953

4.) Date Facility began/will begin operating when permitted

5.) Expected Facility(s) Operational Lifetime 30 - 50 years depending on volume received

6.) List any other environmental permits issued to the facility(s) (i.e. air quality permit, NPDES permit, hazardous waste permit)
Pinal - Gila Counties Air Quality Control District permits Nos. 05108 through 05109

7.) a. Describe disposal activites at the facility(s)
Proposed activity would convert this shutdown open pit copper mine to a sanitary landfill by following the guidelines set forth by ADHS. These are to be addressed in an operational plan for proper operation of a sanitary landfill.

b. Describe any control measures and treatment processes designed and operated to protect groundwater quality from effects of the disposal
The site is considered to be competent and nonthreatening to water quality downgradient. Stormwater will be gathered in a leachate pumpage system and treated if necessary by evaporation or other methods.

c. Describe existing groundwater use(s) of the receiving aquifer(s)
Downgradient aquifer is of poor quality exceeding 3000 ppm TDS. Is used for agricultural irrigation, livestock watering and domestic insofar as quality limitations allow.

d. Note of depth to groundwater 322 feet at mine shaft; 102 feet at tailing monitor well

Source of data ASARCO Incorporated

Date of measurement May 14, 1985

e. Enter in Appendix A - Part I the ambient groundwater concentrations of the receiving aquifer(s) for those constituents listed that are contained in the disposal. Indicate source of data and date of sampling for all values listed.

8.) a. Identify the type(s) of waste(s) generated by each process within the facility. Be as descriptive as possible without listing specific constituents.

Solid waste will be generated in nearby cities and towns that will be expected to transport these municipal wastes to the Sacaton site. No hazardous wastes will be accepted. Landfill leachate will be gathered and disposed in an environmentally acceptable manner.

b. Check of list in Appendix A - Part II of the specific pollutants disposed by the facility. Include those disposed materials that are listed in Tables I and II of this document, in Title 40 Code of Federal Regulations Part 261, or any other constituent contained in the disposed waste stream.
To be addressed as to leachate disposal and treatment.

c. Enter in Appendix A - Part II the maximum disposal concentration of those constituents you checked or listed, as required by 8b. Indicate the date of sampling in parenthesis next to the sample value and the source of the data at the bottom of page three in Appendix A.
To be addressed as to leachate disposal and treatment

d. Estimate the disposal schedule including the annual average in hours per day, days per year, and the disposal periods if the disposal is seasonal.

Hours/day 8

Days/year 260

Seasonal Distribution of Disposal non seasonal

e. Estimate the flow rate(s) of the disposal (i.e. minimum, average, and maximum daily flow; mean annual flow; or mean, minimum, and maximum flow by season if disposal is periodic; or by whatever other units appropriate to the type of disposal.

The site is proposed as a sanitary landfill and will dispose solid wastes from municipalities under managed conditions addressed in a sanitary landfill operational plan.

9.) Describe any existing groundwater quality monitoring program(s) (attach supporting technical reports if available)

A monitor well was drilled about 400 ft SW of the SW corner of the tailing dam. Drilled by cable tools; cased to total depth of 400' with 8 5/8" casing, with perforations 155' to 400'. Alluvial gravel and clayey silt 0-135'; conglomerate 135-400'. Depth to groundwater 201'. Well sampled annually for major constituents from 155' - 400'. Parameters tested for listed in Appendix A.

10.) Include any other data or information which, in the judgement of the owner/operator, demonstrates that the facility qualifies for a groundwater quality protection permit based on compliance with the criteria listed in R9-20-208.A. Use attachments if applicable (i.e. depth to groundwater, geology at the site).

See letter of proposal and hydrogeological report by Erroll L. Montgomery and Associates.

11.) Certification:

"I certify that under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

T. E. SCARTACCINI
Printed Name of Applicant

General Manager, Southwestern Mining Department
Title

July 23, 1986
Date Application Signed

T E Scartaccini
Signature of Applicant

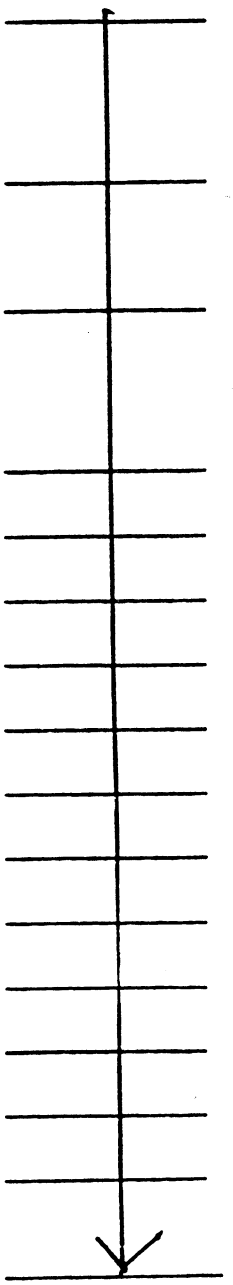
Appendix A - NOTICE OF DISPOSAL FORM

Ambient Groundwater and Maximum Disposal Waste Stream Constituent Concentrations

	PART I Ambient 8-22-73 Groundwater	Units	PART II Disposal Waste Stream
Microbiological			
Fecal Coliform Bacteria	Does not apply	#/100 ml	To be addressed in permitting process
Inorganic Chemicals			
Arsenic	0.02	mg/l	
Barium	not assayed	mg/l	
Cadmium	"	mg/l	
Chromium (Total)	0.08	mg/l	
Lead	< 0.05	mg/l	
Mercury	not assayed	mg/l	
Nitrate (as N)	1.86	mg/l	
Selenium	< 0.01	mg/l	
Silver	not assayed	mg/l	
Fluoride	10.00	mg/l	
Organic Chemicals			
Chlorinated Hydrocarbons			
Endrin	None added	mg/l	
Lindane		mg/l	
Methoxychlor		mg/l	
Toxaphene		mg/l	
Chlorophenoxys			
2, 4-D		mg/l	
2, 4, 5TP Silvex		mg/l	
Total Trihalomethanes		mg/l	

ADHS/BWWQM-218 (1/84)
Revised 7/84

	PART I Ambient Groundwater	Units	PART II Disposal Waste Stream
Radiochemicals			To be addressed in permitting process
Combined radium-226 and radium-228	--	pCi/l	
Gross alpha particle activity (including radium-226 but excluding radon and Uranium)	--	pCi/l	
Beta particle and photon emitters from man-made radionuclides	--	pCi/l	
Secondary Contaminants			
Alkalinity	--	mg/l	
Calcium	28.0	mg/l	
Chloride	633.7	mg/l	
Copper	< 0.01	mg/l	
Hardness	--	mg/l	
Iron	0.07	mg/l	
Magnesium	11.3	mg/l	
Manganese	0.08	mg/l	
pH	7.7	mg/l	
Sodium	1140	mg/l	
Sulfate	1213	mg/l	
Total Dissolved Solids (TDS)	3080	mg/l	
Zinc	0.11	mg/l	



	PART I Ambient Groundwater	Units	PART II Disposal Waste Stream
Priority Pollutants			To be addressed in the permitting process
None Added	None added		
Others: (list all other constituents contained in the disposal waste stream)			
Potassium	14.5	Mg/L	"
Carbonate	0	"	"
Bicarbonate	553.3	"	"
Phosphorous	< 0.3	"	"
Boron	3.0	"	"
CN	< 1.0	"	"

Source of data: _____

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CASA GRANDE WEST QUADRANGLE
ARIZONA—PINAL CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CASA GRANDE 15' QUADRANGLE

3650 II SW (SACATON BUTTE)
3650 III SE (GILA BUTTE SE)
3650 II (SACATON 162 5000)
3649 IV NW (STANFIELD)
3649 IV SW (DOUBLE PEAK)
3649 I NW (CASA GRANDE EAST)
3649 I SW (CASA GRANDE MTS.)

111°52'30" 33°00' 111°45' 32°52'30"
419 000m E. 540 000 FEET
3651 000m N. 3639 000m N.
520 000 FEET 720 000 FEET
690 000 FEET

R. 5 E. R. 6 E.
T. 5 S. T. 6 S.

PHOENIX 47 MI. 16 MI. TO ARIZ. 87
COOLIDGE 18 MI.
CHUICHU 9.4 MI
ELEVEN MILE CORNER 11 MI.
COOLIDGE 6.8 MI.
TUCSON 65 MI.
GILA BEND 49 MI.
STANFIELD 5 MI.
MARICOPA 11 MI.

GILA RIVER INDIAN RESERVATION BOUNDARY

SACATON MOUNTAINS

WEST VAL VISTA ROAD
DESERT VISTA DRIVE
HOPI DRIVE
SCOTT DRIVE
MONTEZUMA DR.
VAL VISTA BLVD
BIANCO ROAD
BURRIS ROAD
ETHINGTON ROAD
MONTGOMERY ROAD
CASA GRANDE CANAL
SOUTHERN PACIFIC
MARICOPA 13 MI.
3 MI.-CASA GRANDE 3 MI.
KORTSEN ROAD
CLAYTON ROAD
COTTONWOOD LANE
CANDLESTICK DRIVE
RODEO ROAD
CASA GRANDE BLVD.

Tailing Pond
Sacaton Plant Site
Open Pit
East Dump
Dirt Dump
Dirt Dump
South Dump (Rock)
Dry Well 1358
Dry Well 1347
Gravel Pit
Water Tank
Water Tanks
Sewage Disposal
Well 1415
Well 1386
Well 1372
Well 1376
Well 1358
Well 1382
Rodeo Grounds
Mormon Battalion Historical Monument
Three Point Airport
Burgess Peak
Trailer Park
Drive-in Theater
Jr High Sch
Substation
CASA GRANDE MUNICIPAL AIRPORT
GOLF COURSE
FRANCISCO GRANDE
Athletic Fields
Landing Strip
Santa Cruz Wash
North Branch Santa Cruz Wash
BM 1338
BM 1345
BM 1340
BM 1337
BM 1341
BM 1350
BM 1344
BM 1375
BM 1388
BM 1399
BM 1415
BM 1460
BM 1449

CASA GRANDE

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1965

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Red tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence lines

A portion of the southwest quarter of this map lies within a subsidence area

Vertical control based on latest available adjustment

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
GN MN 0°27' 8 MILS 13½° 240 MILS

SCALE 1:24000
1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ARIZONA
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
State Route

JUL 1986
RECEIVED
WATER PERMITS UNIT
1820-G
1820-F

ASARCO SACATON UNIT
CASA GRANDE WEST, ARIZ.
NE/4 CASA GRANDE 15' QUADRANGLE
N3252.5—W11145/7.5
1965
AMS 3649 IV NE—SERIES V898

JUL 1986
RECEIVED
WATER PERMITS UNIT

86-142

June 16, 1986

GROUNDWATER QUALITY PROTECTION
PERMIT APPLICATION PROPOSAL
ASARCO SACATON PIT
PINAL COUNTY, ARIZONA



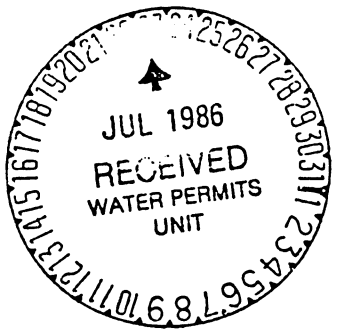
ERROL L. MONTGOMERY & ASSOCIATES, INC.

CONSULTANTS IN HYDROGEOLOGY

1075 EAST FORT LOWELL ROAD, SUITE B

TUCSON, ARIZONA 85719 (602) 881-4912

TELEX: 165597 MONTE TUC



GROUNDWATER QUALITY PROTECTION PERMIT APPLICATION PROPOSAL ASARCO SACATON PIT PINAL COUNTY, ARIZONA

INTRODUCTION

The Sacaton pit is an open pit mine owned by ASARCO Inc. The mine was closed in March 1984. Based on favorable hydrogeologic and climatic conditions, ASARCO Inc. is proposing to establish and maintain a sanitary landfill at the Sacaton mine pit. In accordance with Arizona Department of Health Services requirements, ASARCO Inc. is in the process of applying for a groundwater quality protection permit for the proposed landfill. The proposal given herein sets forth the methods of hydrogeologic investigation to support the permit application.

GENERAL INFORMATION

LOCATION OF PROPOSED LANDFILL

The Asarco Sacaton mine pit comprises about 150 acres of land in the south half of Section 26 and the north half of Section 35, Township 5 South, Range 5 East. The mine pit is located in western Pinal County, about four miles north from Santa Cruz Wash and about five miles northwest from Casa Grande, Arizona. The area lies within the Eloy Sub-Basin of the Pinal Active Management Area. Location for the ASARCO Sacaton Mine area is shown on Figure 1.

OWNER OF LAND

ASARCO Inc.
P. O. Box 5747
Tucson, Arizona 85703

Contact: Mr. T. E. Scartaccini
Phone: (602) 792-3010

JUL 1986
RECEIVED
WATER PERMITS
UNIT

HYDROGEOLOGIC CONSULTANT

Dr. Errol L. Montgomery
Errol L. Montgomery & Associates, Inc.
1075 East Fort Lowell Road
Suite B
Tucson, Arizona 85719

Phone: (602) 881-4912

CORRESPONDENCE

Please direct correspondence to the hydrogeologic consultant, with copies to the owner.

SITE CONDITIONS AT PROPOSED LANDFILL

The ASARCO Sacaton mine pit is approximately 3,000 feet in diameter at land surface and about 1,040 feet in depth below land surface. Slope of the pit wall is about 45 degrees and the pit has the shape of an inverted cone with a truncated base. Mine roads have been constructed in the pit walls and would provide access for placement and compaction of landfill materials in the pit.

Site conditions that would minimize impact on groundwater at the proposed landfill include: dry climate; easily controlled ephemeral surface water runoff; dewatered conditions in unconsolidated rocks and low permeability conditions in the underlying consolidated rocks penetrated by the

pit; small groundwater inflow from the pit walls; an upward hydraulic gradient in the groundwater system below the mine pit; and naturally occurring poor chemical quality of groundwater.

The mine pit occurs in an arid climate area of high evaporation, moderate to high mean annual temperatures, and low precipitation. Mean annual temperature ranges from 52.2 to 87.3 degrees Fahrenheit. Mean annual precipitation is 8.20 inches.

The mine pit does not lie in the path of major surface water drainages. Surface water flow is ephemeral and occurs as sheet flow or flow in small washes after heavy rainfall. A berm has been built around the pit to divert these ephemeral flows from entering the pit.

The principal rock units in the pit area, in descending order, include: alluvial deposits; lithified conglomerates; intrusive igneous rocks, which contain the ore body; and a basement rock complex. The mine pit penetrates the alluvial deposits, the conglomerates, and the top of the intrusive igneous rocks. A deep mine shaft located a few hundred feet southeast from the pit encountered nearly dry conditions from land surface to a depth of 1,235 feet, which is about 200 feet below the bottom of the mine pit. Reports indicate that small amounts of groundwater seep from the pit walls. Tests indicate low permeability for the alluvial deposits and conglomerates. Permeability of the intrusive igneous rocks is low.

The mine pit occurs over the Casa Grande Ridge, a bedrock high which extends south from the Sacaton Mountains. In the mine pit area, the contact between the basement rock complex and the overlying rock units is a low-angle, shaley fault zone, which is believed to function, together with overlying rocks, as a confining unit to groundwater flow. Two boreholes drilled downward from the base of the shaft, when the shaft was at a depth of 1,224 feet, encountered groundwater. Shut-in pressures on the boreholes were approximately 350 to 400 pounds per square inch (809 to 924 feet of head).

The unconsolidated alluvial deposits located east and west of the Casa Grande Ridge comprise the principal aquifer in the area. The alluvial deposits in the mine pit area lie above the water table. Naturally high total dissolved solids content occurs in groundwater in the vicinity of the Casa Grande Ridge; concentrations as high as 4,514 milligrams per liter have been reported.

METHOD OF INVESTIGATION

The hydrogeologic investigation for the proposed landfill site is designed to include all pertinent items contained in the Arizona Department of Health Services draft guidelines for the groundwater quality protection permit application process. Abundant data for the mine pit area are given in hydrologic, geologic, and engineering reports, and in field notes from the files of ASARCO Inc. Other than additional investigations for drillers' logs, current water level data, and current well inventory data for the mine pit area, these existing data will comprise the principal source of information for the hydrogeologic investigation for the proposed landfill.

HYDROGEOLOGIC REPORT

A hydrogeologic report will be submitted as part of the permit application. This hydrogeologic report will include, at a minimum, the following information:

- **Descriptions of the mine pit area**, including regional location map, site plan, pit dimensions and features, land use in the mine pit area, topography, and mean annual precipitation, evaporation, and temperatures;
- **Descriptions of geologic conditions**, including a geologic map, lithology and stratigraphy of rock units, geologic sections, and structural features;
- **Well inventory**, including well location map, construction details, use, ownership, and water level data;
- **Descriptions of surface water hydrology**, including drainage features, and flow measurements of surface water discharge, where available;
- **Descriptions of groundwater hydrology**, including water level contour map, hydraulic gradients, aquifer transmissivity and storage coefficient, estimated quantity of groundwater

in storage, water level hydrographs, estimated groundwater recharge and discharge for the pit area; and historic changes in water level;

- Descriptions of groundwater quality, including tabulations of chemical water quality data, water chemical types, and, if possible and informative, chemical hydrographs and contour maps;

- Recommendations for leachate collection and disposal;

- Description of groundwater monitoring plan, including design and location of monitor wells, parameters to be monitored, frequency groundwater sample collection, frequency of report submittal, and protocols for groundwater sample collection and analysis;

- Projections of potential impact of the proposed landfill on groundwater in the mine pit area, including potential area of impact, and estimates of travel time assuming worst case conditions for migration of leachate to wells;

EXISTING DATA AND REPORTS

Sources for existing hydrogeologic data for the ASARCO Sacaton mine pit area include published reports by U. S. Geological Survey, Arizona State Land Department, Arizona Oil and Gas Conservation Commission, and Arizona Water Commission, and reports and data in the files of ASARCO Inc. Drillers' logs and information for the well inventory for the mine pit area will be obtained from files of the Water Resources Division of U. S. Geological Survey and the Arizona Department of Water Resources. Pertinent published and unpublished hydrogeologic data and reports that relate to the project include:

- "History of ground-water development in Casa Grande area and effect of proposed Sacaton project upon hydrology of surrounding region"; Water Development Corporation consulting report, by L. C. Halpenny and D. K. Greene, December 1972.

- "Review of present and future ground-water supply for ASARCO Sacaton unit and ASARCO Santa Cruz project"; Water Development Corporation consulting report, by D. K. Greene and L. C. Halpenny, November 1977.

- "Review of ground-water inflow to Sacaton shaft, ASARCO Sacaton unit, Arizona"; Water Development Corporation consulting report, by D. K. Greene and L. C. Halpenny, June 1978.

- "Memorandum report on Sacaton unit shaft site test well"; Water Development Corporation consulting report, by L. C.Halpenny and D. K. Greene, March 1975.

- "Memorandum report, review of ground water supply, ASARCO Sacaton unit"; Water Development Corporation consulting report, by D. K. Greene and L. C. Halpenny, November 1978.

- "Interim report on investigation of potential ground water sources, Sacaton deep ore body site near Casa Grande, Arizona"; Water Development Corporation consulting report, by L. C. Halpenny and D. K. Greene, December 1968.

- "Memorandum report related to potential ground water supply for ASARCO Sacaton project"; Water Development Corporation consulting report, by D. K. Greene and L. C. Halpenny, March 1970.

- "Basic data report, ASARCO Sacaton tailing pond well"; Water Development Corporation consulting report, by L. C. Halpenny, October 1973.

- "Summary report, evaluation of the influence of seepage water on regional groundwaters, ASARCO Sacaton mill tailings pond"; by Division of Engineering and Consulting Services, Utility Engineering Corporation and others, November 1973.

- "Hydrological investigations in the Sacaton shaft area, June to October 1979"; by ASARCO Inc., October 1979.

- "Evaluation of geologic & ground water conditions, proposed ASARCO Sacaton unit shaft, Casa Grande, Arizona, with a section on potential groundwater inflow prepared by J. W. Harshbarger"; prepared for The Cementation Company of America, by Arthur R. Still, Still, Lowell & Still, September 1974.

- "Geology of the Sacaton porphyry copper deposit, Pinal County, Arizona"; by R. B. Cummings, in Advances in Geology of the Porphyry Copper Deposits, Southwestern North America, University of Arizona Press, 1982.

- Groundwater data and exploration drillhole data in the files of ASARCO Inc.

. "Sacaton unit, geological and hydrological data presented in support of ASARCO's application for a groundwater quality permit and a sanitary landfill plan and permit"; ASARCO Inc., by S. A. Anzalone, February 1986.

. "Ground water in the Gila River Basin and adjacent areas, Arizona; U. S. Geological Survey, Open-File Report, by L. C. Halpenny and others, October 1952.

. "Geohydrology and water resources of the Tucson basin, Arizona;" U. S. Geological Survey, Water-Supply Paper 1939-E, by E. S. Davidson, 1973.

. "Electrical-analog analysis of ground-water depletion in central Arizona"; U. S. Geological Survey, Water-Supply Paper 1860, by T. W. Anderson, 1968.

. "Description and analysis of the geo-hydrologic system in western Pinal County, Arizona"; U. S. Geological Survey, Open-File Report, by W. F. Hardt and R. E. Cattany, 1965.

. "Salinity of the ground water in western Pinal County, Arizona"; U. S. Geological Survey, Water-Supply Paper 1819-E, by L. R. Kister and W. F. Hardt, 1966.

. "Ground-water resources of the Santa Cruz Basin, Arizona"; U. S. Geological Survey, mimeographed report, by S. F. Turner and others, 1943.

. "Ground-water units and withdrawal, Basin and Range Province, Arizona"; U. S. Geological Survey, Water Resources Investigation Report 83-4114-A, by M. S. Bedinger, T. W. Anderson, and W. H. Langer, 1984.

. "Maps showing ground-water levels, springs, and depth to water, Basin and Range Province, Arizona"; U. S. Geological Survey, Water Resources Investigation Report 83-4114-B, by W. H. Langer, D. A. Mulvihill, and T. W. Anderson, 1984.

. "Maps showing distribution of dissolved solids and dominant chemical type in ground water, Basin and Range Province, Arizona"; U. S. Geological Survey, Water Resources Investigation Report 83-4114-C, by T. H. Thompson, J. A. Nuter, and T. W. Anderson, 1984.

. "Ground-water conditions in and near the Gila River Indian Reservation, south-central Arizona"; U. S. Geological Survey, Water Resources Investigation Report 85-4073, by B. W. Thomsen and S. Baldys III.

- "Ground-water resources of the Santa Cruz Basin, Arizona"; U. S. Geological Survey, Open-File Report, by S. F. Turner and others, May 1943.

- "Further investigations of the ground-water resources of the Santa Cruz Basin, Arizona"; U. S. Geological Survey, Open-File Report, by S. F. Turner and others, March 1947.

- "Maps showing ground-water conditions in the lower Santa Cruz area, Pinal, Pima, and Maricopa Counties, Arizona-1977"; U. S. Geological Survey, Open-File Report, Water-Resources Investigations 79-56, by A. D. Konieczki and C. S. English, March 1979.

- "Bouguer gravity map of parts of Maricopa, Pima, Pinal, and Yuma Counties, Arizona"; U. S. Geological Survey, Geophysical Investigations Map GP-615, by D. L. Peterson, 1968.

- "Groundwater conditions in the Gila River Indian Reservation, Pinal and Maricopa Counties, Arizona"; U. S. Geological Survey, Open-File Report, by H. M. Babcock, August 1970.

- Annual reports on ground water in Arizona; by Arizona State Land Department or Arizona Water Commission.

- "Basic ground-water data for western Pinal County, Arizona"; Arizona State Land Department, Water-Resources Report No. 18, by W. F. Hardt, R. E. Cattany, and L. R. Kister, 1964.

- "Arizona climate"; by C. R. Green and W. D. Sellers, 1974.

- "Climatologic data, Arizona"; monthly reports by National Oceanic and Atmospheric Administration.

- "Depth to bedrock map, Basin and Range Province, Arizona"; Laboratory of Geophysics, The University of Arizona, by J. M. Oppenheimer and J. S. Sumner, 1980.

- "Water level change, 1940-1970, and earth fissure zones, Santa Cruz-San Pedro River basins, Arizona"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-E-23185-4, 1974.

- "Depth to water, 1970, Santa Cruz-San Pedro River basins, Arizona"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-E-23185-6, 1974.

- "Well water irrigation classification, Santa Cruz-San Pedro River basins, Arizona, 1974"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-E-23185-11, 1974.

- "Vegetation, croplands, urban & mining areas, Santa Cruz-San Pedro River basins, Arizona, 1972"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-EN-23185-10, 1974.

- "Erosion classification, Santa Cruz-San Pedro River basins, Arizona, July 1974"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-E-23185-2,]974.

- "General soil map, Santa Cruz-San Pedro River basins, Arizona, July 1974"; Arizona Water Commission and U. S. Department of Agriculture, Map M7-E-23185-1, 1974.

ADDITIONAL DATA TO BE COLLECTED

Existing data and reports for the mine pit area are believed to be sufficient for conduct of the hydrogeologic investigation to support the permit application. In addition to these data, drillers' logs, current water level data, and current well inventory data will be obtained from the Water Resources Division of U. S. Geological Survey and the Arizona Department of Water Resources.

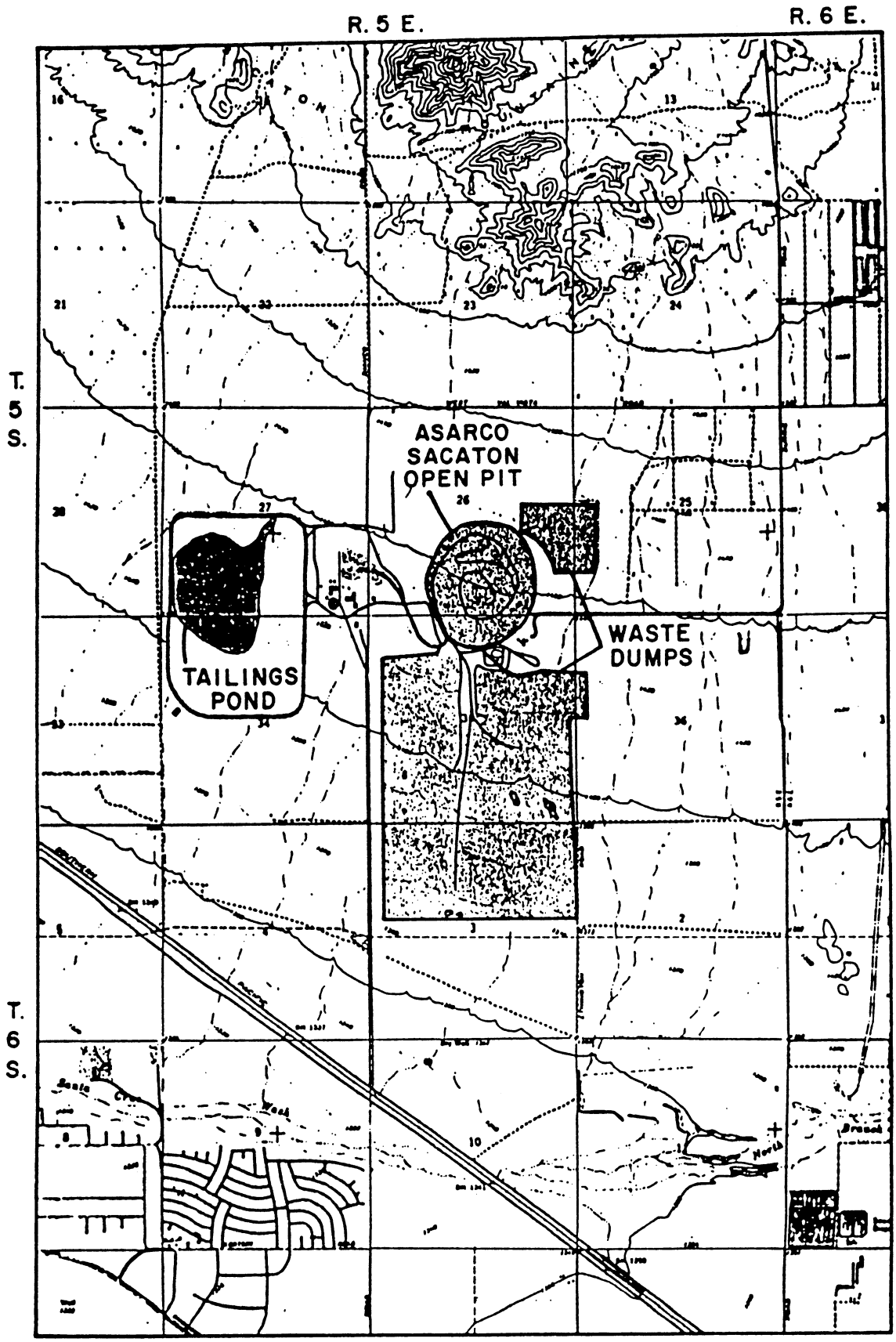


FIGURE I. LOCATION MAP FOR ASARCO SACATON MINE PROPERTY

ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

January 10, 1985

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Lyndon Hammon
Water Permits Unit
Office of Waste and Water Quality Management
ARIZONA DEPARTMENT OF HEALTH SERVICES
1740 West Adams Street
Phoenix, Arizona 85007

NOTICE OF DISPOSAL - Sacaton Unit

Dear Sir:

You will find attached a Notice of Disposal Form for ASARCO Incorporated, Sacaton Unit, pursuant to R9-20-205.

The notice describes "disposal activities" including mine waste rock dumps, mining overburden dumps and mill tailings impoundments. ASARCO Incorporated does not, by the filing of this Notice of Disposal, intend to waive any right it may have to object to the validity of the Chapter 20 Water Pollution Control Permit System Regulations (the "Regulations)), the jurisdiction of the Director to issue the Regulations, or the applicability of the Regulations to the "disposal activities" described in the Notice of Disposal. It is our position that the described "disposal activities" are not point source discharges subject to the Director's authority or the Regulations. Further, the overburden dumps are exempt from the Regulations under R9-20-202.B.6.

The Sacaton Unit was permanently shutdown on March 29, 1984. Soils have been placed on the outside berm of the tailing impoundment and re-vegetation of the area has begun. During the operational lifetime of the Unit, monitoring indicated enhancement of the very poor quality underlying aquifer by the influence of the impoundment. This is demonstrated in the notice.

Very truly yours,

T. E. Scartaccini

T. E. Scartaccini

TES/kh
Attachments
cc: TREdwards - w/attach.

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue (602) 792-3010

TICE OF DISPOSAL FORM

1.) a. Facility name SACATON UNIT

b. Facility Owner ASARCO Incorporated

c. Name, title, address, and telephone number of contact person for facility.

Name: T. R. Edwards,

Title: Manager

Mailing address: ASARCO Incorporated, Sacaton Unit

P O Box V

Casa Grande, AZ Zip Code 85222

Telephone number: (602) 836-2171
(Area Code)

d. Address and telephone number of facility:

Mailing address: P. O. Box V

Casa Grande, AZ

85222 Zip Code

Telephone number: 602-836-2171
(Area Code)

e. Facility location information:

6 miles northwest at Casa Grande, AZ

Zip Code

Pinal County, Arizona

Township 5 South

Range 5 East

Section 34

NE ¼ NE ¼ NE

f. Describe access to facility Via Casa Grande-Maricopa Highway 4 miles NW of Casa Grande, thence 2 miles north on Bianco Road

g. Landowner of facility site ASARCO Incorporated

h. Type of Permit you are applying for:

area permit X individual facility permit _____

i. Type of facility requesting permit:

new _____ existing X

2.) a. Attach a topographic map (preferably a 7.5 minute quadrangle base), showing the geographic location of the facility(s) and all disposal locations. In addition, show the location of any existing groundwater withdrawal wells within the approximate vicinity (½ mile radius) of the disposal area and identify the use of each well (i.e. industrial wells, drinking water supply wells, etc.). (If applying for an area permit as described in R9-20-211, indicate on the map the location of each facility and disposal location in the proposed permitted area).

b. List Latitude/Longitude of all disposal locations indicated on the attached map N 32°57'09" Lat., W 111°50'12" Long.

3.) a. Type of Facility(s) Copper mining and beneficiation

b. Nature of Activity conducted at facility(s) Copper ore is mined, crushed and ground to fine mesh, then beneficiated by flotation. Copper concentrate is shipped to smelter, tailings are disposed of at the site.

c. List applicable U.S. Department of Commerce Standard Industrial Classification (SIC) Codes for above activities

SIC 1021

4.) Date Facility b /will begin operating March, 1974

5.) Expected Facility(s) Operational Lifetime Was 10 years - permanently ~~shutdown 3/29/84~~

6.) List any other environmental permits issued to the facility(s) (i.e. air quality permit, NPDES permit, hazardous waste permit).

Pinal-Gila Counties Air Quality Control District Permits Nos. 4368 through 4372.

7.) a. Describe disposal acitivites at the facility(s) Tailings are collected in a 275' dia. thickener. Surplus water is reclaimed, and slurry at 50% solids is pumped to the disposal area. The solids settle out in the disposal area, water is decanted through a decantation tower and underflow pipeline, then pumped to the plant for reuse. Since the plant was shut down 3/29/84, this activity has been discontinued.

b. Describe any control measures and treatment processes designed and operated to protect groundwater quality from effects of the disposal A decant system was installed to reclaim all water possible to protect the groundwater. Before operations began, a monitor well was drilled downstream of the disposal area so the effect of tailing water percolation could be evaluated. Results of these observations indicate that quality of the groundwater was enhanced. Groundwater is of very poor quality with TDS at 3080 ppm.

c. Describe existing groundwater use(s) of the receiving aquifer(s) None

d. Note of de[illegible] to groundwater 201.5'

Source of data Report of Water Development Corporation

Date of measurement 8/20/73

e. Enter in Appendix A - Part I the ambient groundwater concentrations of the receiving aquifer(s) for those constituents listed that are contained in the disposal. Indicate source of data and date of sampling for all values listed.

8.) a. Identify the type(s) of waste(s) generated by each process within the facility. Be as descriptive as possible without listing specific constituents.

All ore is crushed then ground with water to a fine mesh. From the resultant slurry, the copper minerals are removed by selective flotation. The residual material, tailings, is the ground barren rock and minerals that are not removed by flotation.

b. Check of list in Appendix A - Part II of the specific pollutants disposed by the facility. Include those disposed materials that are listed in Tables I and II of this document, in Title 40 Code of Federal Regulations Part 261, or any other constituent contained in the disposed waste stream.

c. Enter in Appendix A - Part II the maximum disposal concentration of those constituents you checked or listed, as required by 8b. Indicate the date of sampling in parenthesis next to the sample value and the source of the data at the bottom of page three in Appendix A.

d. Estimate the disposal schedule including the annual average in hours per day, days per year, and the disposal periods if the disposal is seasonal.

Hours/day 24 discontinued 3/29/84

Days/year 356 discontinued 3/29/84

Seasonal Distribution of Disposal ----

e. Estimate the flowrate(s) of the disposal (i.e. minimum, average, and maximum daily flow; mean annual flow; or mean, minimum, and maximum flow by season if disposal is periodic; or by whatever other units appropriate to the type of disposal.

For 1983 Average flow 476.6 tons per hour

Plant shut down permanently March 29, 1984

9.) Describe any existing groundwater quality monitoring program(s) (attach supporting technical reports if available) A monitor well was drilled about 400' SW of the SW corner of the tailing dam. Drilled by cable tools, cased to total depth of 400' with 8-5/8" casing, with perforations 155' to 400'. Alluvial gravel and clayey silt 0-135; conglomerate 135-400'. Depth to groundwater 201'. Well sampled annually for major constituents from 155'-400'. Parameters tested for listed in Appendix A.

10.) Include any other data or information which, in the judgement of the owner/operator, demonstrates that the facility qualifies for a groundwater quality protection permit based on compliance with the criteria listed in R9-20-208.A. Use attachments if applicable (i.e. depth to groundwater, geology at the site).

There are no producing wells in the vicinity of the disposal area; process water was pumped from a site 6 miles away. Periodic sampling of the monitor well indicates enhancement of groundwater quality by disposal of tailings. Use of the area has been discontinued because of permanent plant shutdown. The pond has been drained and efforts are underway to assure proper drainage and vegetation.

11.) Certification:

"I certify that under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

T. E. SCARTACCINI
Printed Name of Applicant

General Manager
Title

January 10, 1985
Date Application Signed

T. E. Scartaccini
Signature of Applicant

GROUNDWATER PRIORITY POINT SYSTEM WORKSHEET

Facility Number: _____

Facility Name: ASHCO-[illegible]

			Points
A. 1.	Depth to Groundwater:	201'	10
2.	Productivity of Aquifer:	50-2500	15
B.	Existing Groundwater Quality:	TDS-900	12
C.	Pollution Documentation:		5
	Source of Data:	[illegible]	
D.	Drinking Water Population Potentially Affected:	5,000-50,000	10
E.	Waste Hazard Potential:		20
	Based on (Circle One): Source - give SIC number		102
	Waste type - list type(s)		

A.1	A.2	B	C	D	E	Priority Points
10 +	15 +	12 +	5 +	10 +	20 =	72

Performed by: Team Date 3-13-85

	PART I * Ambient Groundwater	Units	PART II Disposal Waste Stream	Tailing ** Reclaim Water
Priority Pollutants				
None added	None added		None added	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
"	"		"	
Others: (list all other constituents contained in the disposal waste stream)				
Potassium	14.5	Mg/l	110	
Carbonate	0	Mg/l	0	
Bicarbonate	553.3	Mg/l	36.4	
Phosphorus	<0.3	Mg/l	--	
Boron	3.0	Mg/l	---	
CN	<1.0	Mg/l	None added	

Source of data: *Monitor well downgradient from tailing pond-ambient water 8/22/73 before ~~start-up in 4/74.~~

** Reclaim water stream from operating mill-8/16/83

Appendix A - NOTICE OF DISPOSAL FORM

Ambient Groundwater and Maximum Disposal Waste Stream Constituent Concentrations

	PART I * 8-22-73 Ambient Groundwater	Units	PART II Disposal ~~Waste Stream~~	Tailing ** Reclaim Water 8/16/83
Microbiological				
Fecal Coliform Bacteria	Does not apply	#/100 ml	Does not apply	
Inorganic Chemicals				
Arsenic	0.02	mg/l	< 0.01	
Barium	Not assayed	mg/l	< 0.5	
Cadmium	"	mg/l	< 0.005	
Chromium (Total)	0.08	mg/l	< 0.01 (tot.)	
Lead	< 0.05	mg/l	< 0.01	
Mercury	Not assayed	mg/l	< 0.0002	
Nitrate (as N)	1.86	mg/l	10.6	
Selenium	< 0.01	mg/l	0.019	
Silver	Not assayed	mg/l	< 0.01	
Fluoride	10.00	mg/l	17.0	
Organic Chemicals				
Chlorinated Hydrocarbons				
Endrin	None added	mg/l	None added	
Lindane	"	mg/l	"	
Methoxychlor	"	mg/l	"	
Toxaphene	"	mg/l	"	
Chlorophenoxys				
2, 4-D	"	mg/l	"	
2, 4, 5TP Silvex	"	mg/l	"	
Total Trihalomethanes	"	mg/l	"	

	PART I * Ambient Groundwater	Units	PART II ~~Discharge Screen~~ Tailing** Reclaim Water 8/16/83
Radicchemicals			
Combined radium-226 and radium-228	---	pCi/l	None added
Gross alpha particle activity (including radium-226 but excluding radon and Uranium)	----	pCi/l	None added
Beta particle and photon emitters from man-made radionuclides	-----	pCi/l	None added
Secondary Contaminants			
Alkalinity	-----	mg/l	-----
Calcium	28.0	mg/l	108
Chloride	633.7	mg/l	258
Copper	<0.01	mg/l	0.16
Hardness	----	mg/l	-----
Iron	0.07	mg/l	0.76
Magnesium	11.3	mg/l	0.80
Manganese	0.08	mg/l	0.04
pH	7.7	mg/l	7.1
Sodium	1140	mg/l	345
Sulfate	1213	mg/l	710
Total Dissolved Solids (TDS)	3080	mg/l	1593
Zinc	0.11	mg/l	0.02

[redacted]

RETURN TO Skip

4515.50

SUBJECT Asarco's Permit Application DATE 1/18/85

MESSAGE

Please review the attached data submitted by Asarco. Please develop a list and justification for all components that still need to be submitted/addressed. This list will be submitted to the AG's office for review.

RETURN TO → SIGNED [signature]

REPLY A memo was sent to you on Jan. 22. As I have not heard anything further, I am returning the ASARCO permit application.

SIGNED [signature] DATE 4/9/86

REDIFORM 4S 472 SEND PARTS 1 AND 3 INTACT - PART 3 WILL BE RETURNED WITH REPLY. CARBONLESS POLY PAK (50 SETS) 4P472

5/20/86 Conference w/ Dept re Cyprus Pima + ASARCO. Division of Responsibility

10/85 ASARCO Bought Cyprus Pima (CP) — one body bought Mill site end of 88.

9/85 Request for permit App. from CP.

ASARCO Gordon sent memo on 1/22/86. ~~(not found).~~

ASARCO submitted APP 12/85.

based on PAG 208 Report.

ADEQ response to proposal (ASARCO)

requested 2 MW at NE corner of 16S 23E Sec 22 + 23.

Cyprus Pima shut down 1982 (Letter 1/23/86).

Data is in PEDCO Report. + PAC.

8/27/86 DHS - Al Brown. reviewed DEIS for BIA. for San Xavier Planned indicated we were reviewing the NOD for Community. ASARCO. and since permitting not completed unable to state contents or terms of protection to be taken by ASARCO.

4/4/86 Letter w/ results of Survey of ASARCO Mission Mine. Says Mine has taken steps to minimize environmental impacts. Recommended more water qual monitoring. Mine indicated working for DEQ (DHS) to establ parameters

1/22/86 - Gordons Memo Indicated ASARCO had not provided more recent (post PAG) sampling data.

1986 PIMA AGOVERMENTS report

3/8/88 - Request by Tohono O'odham Nation for all info on permits.

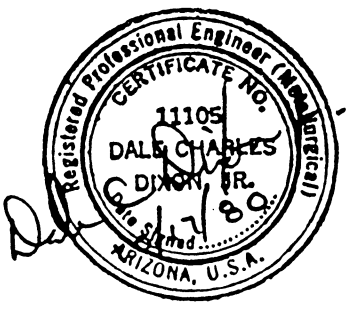
Permit Ap was submitted prior to 1/22/86 + not complete.

100509

ASARCO Incorporated
Sacaton Unit

HAZARDOUS WASTE FACILITY PERMIT APPLICATION TO ARIZONA DEPARTMENT OF HEALTH SERVICES BUREAU OF WASTE CONTROL

AS-40



ARIZONA DEPARTMENT OF HEALTH SERVICES
BUREAU OF WASTE CONTROL

APPLICATION FOR PERMIT
HAZARDOUS WASTE FACILITY

(1) APPLICATION FOR:
- [ ] Permit for new facility
- [ ] Modification of permit
  - [ ] Change in design
  - [ ] Change in operation
  - [ ] Change in ownership/ operator
- [X] Permit for existing facility

(2) FACILITY PERMIT NUMBER

DATE APPLICATION RECEIVED

DATE OF PUBLIC NOTICE

(3) GEOGRAPHIC LOCATION OF FACILITY

LATITUDE 32 57 20 (DEG MIN SEC)

LONGITUDE 111 50 00 (DEG MIN SEC)

QUADRANT (circle one) NE NW (SE) SW

5 S 5 E 27 S½; 34N½ (TWP RANGE SECT ¼ ¼ ¼)

(4) TYPE OF FACILITY (Check all appropriate boxes)
- [ ] Landfill
- [ ] Incinerator
- [ ] Landfarming
- [ ] Storage
- [ ] Processing
- [ ] Transfer station
- [X] Other Materials resulting from beneficiation of ores

(5) DOES THE PUBLIC USE THE FACILITY? [ ] Yes [ ] No

(6) OPERATOR

NAME AND ADDRESS OF BUSINESS OPERATING FACILITY

ASARCO Incorporated
120 Broadway
New York, NY 10271

TELEPHONE (212)-669-1000

(7) NAME AND STREET ADDRESS OF THE FACILITY

ASARCO Incorporated
Sacaton Unit
Minesite
Casa Grande, AZ 85222

(8) TYPE OF BUSINESS OPERATING FACILITY
- [ ] Sole Proprietorship
- [X] Corporation
- [ ] Partnership
- [ ] Government Agency

NAME AND ADDRESS OF OWNER (S) OF BUSINESS OPERATING FACILITY (Must be address where legal notice may be served)

ASARCO Incorporated
120 Broadway
New York, NY 10271

Telephone (212)-669-1000

(9) NAME AND MAILING ADDRESS OF LEGAL OWNER OF FACILITY

ASARCO Incorporated
120 Broadway
New York, NY 10271

TELEPHONE (212)-669-1000

(10) NAME AND ADDRESS OF LEGAL OWNER OF PROPERTY

ASARCO Incorporated
120 Broadway
New York, NY 10271

TELEPHONE (212)-669-1000

(11) ATTACH A LIST OF REGULATORY AGENCIES HAVING JURISDICTION OVER THE FACILITY. INCLUDE PERMIT NUMBERS WHERE APPROPRIATE.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that the submitted information is true, accurate and complete.

(12) SIGNATURE OF OWNER Norman Visnes

PRINTED OR TYPED NAME: N. Visnes

TITLE: Vice President, Mining

DATE:

(13) SIGNATURE OF OPERATOR Norman Visnes

PRINTED OR TYPED NAME: N. Visnes

TITLE: Vice President, Mining

DATE:

SIGNATURE OF REVIEWER

REVIEWING AGENCY

PRINTED OR TYPED NAME

TITLE DATE

SIGNATURE OF REVIEWER

REVIEWING AGENCY

PRINTED OR TYPED NAME

TITLE DATE

POSITION STATEMENT

ASARCO Incorporated
Southwestern Mining Department

Response to Arizona Department of Health Hazardous Waste Program

ASARCO Incorporated, Southwestern Mining Department is composed of three operating facilities in the State of Arizona. They are the Mission Unit, Sahuarita, Arizona, Silver Bell Unit, Silver Bell, Arizona and the Sacaton Unit at Casa Grande, Arizona. These Units mine and mill about 45,000 tons per day of ore producing copper concentrates that are shipped by rail to Asarco's Hayden Smelter at Winkleman, Arizona and to other states. The finely ground ore is subjected to the flotation process for beneficiation resulting in concentrate and tailings (waste). The tailings are stored in impoundment areas using proven methods of disposal above ground. These methods virtually preclude uncontrolled disposal and spills to the surrounding area. No cyanides or pesticides are used in our operations.

Asarco has conducted extraction procedure tests on the tailings. The testing was conducted by Asarco's Department of Environmental Sciences in Salt Lake City, Utah using methods prescribed by the State of Arizona (Hazardous Waste Regulations) and the Federal Environmental Protection Agency. Results of the chemical analyses and EP Tests using the Arizona procedure on mill tailings show in Table I following.

TABLE I

Mission Unit

Substance	State Std. Col. A. (mg/kg)	Asarco Analysis (mg/kg)	State Std. Col. B. (mg/liter)	Asarco Analysis (mg/liter)
arsenic	50.0	5.6	5.0	.01
barium	1000.0	220.0	100.0	< 1.0
cadmium	10.0	< 1.0	1.0	< .02
chromium	50.0	30.0	5.0	.02
lead	50.0	40.0	5.0	.07
mercury	2.0	< 0.10	0.2	< .001
selenium	10.0	1.8	1.0	.004
silver	50.0	1.0	5.0	.02

pH of soil - 9.2

Sacaton Unit

Substance	State Std. Col. A. (mg/kg)	Asarco Analysis (mg/kg)	State Std. Col. B. (mg/liter)	Asarco Analysis (mg/liter)
arsenic	50.0	< 2.0	5.0	< .005
barium	1000.0	250.0	100.0	< 1.0
cadmium	10.0	< 1.0	1.0	< .002
chromium	50.0	30.0	5.0	< .02
lead	50.0	40.0	5.0	.05
mercury	2.0	<0.10	0.2	< .001
selenium	10.0	1.8	1.0	< .004
silver	50.0	2.0	5.0	< .002

pH of soil - 8.0

Silver Bell Unit

Substance	State Std. Col. A. (mg/kg)	Asarco Analysis (mg/kg)	State Std. Col. B. (mg/liter)	Asarco Analysis (mg/liter)
arsenic	50.0	3.6	5.0	.02
barium	1000.0	1090.0	100.0	< 1.0
cadmium	10.0	< 1.0	1.0	.14
chromium	50.0	30.0	5.0	.03
lead	50.0	120.0	5.0	.20
mercury	2.0	< 0.10	0.2	< .001
selenium	10.0	1.8	1.0	.004
silver	50.0	1.0	5.0	.03

pH of soil - 9.1

Some of the chemical analyses in Column A of the regulations exceed the state standards; however, in not one instance do the leachates in Column B (Water Leach), under a state procedure which is more stringent than EPA, exceed the limits set. Leaching of disposed tailings and its effects are of importance, not contained constituents.

On March 27, 1980, PEDCO Environmental sampled the Mission Unit as part of a contract for the Federal EPA using set sampling procedures. Asarco's Department of Environmental Sciences obtained splits of the PEDCO samples at that time and submitted the samples to Extraction Procedure tests using the EPA procedures. Similarly at a later date, the Silver Bell and Sacaton Units were sampled using the EPA approved procedures and assayed by the Department of Environmental Sciences in Salt Lake City. The results of these sampling procedures and EPA Extraction Procedure Testing are listed in Table II below:

TABLE II

mg/liter of Leach Solution

Method A

	Pb	Cd	Cr	Ag	Ba	As	Hg	Se
Mission Unit (PEDCO)	<.060	<.010	<.020	<.010	.04	.0039	<.0011	.0144
Sacaton Unit	**.88**	**.076**	**.036**	**<.002**	**<.1**	**.011**	**<.0005**	**.012**
Silver Bell Unit	.38	.15	.02	.02	<1.0	.02	<.001	<.004
Max. Contaminant Level	5.0	1.0	5.0	5.0	100.0	5.0	0.2	1.0

Method B

	Pb	Cd	Cr	Ag	Ba	As	Hg	Se
Mission Unit (PEDCO)	<.084	<.008	<.001	<.002	.23	.06	<.0002	.104
Sacaton Unit	**.88**	**.076**	**.036**	**<.002**	**<.1**	**.001**	**<.0005**	**.012**
Silver Bell Unit	.38	.15	.02	.02	<1.0	.02	.001	.004
Max. Contaminant Level	5.0	1.0	5.0	5.0	100.0	5.0	0.2	1.0

Reference is made to the letter sent to Mr. Tibaldo Canez on August 19, 1980 from Mr. Newman Porter of the law firm of Evans, Kitchel and Jenckes. Comments of ASARCO Incorporated in regard to the State of Arizona's Application for Interim Authorization to Manage a Hazardous Waste Program were made and are reiterated

once again by attachment to this letter.

Our three mills dispose of tailings that are not hazardous under the State and Federal standards for designation of hazardous waste even as presently proposed. We do declare them to be not hazardous under both sets of standards using prescribed methodology. We request that we be granted a variance from being regulated under the proposed rules.

WILLIAM A. EVANS (1907-1979)
JOS S. JENCKES, JR. (1908-1970)

RALPH J. LESTER
EARL H. CARROLL
EDWARD C. LA BEAU
BURTON M. APKER
NEWMAN R. PORTER
ROBERT R. MILLS
G. STARR ROUNDS
HAROLD J. BLISS, JR.
JERRY L. HAGGARD
F. PENDLETON GAINES, III
ROBERT J. HACKETT
ARNE M. ROVICK
JOSEPH P. MIENTON
JERRY C. BONNETT
H. DAVID HEUMANN
NATHAN R. NIEMUTH
ALVIN H. SHRAGO
BARRY J. DALE
ANDREW S. FRIEDMAN
WILLIAM G. FAIRBOURN
STANTON A. SHAFER
MILTON K. MARSH
WALTER W. KINGSBERY
JOHN F. BOLAND, JR.
JAMES M. BUSH
LESLIE T. JONES, JR.
STEPHEN W. POGSON
WILLIAM H. JURT
FRED E. FERGUSON, JR.
JERRY M. LAWSON
GARY H. FRY
LEON D. BESS
LEX J. SMITH
JAMES G. SPEER
DEAN C. SHORT, II
WILLIAM L. KURTZ
AMY R. COY
DAVID P. KIMBALL, II
KENNETH W. REEVES, II
CRAIG B. TERRY
JOHN W. MAIN, JR.
JOYCE Y. NEELEY
DON J. MINER
LINDA SHANNON HEUMANN
GREGORY L. MAST

LAW OFFICES

Evans, Kitchel & Jenckes, P.C.

363 NORTH FIRST AVENUE
PHOENIX, ARIZONA 85003
(602) 262-8811

DENISON KITCHEL
OF COUNSEL

TWX-910 951-1368

TELECOPIER 602-262-8856

SCOTTSDALE OFFICE
SUITE B-111
6991 EAST CAMELBACK ROAD
SCOTTSDALE, ARIZONA 85251

August 19, 1980

MINING DEPT
AUG 20 1980
TUCSON

HAND-DELIVERED

Mr. Tibaldo L. Canez, Chief
Bureau of Waste Control
Department of Health Services
1740 West Adams Street
Phoenix, Arizona 85007

S.L.B.
AUG 20 1980

Re: Comments of ASARCO Incorporated
Re State of Arizona's Application
for Interim Authorization to
Manage a Hazardous Waste Program

Dear Mr. Canez:

On behalf of our client, ASARCO Incorporated, we hereby urge the Arizona Department of Health Services to reconsider its proposed application to EPA for interim authorization to operate a hazardous waste program for the State of Arizona. Despite the fact that during the rulemaking which preceded the issuance of the regulations in question the Department consistently took the position that it wished to administer a program which would be less burdensome to local industry than EPA's then-proposed hazardous waste regulations, the regulations which the State adopted in fact are much more onerous than and conflict with the final federal regulations in many important respects. Among the most glaring are the following:

1. Definition of Hazardous Waste.

R9-8-1814.A.2(a) incorporates an economic value test into its definition of hazardous waste which is omitted from the federal regulations. Hazardous wastes which are re-

used, recycled or reclaimed are presently not regulated under EPA's program or, in some cases are subject to less stringent requirements, at least until specific guidelines for recycling are published. (See 40 CFR § 261.6 published at 45 F.R. 33120).

R9-8-1814.A.2(b) incorporates into the definition of hazardous waste a ninety-day accumulation period which was not retained in the federal regulations. Under the State's plan any listed waste or waste meeting one of the four "hazardous" criteria is a hazardous waste if it is not reused within ninety days regardless of whether it can be beneficially used beyond that time. As stated in the preceding paragraph, EPA's regulations generally exempt otherwise hazardous wastes which are recycled or reused beneficially regardless of accumulation time. EPA uses the ninety-day accumulation period in a different manner. A facility need not have a hazardous waste facility permit if hazardous wastes accumulated on the property are shipped off-site within a ninety-day period (40 CFR §§ 261.6 and 262.34).

R9-8-1814.A.2(c) makes all used mineral oils hazardous waste, despite the fact this substance is not a listed waste under federal regulations.

R9-8-1814.D contains a corrosivity test more stringent than the federal. EPA is satisfied that materials having a pH of between 2 and 12.5 are non-hazardous. The State of Arizona should be satisfied as well.

R9-8-1814.H, toxic criteria, is far more inclusive than EPA's toxicity test. The State regulations contain a chemical assay test for toxicity set forth in Column A of the mentioned regulation. Wastes which fail this test are deemed toxic whether or not they leach hazardous constitutents into the environment. Despite the fact that R9-8-1814,I. refers to an extraction procedure test to determine whether such hazardous constitutents are leached, passing of the leach test does not exempt the waste from regulation, but merely permits a less onerous method of disposal. The State's extraction procedure test itself is more stringent than the federal. Under the State test, a test sample is agitated in an extractant volume of four times the weight of the test sample for forty-eight hours, whereas the federal extraction procedure requires sixteen times the weight of the test sample to be agitated for twenty-four hours.

2. Hazardous Waste Lists.

Among the listed wastes which should be delted are:

R9-8-1815.C.3, Spent or waste cyanide solutions or sludges, (R,T). To the extent that this listed waste is intended to be similar to or identical with EPA's listed waste No. F013, cyanide bearing selective flotation tailings, the listing should be deleted unless it is shown by some appropriate method that cyanide is present in the tailings in harmful quantities.

R9-8-1815.C.12, Contaminated and waste mineral oils, (I,T). These materials are not on the EPA list and should be deleted from the State's.

R9-8-1815.D.98, Primary copper smelting and refining electric furnace slag, converter dust, acid plant sludge and reverberatory dust. To ASARCO's Hayden smelter converter dust, reverberatory dust and acid plant sludge are not "wastes" at all. Reverberatory dust is recycled through the roasters within five to ten days of generation. Converter dust is shipped to ASARCO's El Paso plant for smelting within approximately ten days of generation. Acid plant sludge is also sent to the El Paso plant for smelting. These economically sound means of beneficially using what the State declares to be a "waste" product should be encouraged, not prohibited.

3. Special Wastes.

R9-8-1816 lists certain mining wastes as special wastes. As the Department is aware, Congress is now considering excluding all mining wastes from regulation as a hazardous waste. Arizona should withhold action on special waste pending final federal action.

4. Comments addressed to the Regulations as a whole.

A delegation of the Arizona Mining Association which met with you recently was told that the Department intends to revise its program during the summer of 1981 to be more consistent with the federal program. Under the circumstances it is senseless to require affected industries to make the financial

commitments necessary to operate under the restrictive regulations for only a few months and then to relax the regulations.

Many of the State's requirements are impossible to meet in the prescribed time in any event--for example, the permit application cannot be properly completed by October 28, 1980. Much of the information called for on the check list accompanying the State's hazardous waste facility permit application form can only be provided as a result of studies which could take a period of months or years.

The ill-conceived nature of the present program seems even clearer when it is remembered that the Department of Health Services arguably acted in the absence of any statutory authority in promulgating its hazardous waste regulations in the first place, a fact which was raised many times in the public hearings preceding the regulations' adoption. Even if the Arizona legislature were to authorize a State hazardous waste program, ASARCO does not believe it would permit the present format. The legislature has specifically provided in both the State air and water pollution control statutes that state regulations may not be more stringent than their federal counterparts.

ASARCO urges the Department, therefore, to take the following action: either to stay its existing hazardous waste regulations until the Arizona state legislature can authorize such a program by appropriate legislation, or at the very least, amend the existing regulations as an emergency measure, to be no more stringent than federal regulations.

On behalf of ASARCO Incorporated, we appreciate the opportunity to submit these comments and ask that this letter be included in the administrative record of these proceedings.

Sincerely,

Newman R. Porter
For EVANS, KITCHEL & JENCKES, P.C.
Attorneys for ASARCO Incorporated

NRP/jw

bcc: J. L. Woods
W. F. Cummins/C. K. Guptill
T. E. Scartaccini
Graham M. Clark, Jr.
Scott L. Burrill

Regulatory Agencies Having Jurisdiction Over Facility

Environmental Protection Agency - Interim Status Application in process

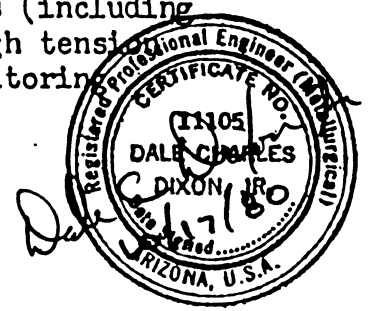
Pinal-Gila Counties Air Quality Control District Permit #1880

MAP AND DESIGN CHECKLIST*

REFERENCE	ITEM	SHEET NUMBER
1820-C-9	One mile topographic map at a scale of 1" = 500'	1
1820-F	Location map showing site relative to state boundaries, population centers, and major site access route(s)	2
1820-F	7½ minute U.S.G.S. topographic map modified to show current land use within 1 mile of the facility and state and local land use restrictions within 1 mile of the facility	3
1820-F	**Preliminary topography map at a scale of 1" = 200' or larger with 5' contour intervals	4
1820-F	Final site topography map at a scale of 1" = 200' or larger with 5" contour intervals	5
1820-F	Engineering designs and/or blueprints for all facilities holding wastes	6
1820-F	Floorplan of all buildings showing room layout and waste handling machinery location	7

Notes: *Maps shall be limited in physical size to no greater than 30" vertical height and 36" horizontal width.

**Plan must show all proposed borrow areas for cover material, all public and private water supplies, bodies of water, dry water courses, all underground mines (including extent of workings, all water, gas, and oil wells, all pipelines and high tensi[illegible] power line right of ways, all proposed surface water and groundwater monitorin[illegible] points, all easements or right of ways, and drinking water systems.



MAP AND DESIGN CHECKLIST* (cont.)

REFERENCE	ITEM	SHEET NUMBER
1820-F	Engineering designs showing sequence of use for all permanent disposal facilities	8
1820-F	**Horizontal grid or coordinate system plan at a scale of 1" = 30' showing all processing, storage or disposal facilities, grid not to exceed 200 foot square sections	9
1820-F	**Vertical grid or coordinate system plan at a scale of 1" = 30', grid to correlate with horizontal grid system, units not to exceed 5' in vertical height	10

NOTES: *Maps shall be limited in physical size to no greater than 30" vertical height and 36" horizontal width.

**Grids shall be controlled and tied to a permanent physical marker of known or designated elevation.

MASTER PLAN CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1820-C-1	Location of the proposed facility	11
1820-C-2	Description of all structures, buildings, equipment and machinery used for storage, treatment, and/or disposal purposes	12
1820-C-2	Specifications for storage, treatment, and/or disposal facilities	13
1820-C-3	Description of all private or public roads, rail lines, easements, pipelines, and utilities located within site boundaries	14
1820-C-4	Description of all land use within one mile of facility boundary	15
1820-C-4	Description of all State and local land use restrictions in effect within one mile of facility boundary	16
1820-C-5	Projected life of the facility, expressed in both years and capacity	17
1820-C-5	Potential for future expansion and/or modification of the facility	18
1820-C-6	Proximity to human habitation and/or population centers within 10 miles of the facility boundrey line and population of such centers	19
1820-C-7	Alternate methods considered for treatment, recovery, or recycling	20
1820-C-8	Description of applications submitted to or permits obtained from any local, State, or Federal agency enforcing environmental quality programs	21
1820-C-9	Legal or survey description of the land comprising the facility	22
1820-C-9	Description of the site geology, hydrology, and climate	23

MASTER PLAN CHECKLIST (cont.)

REFERENCE	ITEM	PAGE NUMBER
1820-C-9	Description of location and type of devices for monitoring and control of surface and subsurface drainage	24
1820-C-9	Description of location and type of devices for monitoring and control of leachate percolation	25
1820-C-9	Description of location and type of devices for monitoring and control of gas generation	26
1820-C-9	Description of location and type of devices for monitoring and control of air pollution emissions	27
1820-C-9	Topographic map indicating all known wells, bodies of surface water, 100-year flood plains, and active fault zones	28

OPERATION AND MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1820-D-1	Education, training and work experience of supervisor and management personnel	29
1820-D-2	Description of hazardous waste accepted for storage, treatment or disposal, including volume, concentration, hazardous qualities, operational procedures and rate of acceptance	30
1820-D-3	Copy of applicant's performance bonds, insurance and policies, and other relevant information indicating financial responsibility	31
1820-D-4	Description of procedures to monitor, control and prevent air pollution	32
1820-D-4	Description of procedures to monitor, control and prevent water pollution	33
1820-D-4	Description of procedures to monitor, control and prevent leachate percolation	34
1820-D-4	Description of procedures to monitor, control and prevent odors and noise	35
1820-D-5	Description of all security and access control facilities and procedures	36

CONTINGENCY PLAN CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1821-E-1	Description of communication for summoning external emergency assistance	37
1821-E-1	Description of internal warning and communication system	38
1821-E-2	Description of equipment available to emergency response team	39
1821-E-2	Description of protective clothing and breathing equipment available on-site to emergency response team	40
1821-E-2	Description of procedures established to handle uncontrolled reaction, combustion or explosion	41
1821-E-2	Description of procedures established to handle spillage, discharge, or disposal in an area not intended for discharge or disposal	42
1821-E-2	Description of procedures established to handle degradation of air or water quality standards	43
1821-E-2	Description of procedures established to handle escape of leachates	44
1821-E-4	List of emergency agencies, including police, fire, ambulance, hospitals, etc., agreeing to provide emergency services	45
1821-E-4	Containment, decontamination, and cleanup procedures to be used in emergency situations	46
1821-E-5	Training and qualifications of on-site Emergency Coordinators	47
1821-E-5	Contingency plan implementation checklist for emergency situations	48
1821-E-5	Training and inspection procedures to be performed by the Emergency Coordinators	49

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1820-E-1	Description of the proposed final elevation	50
1820-E-2	Procedure for the physical inspection, monitoring, and supervision to prevent air and/or water pollution	51
1820-E-3	Procedure for access control and maintenance of posted warning signs	52
1820-E-4	Estimated cost of all closure procedures	53
1820-E-5	Description of performance bonds, insurance carriers, and policies indicating financial responsibility for claims resulting from post-closure discharges	54
1820-E-6	List of future uses of the site or list of uses which would pose a menace to human health or the environment	55

DISPOSAL BY LANDFILLING CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1821-C-8	Description of methods used to reduce water content	56
1821-C-8	Description of methods used to reduce water solubility	56
1821-C-8	Description of methods used to reduce overall toxicity	56
1821-A-3	Description of methods used to neutralize waste	56
1821-C-9	Description of methods used to handle reactive and/or explosive wastes	56
1821-C-9	Description of surface water diversion structures	56
1821-C-9	Design of gas venting system	56
1821-C-9	Design of facilities to assure segregation of incompatible wastes	56
1821-A-3	Presentation of the economic feasibility of resource recovery as opposed to disposal in a hazardous waste site	56
1821-A-3	Presentation of the economic feasibility of waste destruction as opposed to disposal in a hazardous waste site	56

DISPOSAL BY LANDFARMING CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1821-D-2	Waste and soil analysis	57
	Calculations supporting application rates	57
	Signed agreement with Soil Conservation Service regarding cropping requirements	57

LOG CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1821-F-1	Sample of waste log	58
1821-F-2	Sample of summary reports and records	59
1821-F-3	Sample of Emergency Coordinators logs	60
1821-F-4	Sample of operating conditions logs	61
1821-F-5	Sample of monitoring logs	62

STORAGE FACILITIES CHECKLIST

REFERENCE	ITEM	PAGE NUMBER
1821-B-2	Description of flooring or base of storage areas and its resistance to degradation by wastes being stored	63
1821-B-3	Description of protective devices for collection and containment of wastes escaping from storage units	64
	Anticipated storage time of wastes	65
	Anticipated waste disposition once storage is discontinued	66
	"Current inventory" record keeping procedures	67

	PAGE NUMBER
ADDENDUM A	ii
ADDENDUM B	68
ADDENDUM C	69
ADDENDUM D	70
ADDENDUM E	71

REFERENCE	ITEM
1820-C-9	One mile topographic map at a scale of 1" = 500'

See the attached map marked 1820-C-9.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CASA GRANDE WEST QUADRANGLE
ARIZONA—PINAL CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CASA GRANDE 15' QUADRANGLE

SACATON MOUNTAINS

Tailing Pond
Sacaton Plant Site
Open Pit
East Dump
Dirt Dump
Dirt Dump
South Dump (Rock)

NO RESTRICTIONS

GILA RIVER INDIAN RESERVATION BOUNDARY

MARICOPA 13 MI.
SOUTHERN PACIFIC
3 MI.-CASA GRANDE 3 MI.

CASA GRANDE MUNICIPAL AIRPORT

Santa Cruz Wash
North Branch Santa Cruz Wash

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1965

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Red tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence lines

A portion of the southwest quarter of this map lies within a subsidence area
Vertical control based on latest available adjustment

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Heavy duty — Light duty
Medium duty — Unimproved dirt
State Route

ARIZONA
QUADRANGLE LOCATION

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ASARCO SACATON UNIT
CASA GRANDE WEST, ARIZ.
NE/4 CASA GRANDE 15' QUADRANGLE
N3252.5'--W11145/7.5

1965

AMS 3649 IV NE--SERIES V898

1820-C-9
1820-F

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CASA GRANDE WEST QUADRANGLE
ARIZONA—PINAL CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CASA GRANDE 15' QUADRANGLE

3650 III SW (SACATON BUTTE)
3650 III SE (GILA BUTTE SE)
3649 IV NW (STANFIELD)
3649 I NW (CASA GRANDE EAST)
(DOUBLE PEAK) 3649 IV SW
(CHUICHU) 3649 IV SE

111°52'30" 33°00' 111°45' 32°52'30"
4190000m E. 540 000 FEET
R 5 E. R 6 E.
720 000 FEET
690 000 FEET
520 000 FEET
3651 000m N. 3650 3649 3648 3647 3646 3645 3644 3643 3642 3641 3640 3639 000m N. 3638
T. 5 S. T. 6 S.

GILA RIVER INDIAN RESERVATION BOUNDARY

SACATON MOUNTAINS

ROAD, DRIVE, BLVD: BIANCO ROAD, BURRIS ROAD, DESERT VISTA DRIVE, HOPI DRIVE, SCOTT DRIVE, MONTEZUMA DR., WEST VAL VISTA ROAD, VAL VISTA BLVD, KORTSEN ROAD, CANDLESTICK ROAD, COTTONWOOD LANE, CASA GRANDE CANAL, ETHINGTON ROAD, THORNTON ROAD, PACIFIC SOUTHERN RAILROAD, MONTGOMERY ROAD, CLAYTON ROAD

Water Tank
Tailing Pond
Sacaton Plant Site
Open Pit
East Dump
Dirt Dump
Dirt Dump
South Dump (Rock)
No Restrictions
Dry Well 1358
Dry Well 1347
Gravel Pit
Wells
Well
Sewage Disposal
Athletic Fields
Landing Strip
Golf Course
Francisco Grande
Gravel Pit
Sewage Disposal
Suostation
Rodeo Grounds
Mormon Battalion Historical Monument
Three Point Airport
Burgess Peak
Trailer Park
Drive-in Theater
Jr High Sch
Casa Grande
Casa Grande Municipal Airport

BM 1338
BM 1345
BM 1340
BM 1337
BM 1341
BM 1350
BM 1449
BM 1415
BM 1388
BM 1386
BM 1375

MARICOPA 11 MI.
3 MI.-CASA GRANDE-3 MI.
MARICOPA 13 MI.
GILA BEND 49 MI. STANFIELD 5 MI.
ELEVEN MILE CORNER 11 MI. COOLIDGE 20 MI.
TOLTEC 9.8 MI. TUCSON 65 MI.
PHOENIX 47 MI. 16 MI TO ARIZ 87
COOLIDGE 18 MI
CHUICHU 9 4 MI

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1965

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Red tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence lines

A portion of the southwest quarter of this map lies within a subsidence area
Vertical control based on latest available adjustment

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Heavy duty — Light duty
Medium duty — — Unimproved dirt
State Route

ARIZONA
QUADRANGLE LOCATION

ASARCO SACATON UNIT
CASA GRANDE WEST, ARIZ.
NE/4 CASA GRANDE 15' QUADRANGLE
N3252.5--W11145/7.5

1965

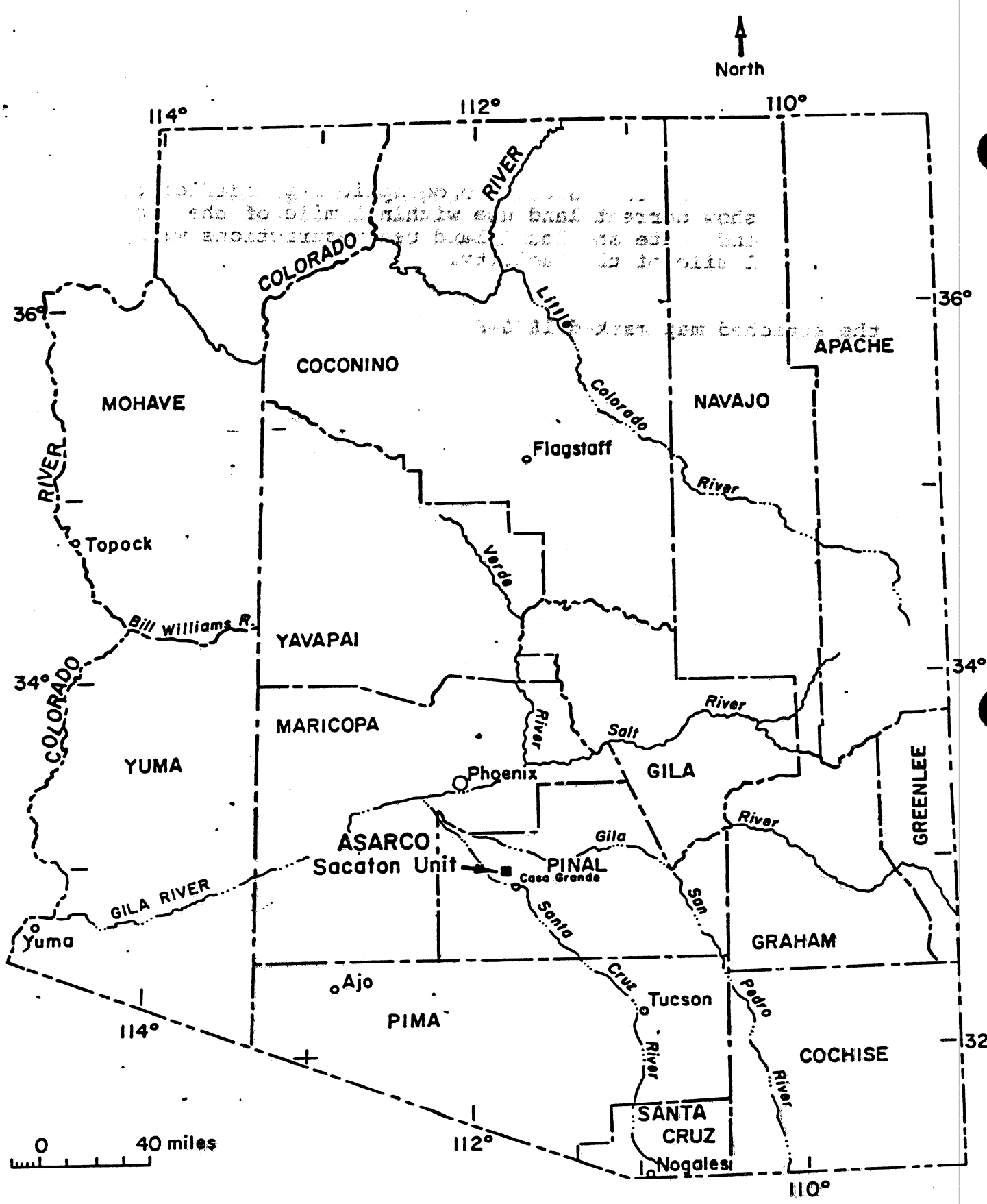
AMS 3649 IV NE—SERIES V898

1820-C-9
1820-F

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

REFERENCE	ITEM
1820-F	Location map showing site relative to state boundaries, population centers and major site access route(s)

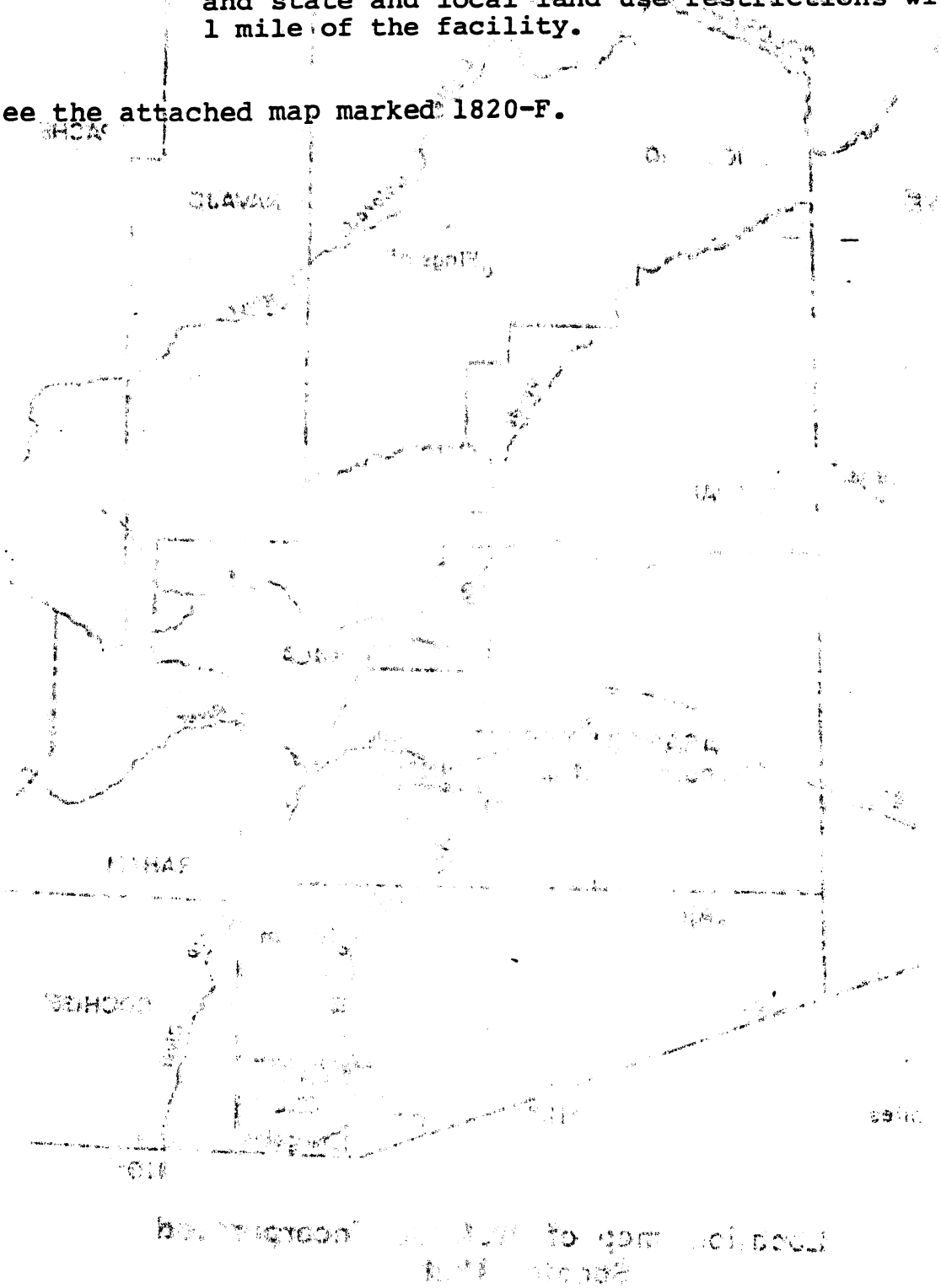
See the attached map marked 1820-F-1.



Location map of ASARCO Incorporated
Sacaton Unit

REFERENCE	ITEM
1820-F	7½ minutes U.S.G.S. topographic map modified to show current land use within 1 mile of the facility and state and local land use restrictions within 1 mile of the facility.

See the attached map marked 1820-F.



REFERENCE	ITEM
1820-F	Preliminary topography map at a scale of 1" = 200' or larger with 5' contour intervals

See the attached map marked 1820-F-3.

25,000 N
24,000 N
23,000 N
22,000 N
000 N
,000 N
000 N
000 N
000 N
000 N
000 N
000 N
000 N

N

28 | 27
33 | 34

27 | 26

26 | 25
35 | 36

33 | 34
5 | 4

34 | 35
4 | 3

35 | 36
3 | 2

T5S
T6S

STA.-7
1446.7

STA.-2
1498.9

STA.-5
1413.5

STA.-4

STA.-12
1361.7

STA.-1
1340.0

1450

1400

1350

1347

1343

1342

1349

1346

1351

1363

1365

TR-1

1820-F-3

ASARCO
SACATON UNIT

Topographic Map
T5&6S R.S.E. G & S.R. B & M.
Scale 1" = 400' Contour Interval 10'

REFERENCE	ITEM
1820-F	Final site topography map at a scale of 1" = 200' or larger with 5' contour intervals

See the attached map marked 1820-F-4.

REFERENCE	ITEM
1820-F	Engineering designs and/or blueprints for all facilities holding wastes

See the attached drawings marked 1820-F-5 (4) and 1820-F-6.

ASARCO
SACATON UNIT

Sacaton Topographical

Scale 1" = 400' Contour Interval 10'

1820-F-4

N

Final Dam Crest

Tailing Pond

Decant tower

Final Pit Outline

Pit Water Line

Mine Haul Road

Drainage Channel

Storage Area

Pit Power Line

16" fresh water line (buried)

12" Concrete-Asbestos Pipeline (Buried)

Buried Telephone Cable

Buried reclaim water line

ASARCO 5 KV Power Line

APS 115 KV Power Line

B.I.A. LINE

BIANCO ROAD

ASARCO R.R.

MARICOPA HWY.

S.P.R.R.

1503 EL.

1495 EL.

1490 EL.

1445 EL

1465 EL.

1408 EL.

GRAVELS

ROCK

1490 Elev.

1435 EL.

1429.5 EL.

1432.9 EL.

1453 EL.

1443 EL.

1410 EL.

1380 EL. Decant Pond

primary crusher

inter. ore pup

reagent stg.

shop

warehouse

haul truck parking

washrm.

assay lab.

concentrator

sub station

tailing thickener

fuel storage

tire storage

tire shop

mine office

weather station

parking area

main office

Core Shed

Field Warehouse

vent shaft

shaft

compressor house

hoist house

sub. sta.

drainage ditch

underground settling pond

clear water sump

powder mag.

high explosive magazine

STA-7

STA-10

STA-14

STA-15

STA-16

STA-18

STA-19 Pit storage

STA-21A

STA-11

STA-12

PP-2

PP-4

PP-14

PP-17

PP-20

PP-23

PP-26

PP-29

PP-32

PP-34

PP-36

SP-4

TM-1

S-143

S-144

S-150

S-151

1820

1810

1800

1790

1780

1770

1760

1750

1740

1730

1720

1710

1700

1690

1680

1670

1660

1650

1640

1630

1620

1610

1600

1590

1580

1570

1560

1550

1540

1530

1520

1510

1500

1490

1480

1470

1460

1450

1440

1430

1420

1410

1400

1390

1380

1370

1360

1350

25,000 N

24,000 N

23,000 N

22,000 N

14,000 E

15,000 E

16,000 E

17,000 E

18,000 E

19,000 E

20,000 E

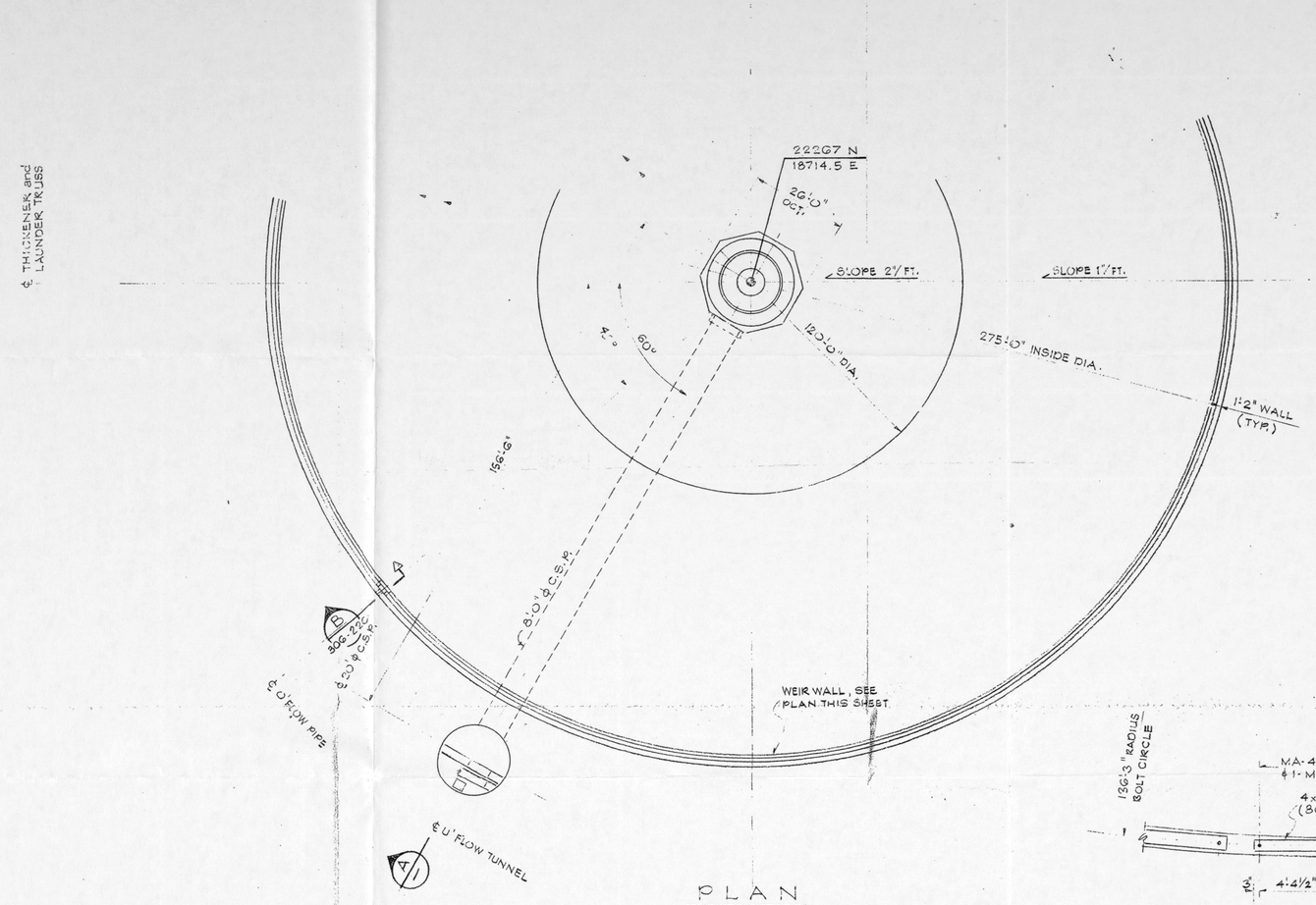
21,000 E

22,000 E

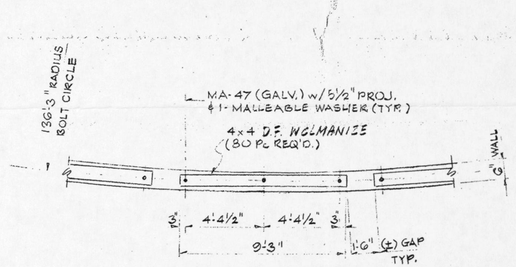
23,000 E

24,000 E

DRAWING NO. SAC 306-21C

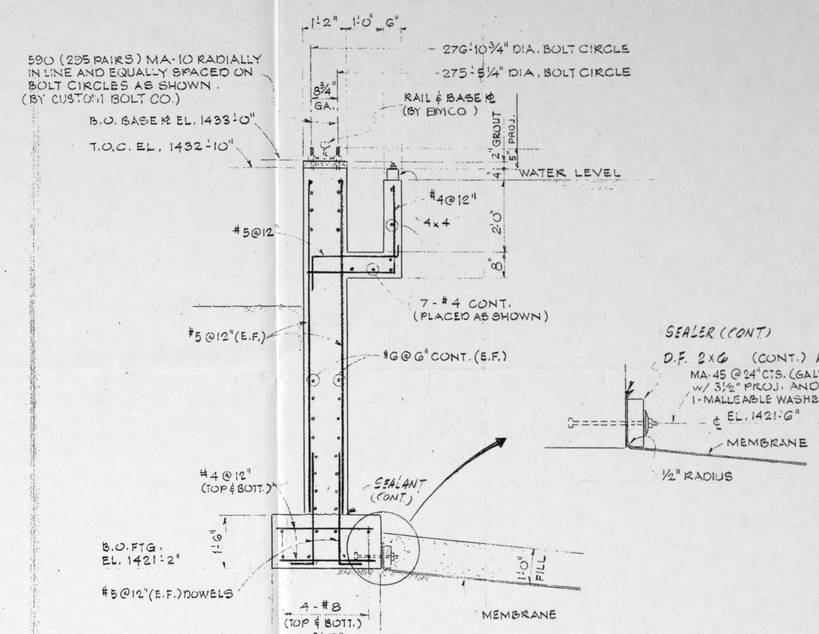


PLAN

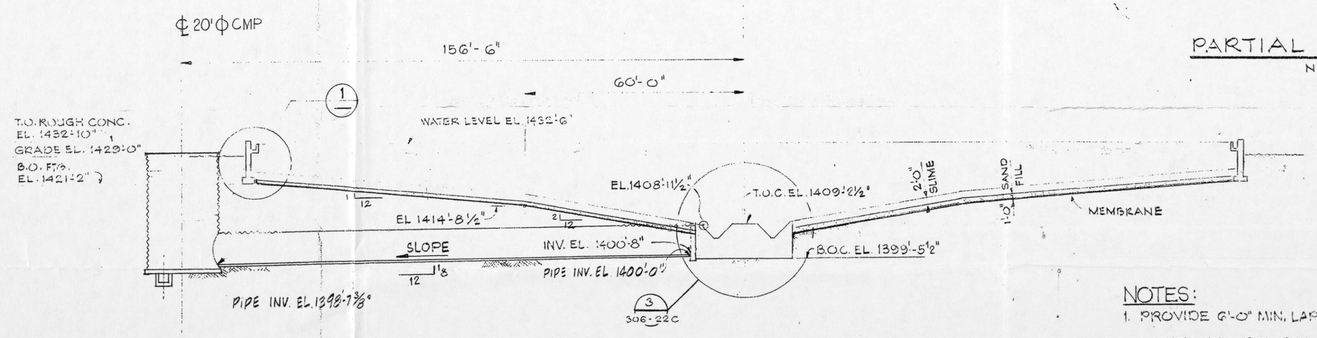


PARTIAL PLAN - WEIR WALL

NO SCALE



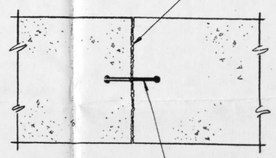
DETAIL 1
1½" = 1'-0"



SECTION A

NOTES:

1. PROVIDE 6'-0" MIN. LAP FOR HORIZONTAL BARS.
2. HORIZONTAL REINF. BARS FOR FIRST 20'-0" WIDE POUR WILL BE 32'-0" LONG MIN.
3. SAND FILL ABOVE MEMBRANE SHALL BE COMPACTED TO 90% RELATIVE DENSITY, ASTM D698-64T METHOD A.



TYPICAL VERTICAL CONSTRUCTION JOINT
(MAIN WALL ONLY)

APPROVED for CONSTRUCTION

1820-F-5

REFERENCES	DWG. NO.	TITLE
	304-24G	CONCENTRATOR AREA
	301-26G	TAILING THICKENER SECTIONS
	301-27G	" " PLAN
	301-04C	ROUGH GRADING PLAN

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	SAJ	10-11-72	PRELIMINARY
	B	SAJ	10-12-72	FOR FINAL APPROVAL
	0	SAJ	10-18-72	ISSUED FOR CONSTRUCTION
	1	GCF SAJ	10-25-72	Jt SULFIDE & CONST NOTES Added.
	2			U-FLOW TUNNEL ADDED

REVISIONS	NO.	BY	DATE	DESCRIPTION
	2	GCF	11-27-72	REV. BOTTOM, ADD WEIR DETS.
	3	GCF	11-15-73	REV. ELEVATION
	4	[illegible]	7-30-73	Drawn Corrected To (AS BUILT)

	BY	DATE
DESIGNED	SAB	OCT. '72
DRAWN	[illegible]	OCT. '72
CHECKED	SAJ	10-12-72
APPROVED 1	[illegible]	10-12-72
APPROVED 2	[illegible]	10-18-72
APPROVED 3	[illegible]	10-18-72
MICROFILM		

DATE TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	11/1	10/13		10/18	10/25	11/15	1/4				
FIELD				10/18	10/25	11/15	1/4				
Border St.				10/18	10/25	11/15					
					1/8	1/21		1/22			

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT

514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2107A

N.Y. APPROP. NO.	PLANT NO.	C. E. PROJECT NO.	DRAWING CLASSIFICATION AREAS

SACATON PROJECT
TAILING THICKENER
PLAN & DETAILS

SCALE 1" = 20'-0" U.N.
REV. 2
DRAWING NUMBER SAC 306-21C

DRAWING NO. SAC 306-41C

N 22440
E 18493.96

SLAB TO WALL CONN. DET. SIM. (C)

SLOPE 1:1

SLOPE 1/4"/1'-0"

L.P. 1417'-6 1/2"

1'-3 1/2"

H.P. EL. 1419'-0"

MA-65 (REQ. 3)

84"ø HOLE TYP.

12'-0" DOUBLE GATE

H.K.

FOR LOCATION OF PIPES SEE DWG. 306-10P

OVER FLOW

CURB 6" (TYP.)

70'-0 1/2"

8 FOOT CYCLONE FENCE ALL AROUND (BY FIELD)

4'-0" MAN GATE (A) SIM.

PLAN

#5 @ 12" E.W.

2-#5 EXTRA @ OPNG

#5 @ 8 E.W.

#5 @ 8

#5 @ 12

5'-8"

5" (TYP.)

#5

#4 DOWELS @ 12"

SECTION (B)
1/4" = 1'-0"

NOTES:

1. FOR GENERAL CONCRETE NOTES & DETAILS SEE DWG. 301-12C
2. ALL SIDE WALLS & BOTTOM SLABS TO BE CONSTRUCTED WITH SHOTCRETE UNLESS NOTED OTHERWISE. REFER TO ACI COMMITTEE 506 REPORT, FOR RECOMMENDED PRACTICE FOR SHOTCRETING.

6" CURB

GRADE EL. 1427'-7"

5"

5"

SECTION (E)
1" = 1'-0"

GRADE EL. 1429'-0"

#4 @ 12 E.W. (TYP.)

5" (TYP.)

POUR IN PLACE CONC. WALL & FOOTING

SECTION (A)

2-#5 x 4'-0" LG. @ OPNG. TYP

1" GROUT

EL. 1429'-0"

#5 @ 12

#4 DWLS @ 12 1'-0" 2'-6"

5'-6 3/4" 8" 5'-6" 8"

#5 @ 12

#4 DOWELS

#4 DWLS @ 12 1'-0" 2'-6"

#5 @ 12 E.W.

POUR IN PLACE CONC. WALLS & FTG'S.

SECTION (C)
1/4" = 1'-0"

#5 @ 12

#4 DWLS @ 12 x 4'-0" LG.

SEALER (CONT.) TYP.

#4 @ 12 O.C.

3-#5 (CONT.)

#5 @ 12 ALT. BEND @ 24" O.C.

SECTION (D)
1 1/2" = 1'-0"

4-3/4" ø EXP. BOLTS INTO SLAB

(GALV.) W4x13

3/4 BASE PL

2-4x12 D.F. WOLMANIZE

(GALV.) C4x5.4 W/CLIP L & 2-3/4 ø EXP. BOLTS TO WALL

(GALV.) C4x5.4 W/2-3/4 ø EXP. BOLTS TO WALL

DETAIL (1)

1820-F-5

APPROVED for CONSTRUCTION

REFERENCES	DWG. NO.	TITLE
	306-10P	TAILING THICKNER PLAN

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	GCP	12-27-72	PRELIMINARY
	B	GCP	1-8-73	ISSUED FOR APPROVAL
	C	GCP	1-12-73	ISSUED FOR CONSTRUCTION
	1			REVISED RESERVOIR

REVISIONS	NO.	BY	DATE	DESCRIPTION

	BY	DATE
DESIGNED	S.V.T.	
DRAWN	K. GAYTON	
CHECKED	GC	
APPROVED 1	[illegible]	12-21-72
APPROVED 2	[illegible]	1-12-73
APPROVED 3	[illegible]	1-12-73

DATE TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	11/4	1/4			1/16	1/8					
FIELD					1/16	1/8					
2107A-2					1/16	1/8					
CS-2					1/16	1/8					
MICROFILM					1/16	1/8					

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2107A

N.Y. APPROP. NO. | PLANT NO. | C. E. PROJECT NO. | DRAWING CLASSIFICATION AREAS

SACATON PROJECT
RECLAIM WATER RESERVOIR
PLAN & SECTIONS

SCALE 1/8" = 1'-0" U.N.

DRAWING NUMBER SAC 306-41C

REV. 1

23,000 E

23,500 E

24,000 E

N

WELL No.6

PRODUCTION SHAFT

WELL No.5

HOIST HOUSE

COMPRESSOR HOUSE

PIPELINE CONTINUES TO MAIN PLANT, FOR REFERENCE SEE SAC-207-E202, SAC-2-E65

MW

"A"

#7 21,186.99 N 23,284.04 E EL. 1446.84

#6 21,186.99 N 23,593.12 E EL. 1446.83

#5 21,186.99 N 23,835.75 E EL. 1445.33

BUTTERFLY VALVE

8"Ø PIPE

DRAINAGE DITCH

WATER STORAGE TANK

SPIGOT

STORAGE BUILDING

SUB STATION

45.3

40.8

44.1

21,000 N

S.T.-18

SHAFT MOCK-UP

8"Ø PIPE

44.4

POWDER MAGAZINE

UNDERGROUND SETTLING POND

CAP-250,000 GALLONS

"B"

"C"

43.7

44.6

45.5

45.2

CLEAR WATER SUMP CAP-22,500 GAL.

OVERFLOW PIPE DITCH

WOOD GUIDE STORAGE BUILDING

44.5

45.2

44.8

ROAD TO HI-EXPLOSIVE STORAGE

20,500 N

EL. 1492.50

SECTION B-B

SCALE: 1" = 10'

7'-0"

SECTION A-C

SCALE: 1" = 10'

6'-0"

CLEAR WATER SUMP

WATER STORAGE TANK

8'-0"

10'-0"

7'-0"

SHAFT MOCK-UP

CONGLOMERATE FILL & RAMP

CLEAR WATER SUMP

6'-0"

PLASTIC LINED

SETTLING POND

COAT SIDES & BOTTOM WITH BENTONITE

PUMP

8" PIPE

CRIBBING

8" PIPE

EXISTING PIPELINE 12" CONCRETE-ASBESTOS PIPE

8" BUTTERFLY VALVE

SECTION A-A

VERTICAL SCALE: 1" = 20'

HORIZONTAL SCALE: 1" = 50'

1820-F-5

REVISIONS			
No	Date	By	CHANGE

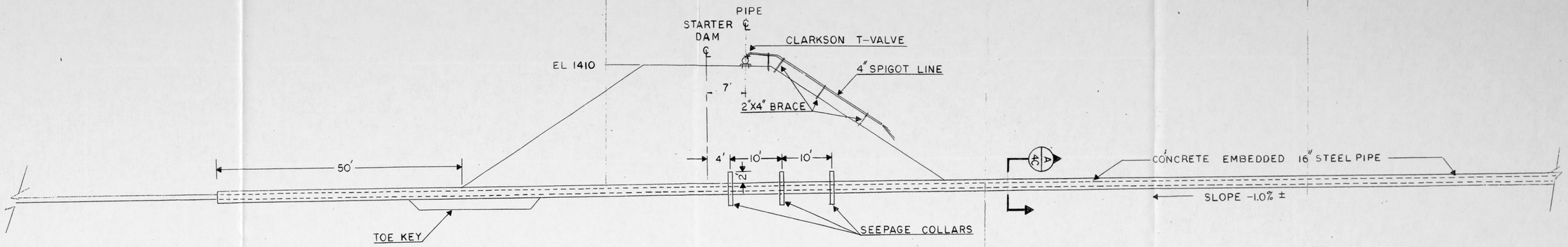
ASARCO
SACATON UNIT

GENERAL AREA SHAFT SITE

Scale	Dwn. by	Date	File
1" = 50'	B.D.K.	6-20-80	SAC-207-E230

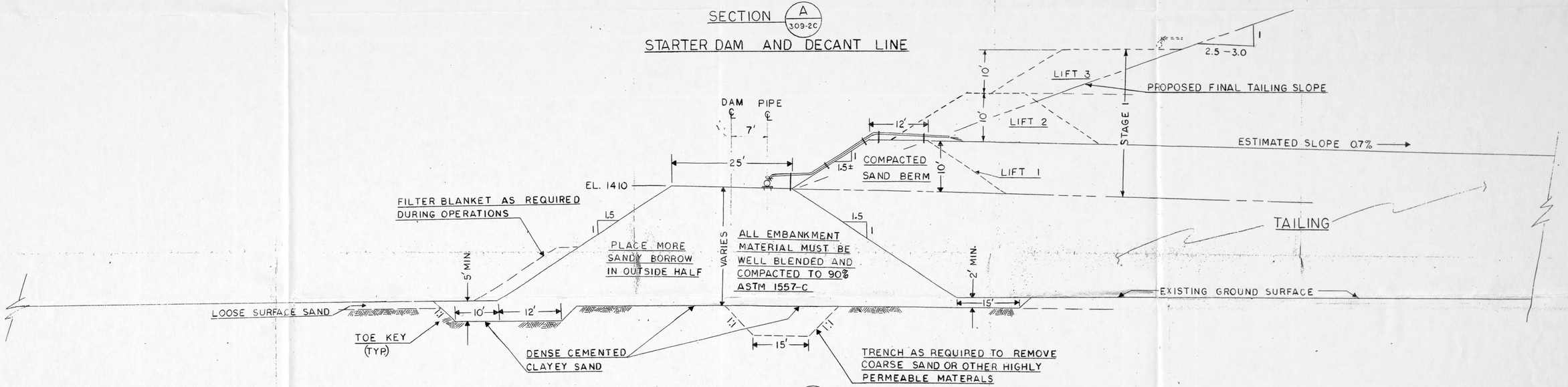
SCALING RULES

DRAWING NO. SAC 309-3C



SECTION A 309-2C

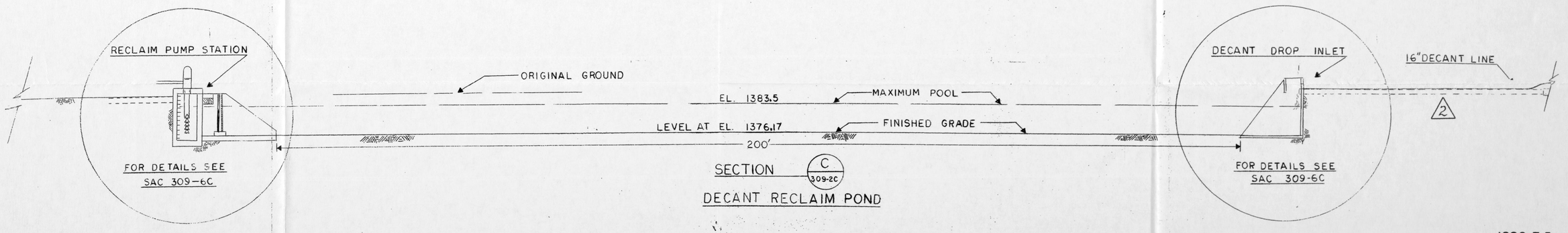
STARTER DAM AND DECANT LINE



SECTION B 309-2C

STAGE I SAND BERMS

BY OPERATIONS



SECTION C 309-2C

DECANT RECLAIM POND

1820-F-5
1820-C-2

APPROVED for CONSTRUCTION

REFERENCES	DWG. NO.	TITLE
	309 CIC	TAILING DISPOSAL-GENERAL PLAN

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	J.H.T.	12-15-72	PRELIMINARY
	B	JHT	1-3-73	ISSUED FOR APPROVAL
	C	JT/GP	1-12-73	ISSUED FOR CONSTRUCTION
	1	JHT	3-12-73	REVISED FOR NEW LOCATION
	2	DAM	4-30-73	DECANT LINE SWISSURFACE

REVISIONS	NO.	BY	DATE	DESCRIPTION

	BY	DATE
DESIGNED		
DRAWN	TINTO	11-30-72
CHECKED	J. LEE	12-20-72
APPROVED 1		1-12-73
APPROVED 2		1-12-73
APPROVED 3		1-18-73

DATE TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	1/18	1/3			1/17	3/6					
FIELD					1/17						
MICROFILM					1/19	3/14					

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

N.Y APPROP. NO.	PLANT NO.	C. E. PROJECT NO.	DRAWING CLASSIFICATION AREAS

CONTRACT 2112

SACATON PROJECT
TAILING DISPOSAL
STARTER DAM DETAILS
Sheet 2 of 2

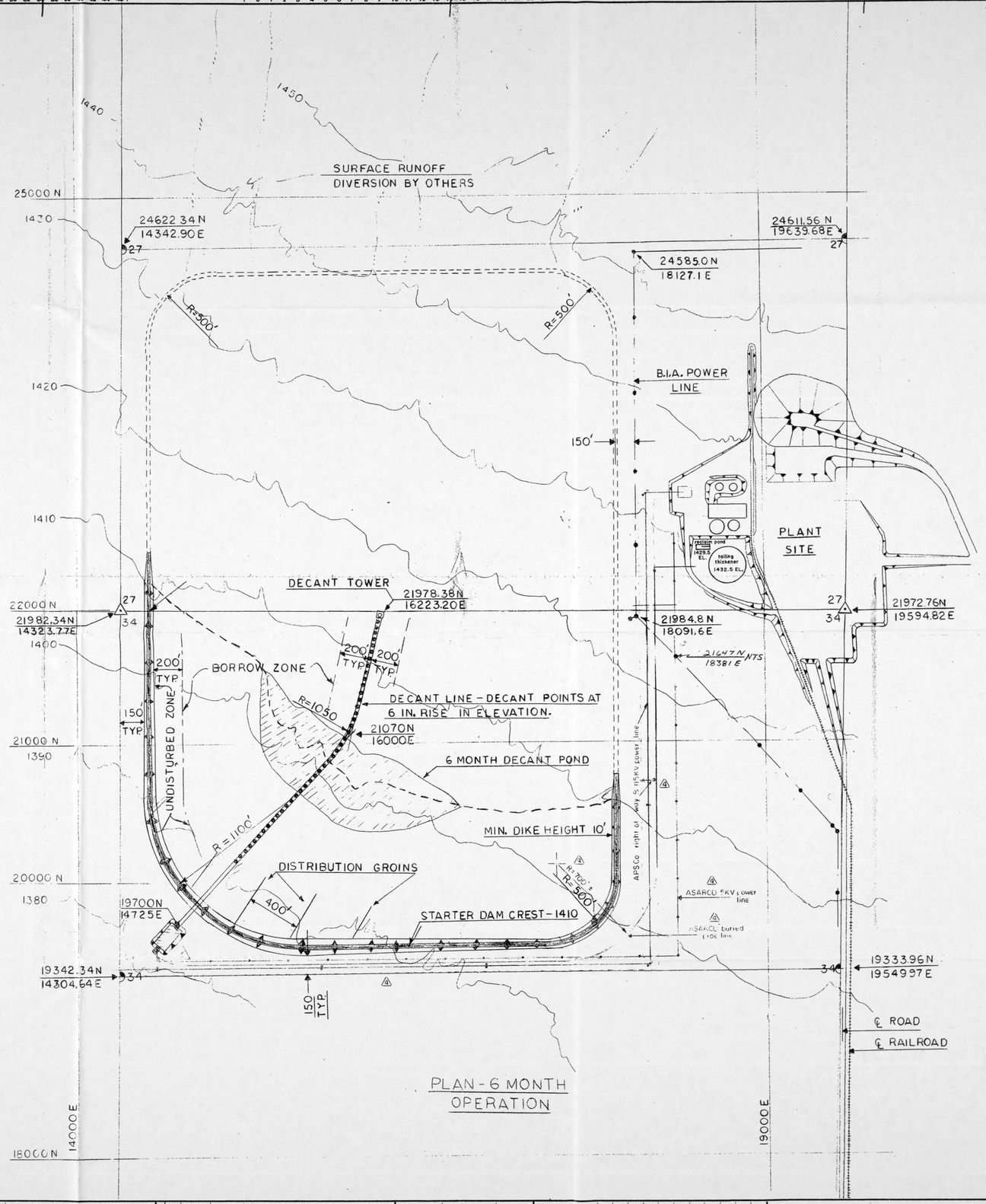
SCALE 1" = 10'

DRAWING NUMBER SAC 309-3C

REV. 2

SCALING RULES

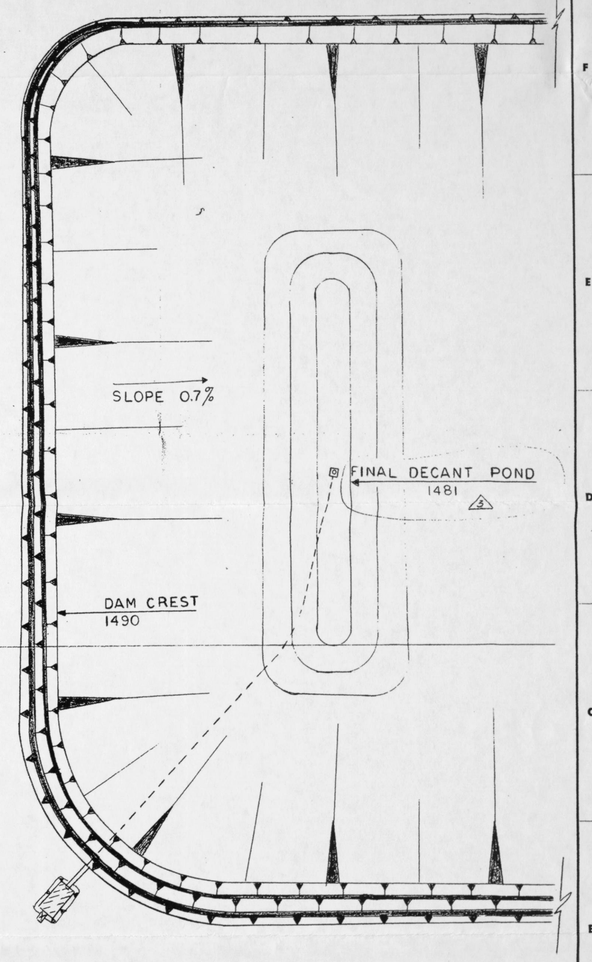
DRAWING NO.



PLAN - 6 MONTH OPERATION

NOTE

1. TAILING POND LAYOUT AND DETAILS ARE IN ACCORDANCE WITH CRITERIA AS SPECIFIED BY AMERICAN SMELTING AND REFINING COMPANY.
2. STARTER DAM EMBANKMENT DESIGN AND DETAILS ARE IN ACCORDANCE WITH CRITERIA SPECIFIED IN THE FINAL SOIL AND FOUNDATION REPORT - TAILING DAM AND STARTER DIKE, PREPARED FOR A.S.A.R.C.O. BY SERGENT, HAUSKINS AND BECKWITH CONSULTING SOIL AND FOUNDATION ENGINEERS.
3. FINAL ELEVATIONS AND COORDINATES MUST BE CONFIRMED IN THE FIELD.



PLAN - FINAL DISPOSAL

APPROVED
for
CONSTRUCTION

1820-F-6

REFERENCES	DWG. NO.	TITLE
	SAC 309.2C	STARTER DAM DETAILS 1 of 2
	-3C	" " " 2 of 2
	-4C	DECANT SYSTEM
	-5C	CAPACITY CURVE
	-6C	COLLECTION POND DETAILS

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	JHT	11-9	PRELIMINARY
	B	JHT	1-3-73	ISSUED FOR APPROVAL
	C	JHT	1-12-73	ISSUED FOR CONSTRUCTION
	1	JHT	2-19-73	GENERAL REVISION
	2	JHT	3-16-73	REVISED FOR NEW LOCATION

REVISIONS	NO.	BY	DATE	DESCRIPTION
	3	JT	4-6-73	REVISED FOR NEW FINAL DISPOSAL
	4	DAM	4-25-73	ELECTRICAL & PIPING

	BY	DATE
DESIGNED		
DRAWN	TIN TO	12-1-72
CHECKED	J. LEE	2-20-73
APPROVED 1		
APPROVED 2		3-12-73
APPROVED 3		3-16-73

DATE/TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	1/4	1/3		1/3	3/5	4/5					
FIELD				1/3	1/5						
MICROFILM				1/3	3/5	4/5					

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2112

N.Y. APPROP. NO.	PLANT NO.	C. E. PROJECT NO.	DRAWING CLASSIFICATION AREAS

SACATON PROJECT
TAILING DISPOSAL
GENERAL PLAN

SCALE 1" = 400'

DRAWING NUMBER SAC 309-1C

REV. △

REFERENCE	ITEM
1820-F	Floorplan of all buildings showing room layout and waste handling machinery location

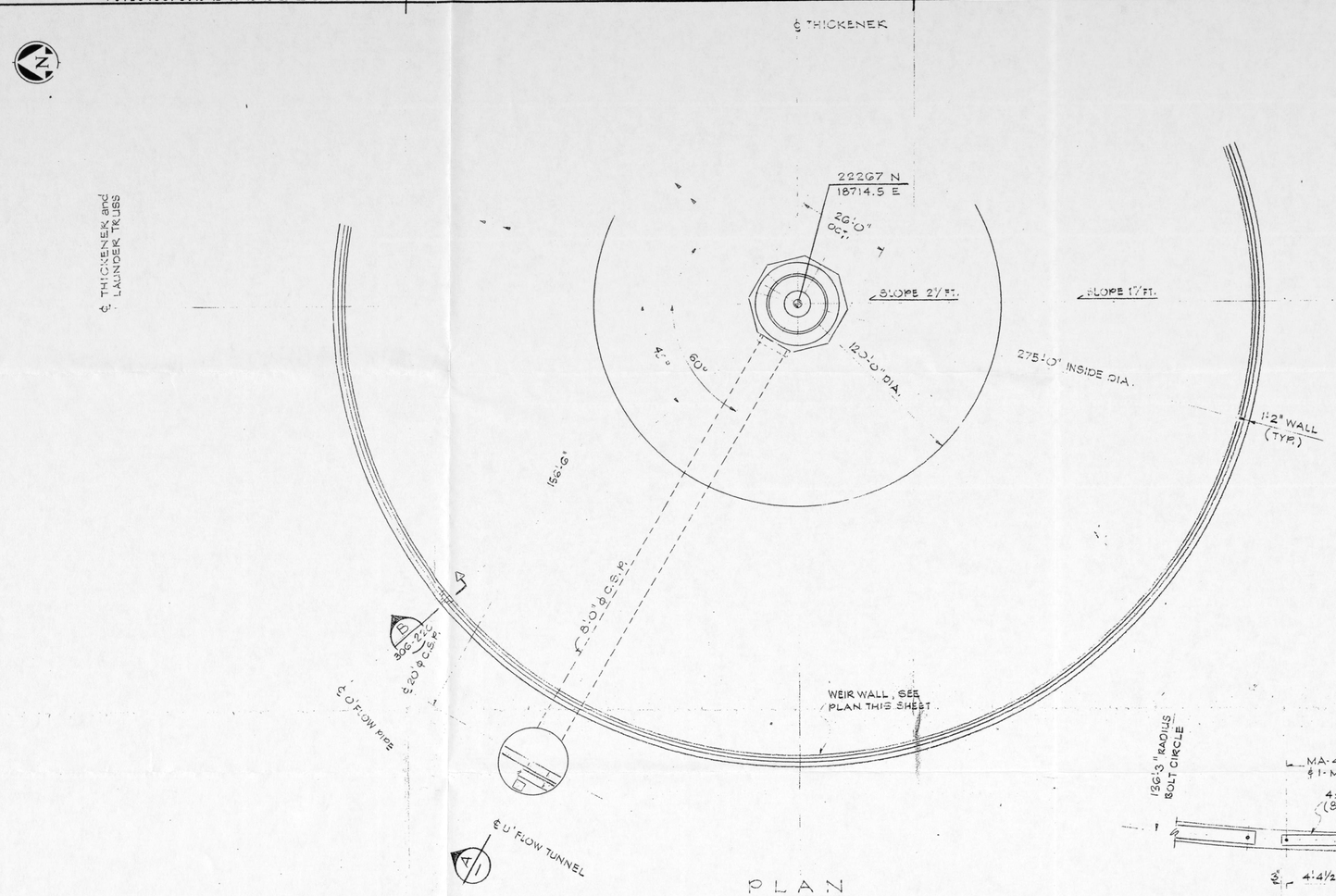
There are no buildings associated with the tailings disposal system. The attached drawing gives the tailings thickener details.

REFERENCE	ITEM
1820-F	Engineering designs showing sequence of use for all permanent disposal facilities

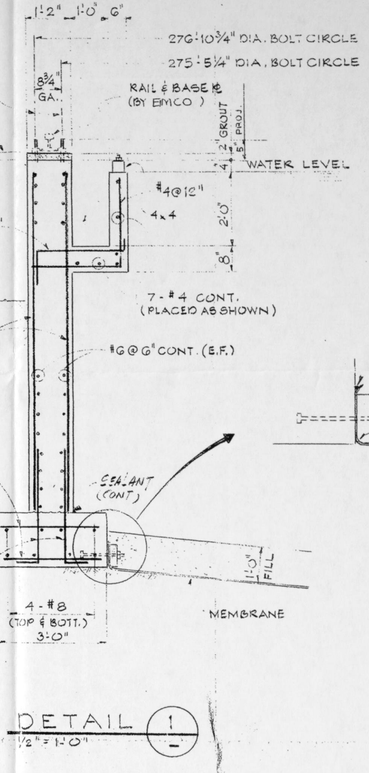
See the attached drawings marked 1820-F-4 and 1820-F-6.

DRAWING NO. SAC 306-21C

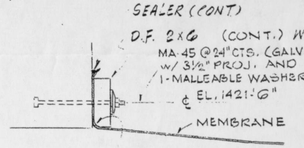
SCALING RULES

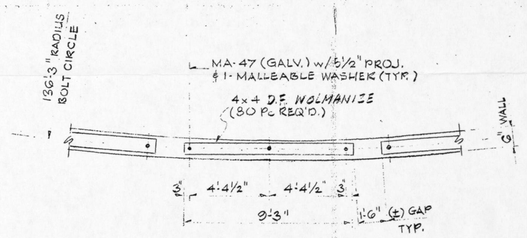


PLAN

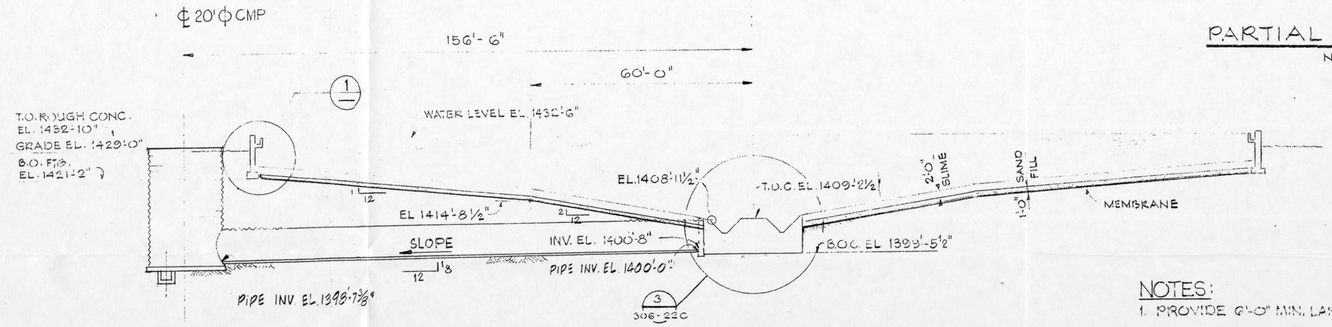


DETAIL 1/1 — 1/2" = 1'-0"



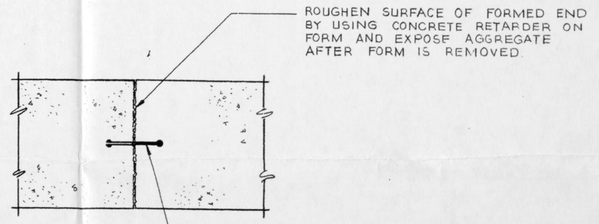


PARTIAL PLAN-WEIR WALL
NO SCALE



SECTION A/1

NOTES:
1. PROVIDE 6'-0" MIN. LAP FOR HORIZONTAL BARS.
2. HORIZONTAL REINF. BARS FOR FIRST 20'-0" WIDE POUR WILL BE 22'-0" LONG MIN.
3. SAND FILL ABOVE MEMBRANE SHALL BE COMPACTED TO 90% RELATIVE DENSITY, ASTM D698-64T METHOD A.



TYPICAL VERTICAL CONSTRUCTION JOINT
(MAIN WALL ONLY)

1820-F-5

APPROVED for CONSTRUCTION

REFERENCES	DWG. NO.	TITLE
	304-24G	CONCENTRATOR AREA
	301-29G	TAILING THICKENER SECTIONS
	301-27G	" " PLAN
	301-04C	ROUGH GRADING PLAN

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	SAJ	10-11-72	PRELIMINARY
	B	SAJ	10-12-72	FOR FINAL APPROVAL
	0	SAJ	10-18-72	ISSUED FOR CONSTRUCTION
	1	SAJ/SAJ	10-25-72	↓↑ SLOPE & CONST NOTES ADDED
	2			U-FLOW TUNNEL ADDED

REVISIONS	NO.	BY	DATE	DESCRIPTION
	2	GCP	11-15-72	REV. BOTTOM, ADD WEIR DETS.
	3	GCP	1-25-73	REV. ELEVATION
	4	[illegible]	7-30-73	[illegible]

	BY	DATE
DESIGNED	SAB	OCT. '72
DRAWN	[illegible]	OCT. '72
CHECKED	SAJ	10-12-72
APPROVED 1	[illegible]	10-12-72
APPROVED 2	[illegible]	10-18-72
APPROVED 3	[illegible]	10-19-72

DATE TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	10/11	10/12		10/18	10/25	11/3					
FIELD				10/18	10/25	11/3					
Preston Sd.				10/18	10/25						
MICROFILM				11/3	11/3	11/21					

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2107A

N.Y. APPROP. NO.	PLANT NO.	C.E. PROJECT NO.	DRAWING CLASSIFICATION AREAS

SACATON PROJECT
TAILING THICKENER
PLAN & DETAILS

SCALE 1" = 20'-0" U.N.

REV.

DRAWING NUMBER
SAC 306-21C

ASARCO
SACATON UNIT

Sacaton Topographical

Scale 1" = 400' Contour Interval 10'

1820-F-4

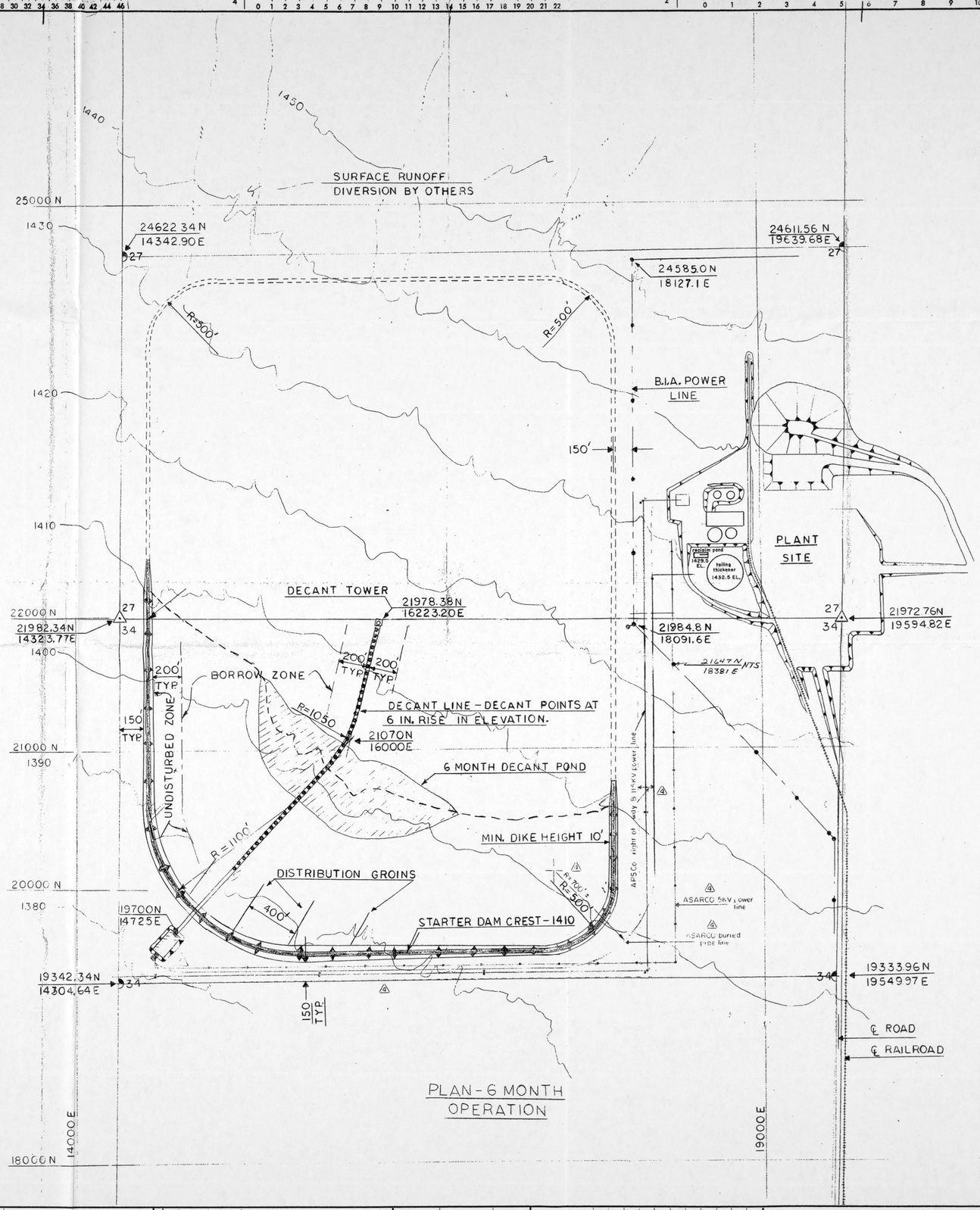
N

25,000 N
24,000 N
23,000 N
22,000 N
000 N
000 N
000 N
000 N
000 N
000 N
000 N

14,000 E
15,000 E
16,000 E
17,000 E
18,000 E
19,000 E
20,000 E
21,000 E
22,000 E
23,000 E
24,000 E
25,000 E

1490
1430
1420
1410
1400
1390
1380
1370
1360
1350

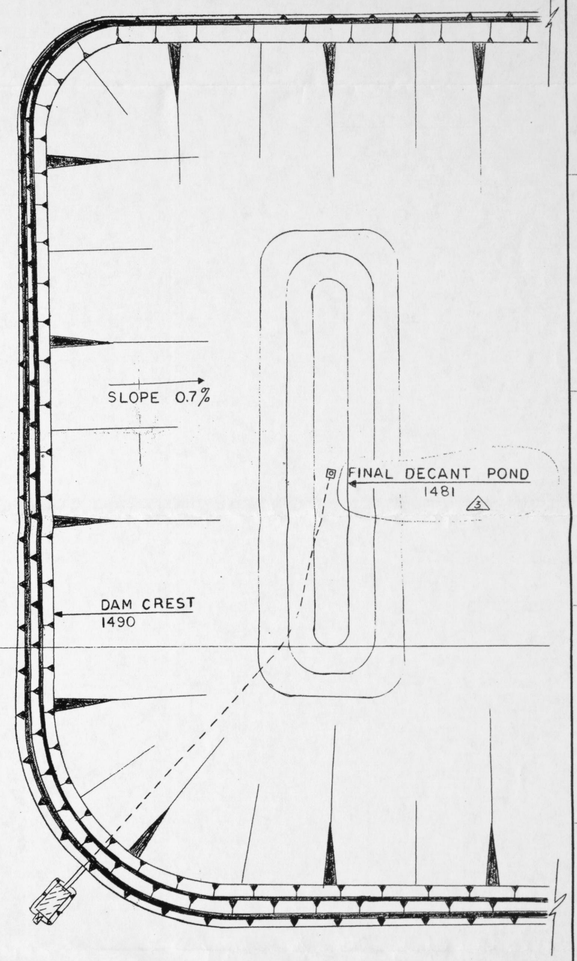
16" fresh water line (buried)
PP-4
Pit Power Line
STA-7
PP-17
PP-20
PP-14
PP-23
Final Pit Outline
1503 EL.
1495 EL.
PP-26
PP-29
PP-32
Pit Water Line
STA-20
STA-21A
PP-34
PP-36
Storage Area
FP-2
STA-15
1490 Elev.
primary crusher
ore pile
conveying
magnet sep.
concentrator
thickener
assay lab.
shop
warehouse
haul truck parking
washrack
STA 19
drill storage
tailing thickener 1432 ft. EL.
tire storage
tire shop
fuel storage
mine office
weather station
parking area
Core Shed
Field Warehouse
main office
Buried Telephone Cable
B.I.A. LINE
Drainage Channel
Mine Haul Road
12" Concrete-Asbestos Pipeline (Buried)
Buried Telephone Cable
vent shaft
shaft
compressor house
hoist house
sub. sta.
drainage ditch
underground settling pond
clear water sump
STA 18
ore
powder mag.
high explosive magazine
1445 EL
1490 EL.
GRAVELS
1495 EL.
GRAVELS
1445 EL.
SP-4
1465 EL.
1445 EL.
ROCK
1495 EL.
1445 EL.
1495 EL.
1495 EL.
1408 EL.
Decant tower
Tailing Pond
TM-1
1380 EL. Decant Pond
1453 EL.
1443 EL.
1410 EL.
buried reclaim water line
APS 115 KV Power Line
S-143
ASARCO 5 KV Power Line
S-144
S-151
S-138
S-141
ASARCO R.R.
B.I.A. LINE
BIANCO ROAD
MARICOPA HWY.
S.P.R.R.
STA. 11
STA. 12
STA-10



PLAN - 6 MONTH OPERATION

NOTE

1. TAILING POND LAYOUT AND DETAILS ARE IN ACCORDANCE WITH CRITERIA AS SPECIFIED BY AMERICAN SMELTING AND REFINING COMPANY.
2. STARTER DAM EMBANKMENT DESIGN AND DETAILS ARE IN ACCORDANCE WITH CRITERIA SPECIFIED IN THE FINAL SOIL AND FOUNDATION REPORT - TAILING DAM AND STARTER DIKE, PREPARED FOR A.S.A.R.C.O. BY SERGENT, HAUSKINS AND BECKWITH, CONSULTING SOIL AND FOUNDATION ENGINEERS.
3. FINAL ELEVATIONS AND COORDINATES MUST BE CONFIRMED IN THE FIELD.



PLAN - FINAL DISPOSAL

APPROVED
for
CONSTRUCTION

1820-F-6

REFERENCES	DWG. NO.	TITLE
	SAC 309-2C	STARTER DAM DETAILS 1 of 2
	-3C	" " " 2 of 2
	-4C	DECANT SYSTEM
	-5C	CAPACITY CURVE
	-6C	COLLECTION POND DETAILS

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	JHT	11-9	PRELIMINARY
	B	JHT	11-13-73	ISSUED FOR APPROVAL
	C	JHT	11-12-73	ISSUED FOR CONSTRUCTION
	1	JHT	2-15-73	GENERAL REVISION
	2	JHT	5-12-73	REVISED FOR NEW LOCATION

REVISIONS	NO.	BY	DATE	DESCRIPTION
	3	JT	4-6-73	REVISED FOR NEW FINAL DISPOSAL
	4	DAM	4-25-73	ELECTRICAL S PIPING

	BY	DATE
DESIGNED		
DRAWN	TINTO	12-1-72
CHECKED	J. LEE	2-20-72
APPROVED 1		
APPROVED 2		3-12-73
APPROVED 3		9-18-73

DATE TO	A	B	C	0	1	2	3	4	5	6	7
CLIENT	1/1	1/2			1/2	3/5	4/1				
FIELD					1/2	1/2					
MICROFILM					1/2	1/2		1/11			

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2112

N Y APPROP. NO.	PLANT NO.	C. E. PROJECT NO.	DRAWING CLASSIFICATION AREAS

SACATON PROJECT
TAILING DISPOSAL
GENERAL PLAN

SCALE 1" = 400'

DRAWING NUMBER
SAC 309-1C

REV. A

REFERENCE	ITEM
1820-F	Horizontal grid or coordinate system plan at a scale of 1" = 30' showing all processing, storage or disposal facilities; grid not to exceed 200 foot square sections

Does not apply to disposal of homogeneous materials.

REFERENCE	ITEM
1820-F	Vertical grid or coordinate system plan at a scale of 1" = 30'; grid to correlate with horizontal grid system; units not to exceed 5' in vertical height

Does not apply to disposal of homogeneous materials.

REFERENCE	ITEM
1820-C-1	Location of the proposed facility

The tailings dam is situated at latitude 32°57'20"N, longitude 111°50'00".

REFERENCE ITEM

1820-C-2 Description of all equipment and machinery used for storage, treatment and/or disposal purposes

The final mill tailings is fed to the center of the 275 foot diameter Eimco traction thickener. The clear water overflow is returned to the mill water circuit to be reused. The thickened underflow, at approximately 50 percent solids, is pumped to the tailings dam by two Allen-Sherman-Hoff D-6-5 pumps located in series. A standby set of pumps is also installed.

A cement box allows the tailings to be pumped into two separate lines, isolated by knife-gate valves. From the knife gate valves the tailings is piped around the dam in class 100 cement-asbestos pipe. Every 52 feet is a four inch diameter outlet with a plug valve. The tailings is distributed around the dam perimeter by opening the desired four inch outlet valves. The tailings from the valve to the top of the dam is handled in schedule 40 steel pipe.

Water is reclaimed from the center of the dam through a 36 inch diameter steel pipe decant tower. The 3/16" wall thickness pipe is encased in five foot square steel re-inforced concrete. Water flows into the tower through six inch diameter schedule 40 steel pipe nipples located on six inch centers on adjacent sides of the square decant tower. The water is carried to the reclaim pond through a 16 inch diameter steel pipe of 1/16" wall thickness encased in 2'10" square steel reinforced concrete that was constructed flush with the ground in compacted soil.

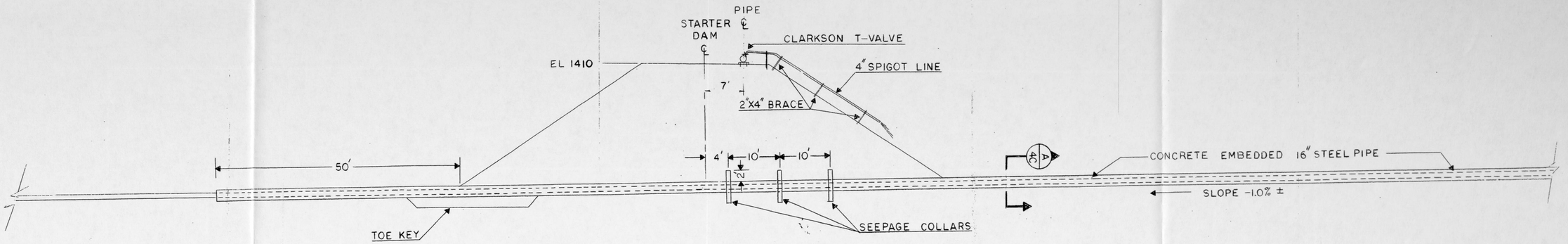
The 200 foot by 100 foot by 7 foot deep reclaim pond holds approximately 1,000,000 gallons when full. Seepage is prevented by use of a soil sealant. The water is returned to the mill through a 12 inch diameter steel pipe.

Presently the mill tailings is classified with cyclones along the periphery of the dam. The coarse fraction is used to build up the side of the dam while the finer fraction flows towards the dam center.

REFERENCE	ITEM
1820-C-2	Specifications for storage, treatment and/or disposal facilities

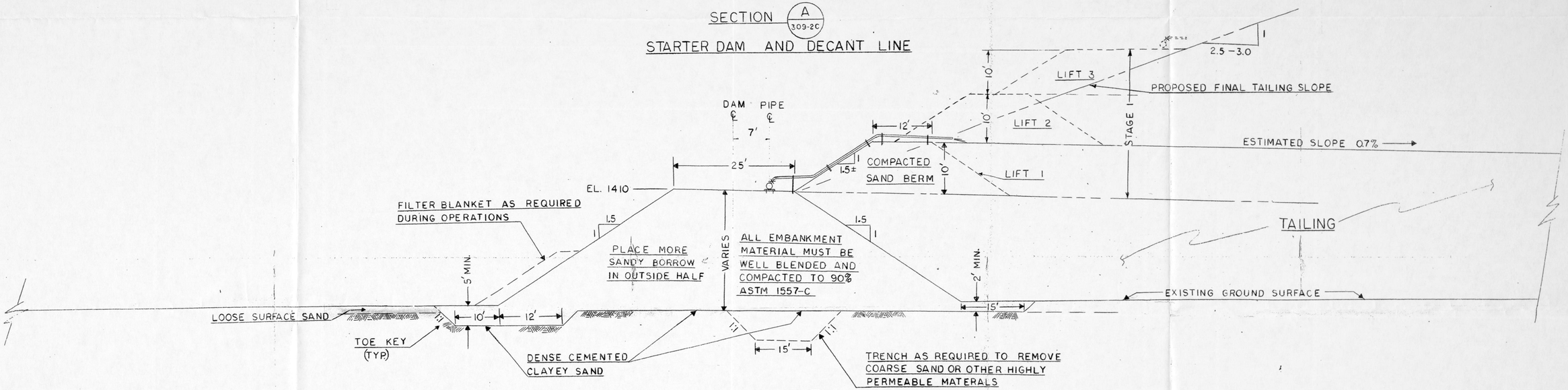
See the attached drawing marked 1820-C-2.

DRAWING NO. SAC 309-3C



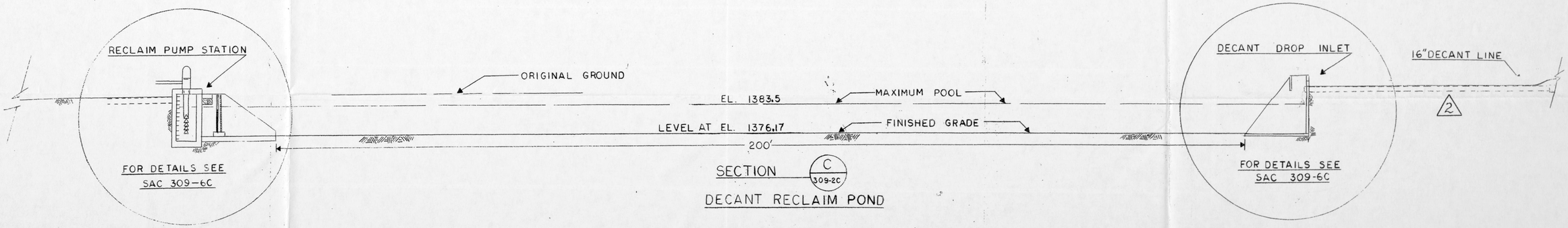
SECTION A 309-2C

STARTER DAM AND DECANT LINE



SECTION B 309-2C

STAGE I SAND BERMS BY OPERATIONS



SECTION C 309-2C

DECANT RECLAIM POND

1820-F-5
1820-C-2

APPROVED for CONSTRUCTION

REFERENCES	DWG. NO.	TITLE
	309 C1C	TAILING DISPOSAL-GENERAL PLAN

REVISIONS	NO.	BY	DATE	DESCRIPTION
	A	J.H.T.	12-15-72	PRELIMINARY
	B	JHT	1-3-73	ISSUED FOR APPROVAL
	O	JT/G/P	1-12-73	ISSUED FOR CONSTRUCTION
	1	JHT	3-12-73	REVISED FOR NEW LOCATION
	2	DAM	4-30-73	DECANT LINE SUBSURFACE

REVISIONS	NO.	BY	DATE	DESCRIPTION

	BY	DATE
DESIGNED		
DRAWN	TINTO	11-30-72
CHECKED	J. LEE	12-20-72
APPROVED 1		1-12-73
APPROVED 2		1-12-73
APPROVED 3		1-12-73

DATE TO	A	B	C	O	1	2	3	4	5	6	7
CLIENT	1/1	1/1		1/1	3/4						
FIELD				1/1							
MICROFILM				1/1	3/4						

AMERICAN SMELTING & REFINING COMPANY
CENTRAL ENGINEERING DEPARTMENT
SACATON UNIT
514 CRANDALL BLDG. SALT LAKE CITY, UTAH 84101

ARTHUR G. McKEE & COMPANY
WESTERN KNAPP ENGINEERING DIVISION
SAN FRANCISCO CALIFORNIA

CONTRACT 2112

N Y APPROP. NO. | PLANT NO. | C. E. PROJECT NO. | DRAWING CLASSIFICATION AREAS

SACATON PROJECT
TAILING DISPOSAL
STARTER DAM DETAILS
Sheet 2 of 2

SCALE 1" = 10'

DRAWING NUMBER SAC 309-3C

REV. A

REFERENCE	ITEM
1820-C-3	Description of all private or public roads, rail lines, easements, pipelines and utilities located within site boundaries

Bianco County Road runs north from Maricopa Road to Township line between 5S and 6S. A private road continues to the plantsite.

A.P.S. 115KV power line runs from ½ mile west of tailings pond in an eastern direction to the southeast corner of the tailings dam. A line branches off running north to the site substation. The A.P.S. line continues east across Bianco Road then south parallel to the road to a point south of the mine dumps where it goes east and continues off the property to the Vista substation north of Casa Grande.

B.I.A. 69KV power line runs north along Bianco Road, around plantsite to the west, continuing north to Indian Reservation.

A buried telephone line runs along Val Vista Road to Bianco Road, south to plantsite. This is for the plant use only. Buried water line runs along Val Vista Road west to Bianco Road, south to plantsite. This is for plant use only.

A southern Pacific railroad spur runs north into plantsite. The track is next to Bianco Road and is for plant use only.

REFERENCE	ITEM
1820-C-4	Description of all land use within one mile of facility boundary

Sacaton Unit is located at the lower end of "Phoenix Desert Shrub Environmental Zone."

All the land around Sacaton property is raw desert, except for the SE¼ of Sec. 33 T5S; R5E and Sec. 19 T5S; R6E where there has been subdividing. Only a pig farm is in Sec. 33. Indian Hills subdivision has been developed in Sec. 19.

REFERENCE	ITEM
1820-C-4	Description of all state and local land use restrictions in effect within one mile of facility boundary

There are no restrictions. As per Pinal County Planning and Zoning Department as listed in State Court Art. 3, Sec. 303-16, Chapter 58, laws 1949, A.R.S. Sec. 11-830.

REFERENCE	ITEM
1820-C-5	Projected life of the facility, expressed in both years and capacity

It is anticipated that 10 years of operating life remains and that an additional 26,700,000 tons of tailings will be placed in the tailings dam. It is not presently anticipated that this will be extended.

REFERENCE	ITEM
1820-C-5	Potential for future expansion and/or modification of the facility

There are presently no plans to extend the life of the facility beyond that previously listed.

REFERENCE	ITEM
1820-C-6	Proximity to human habitation and/or population centers within 10 miles of the facility boundary line and population of such centers

	Direction from Plantsite	Population
Casa Grande	Southeast	14,965
Stanfield	Southwest	1,000

An additional estimated 4,000 people live in unincorporated subdivisions and scattered farms, ranches and homes within 10 miles of the facility boundaries.

REFERENCE	ITEM
1820-C-7	Alternate methods considered for treatment, recovery or recycling

There are none being considered.

REFERENCE	ITEM
1820-C-8	Description of applications submitted to or permits obtained from any local, state or federal agency enforcing environmental quality programs

1. Pinal-Gila Counties Air Quality Control District permit to operate has been issued.

2. E.P.A. interim status application is in process.

REFERENCE	ITEM
1820-C-9	Legal or survey description of the land comprising the facility

The tailings dam is located in Township 5 South, Range 5 East and is the south ½ of Section 27 and the north ½ of Section 34. The tailings thickener is located in the south ½ east ½ of Section 27. Range and Township are from the Gila and Salt River Base and Meridian.

REFERENCE	ITEM
1820-C-9	Description of the site geology, hydrology and climate

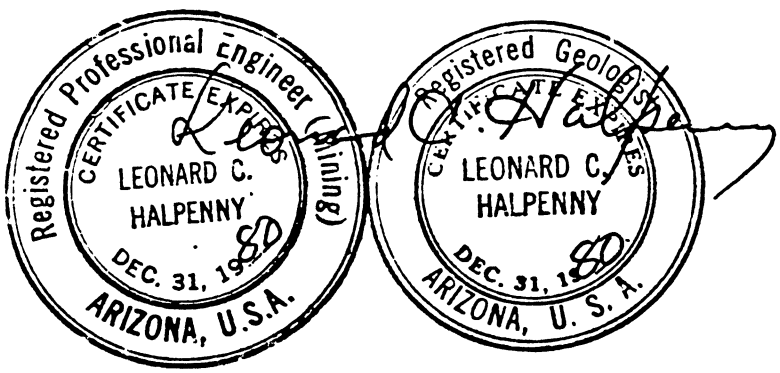
Refer to the attached report from the Water Development Company.

WATER DEVELOPMENT CORPORATION

GEOLOGY AND HYDROLOGY OF ASARCO SACATON MINE UNIT, PINAL COUNTY, ARIZONA

By

Sheldon D. Clark



Tucson, Arizona
October 1980

(AS-40 attach)

CONTENTS

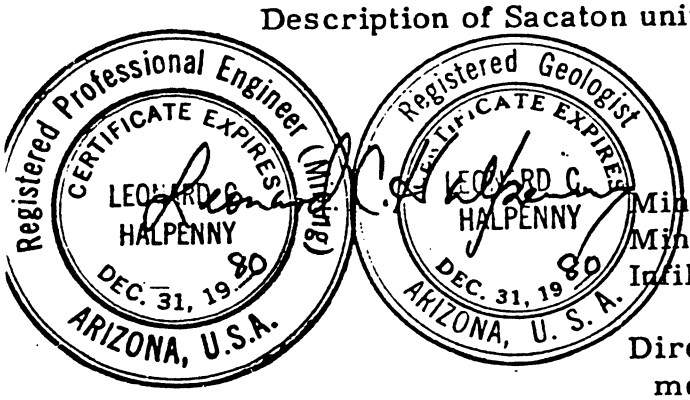
	Page
Introduction	1-1
Location and description of area	2-1
Physiography	2-3
Climate	2-4
Geology	3-1
Regional	3-1
Local geology	3-3
Hydrology	4-1
Surface water	4-1
Groundwater hydrology	4-8
Description of groundwater system	4-8
System boundaries	4-9
Description of aquifer units	4-10
Local gravel unit	4-10
Lower sand and gravel unit	4-10
Silt and clay unit	4-11
Upper sand and gravel	4-11
History of deposition	4-12
Movement of groundwater	4-12
Analysis of regional aquifer network	4-13
Hydrologic parameters	4-13
Specific capacity	4-14
Storage coefficient	4-15
Development of groundwater	4-16
History of groundwater development for irrigation	4-16
Annual production of groundwater	4-16
Changes in groundwater movement	4-17
Declines and water level fluctuations	4-19
Quality of groundwater	4-20
Correlation of water quality with aquifer units	4-20
Changes in water quality	4-21
Description of Sacaton unit hydrology	4-23
Surface water	4-23
Flood potential	4-23
Groundwater	4-23
Mine water supply	4-24

Registered Professional Engineer (Mining) CERTIFICATE EXPIRES DEC. 31, 19 80 LEONARD C. HALPENNY ARIZONA, U.S.A.

Registered Geologist CERTIFICATE EXPIRES DEC. 31, 19 80 LEONARD C. HALPENNY ARIZONA, U.S.A.

CONTENTS
(continued)

	Page
Description of Sacaton unit hydrology (cont.)	
Location	4-24
Annual water production	4-24
Regional effect of mine withdrawal	4-24
Mine water consumption	4-25
Mine water disposal	4-25
Infiltration from tailing pond area	4-25
Quality of tailings pond water	4-26
Direction of groundwater movement	4-26
Tailing pond monitor system	4-28
Location of monitor well	4-28
Monitor well construction	4-28
Sample withdrawal	4-31
Frequency of sampling	4-31
Constituents analyzed	4-31
Results of sampling program	4-32
References cited	5-1



FIGURES

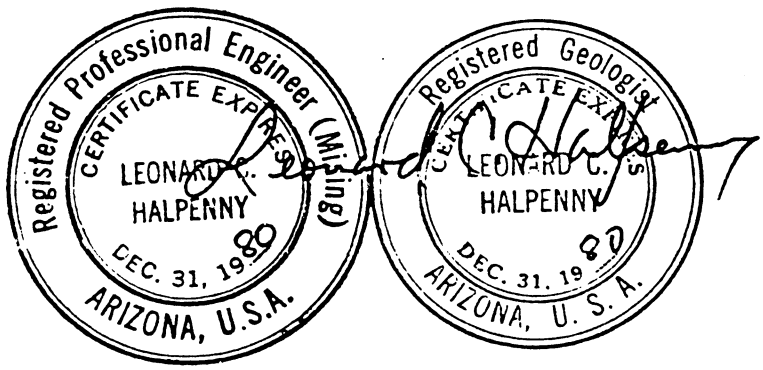
1.	Index map of Arizona showing location of area discussed in this report	2-2
2.	Mean monthly precipitation in inches, Casa Grande station period 1970 thru 1979	2-12
3.	Mean monthly precipitation in inches, Sacaton Mine, period 1970 thru 1079	2-20
4.	Mean monthly discharge, Santa Rosa Wash near Vaiva Vo, Arizona (cfs), period 1955 thru 1957	4-4
5.	Mean monthly discharge, Santa Cruz River near Laveen, Arizona (cfs), period 1948 thru 1977	4-7

TABLES

1.	Climatological data Casa Grande station	2-6
2.	Climatological data Sacaton Mine	2-14
3.	Comparison of total annual precipitation at Casa Grande and Sacaton Mine	2-21

TABLES
(continued)

		Page
4.	Mean discharge of Santa Rosa Wash near Vaiva Vo, Arizona	4-3
5.	Mean discharge of Santa Cruz River near Laveen, Arizona, 1948-1978	4-5
6.	Estimated groundwater pumpage in the Lower Santa Cruz area	4-18
7.	Analyses of Casa Grande ridge water and bedrock water	4-22
8.	Analysis of tailing pond decant water	4-27
9.	Driller's log Sacaton monitor well	4-29
10.	Field geologic log Sacaton monitor well	4-30
11.	Analyses of samples from Sacaton monitor well	4-33



GEOLOGY AND HYDROLOGY OF ASARCO SACATON MINE UNIT, PINAL COUNTY, ARIZONA

By

Sheldon D. Clark

INTRODUCTION

This report was prepared by Water Development Corporation at the request of ASARCO, Incorporated, as partial fulfillment of a Hazardous Waste Facility Permit application. The report provides detailed information on the climate, geology and hydrology of the Lower Santa Cruz River Basin, and Sacaton Mine site as required under Section 1820 of the State of Arizona Hazardous Waste Regulations.

LOCATION AND DESCRIPTION OF AREA

The area discussed in this report is located in western Pinal County in the Basin and Range lowlands province of Arizona (see Fig. 1). The area is within the lower Santa Cruz Basin, and roughly occupies Section 25, Section 26, the south half of Section 27, the north half of Section 34, Section 35, and Section 36 of Township 5 South, Range 5 East, and the north half of Section 3 of Township 6 South, Range 5 East, Gila and Salt Rivers Meridian and Base Line. The area south, southeast and southwest of the Sacaton Unit supports large scale agricultural production, sustained primarily by groundwater pumped from wells with the exception of approximately 16 sections of land lying south, southeast and southwest of Casa Grande. This land is under the San Carlos Irrigation Project and receives surface waters from the adjacent Gila River Valley via the Florence-Casa Grande Canal. Agriculture is the principle industry in the vicinity of the Sacaton Unit. The scale of agricultural production ranges from small farms of perhaps 320 acres to large corporate farms totalling thousands of acres. The principal crop produced is cotton, however, production of grain sorghum, alfalfa, citrus, and livestock are important components of agricultural production in the region. The major population center near the Sacaton Unit is Casa Grande located approximately 7 miles southeast of the mine. North of the mine area approximately two miles lies the Gila Indian Reservation.

The initial phase of development of the Sacaton Unit began with preparation of the west ore-body by open pit mining techniques. The pit is located in the south half of Section 26, and the north half of Section 34, Township 5 South, Range 5 East. Development of the pit required removal of approximately 250 feet of alluvium, conglomerate and barren rock to reach the top of the ore body. On completion, the pit will be circular with a surface diameter of approximately 3,000 feet, and a depth of 980 feet. Overburden dumps are located in most of the Section 34 Township 5 South, Range 5 East, and in the northern portion of Section 3, Township 6 South, Range 5 East. The Sacaton Unit tailing pond covers most of Sections 27 and 34 Township 5 South, Range 5 East. The remaining components of the mining unit including crushers, the concentrator, thickeners, and administrative facilities are located in the southeast quarter of Section 27, Township 5 South, Range 5 East. The remainder of the mine property is retained as buffer lands to prevent encroachment on mine facilities. Total land holdings at the Sacaton Unit amount to approximately 6,500 acres, including retired agricultural land located 5 miles east of the mine site which is used as a water farm. More detail on the water farm will be developed in subsequent sections of this report. Future development plans at the Sacaton Unit include development of a deep ore-body by underground mining techniques

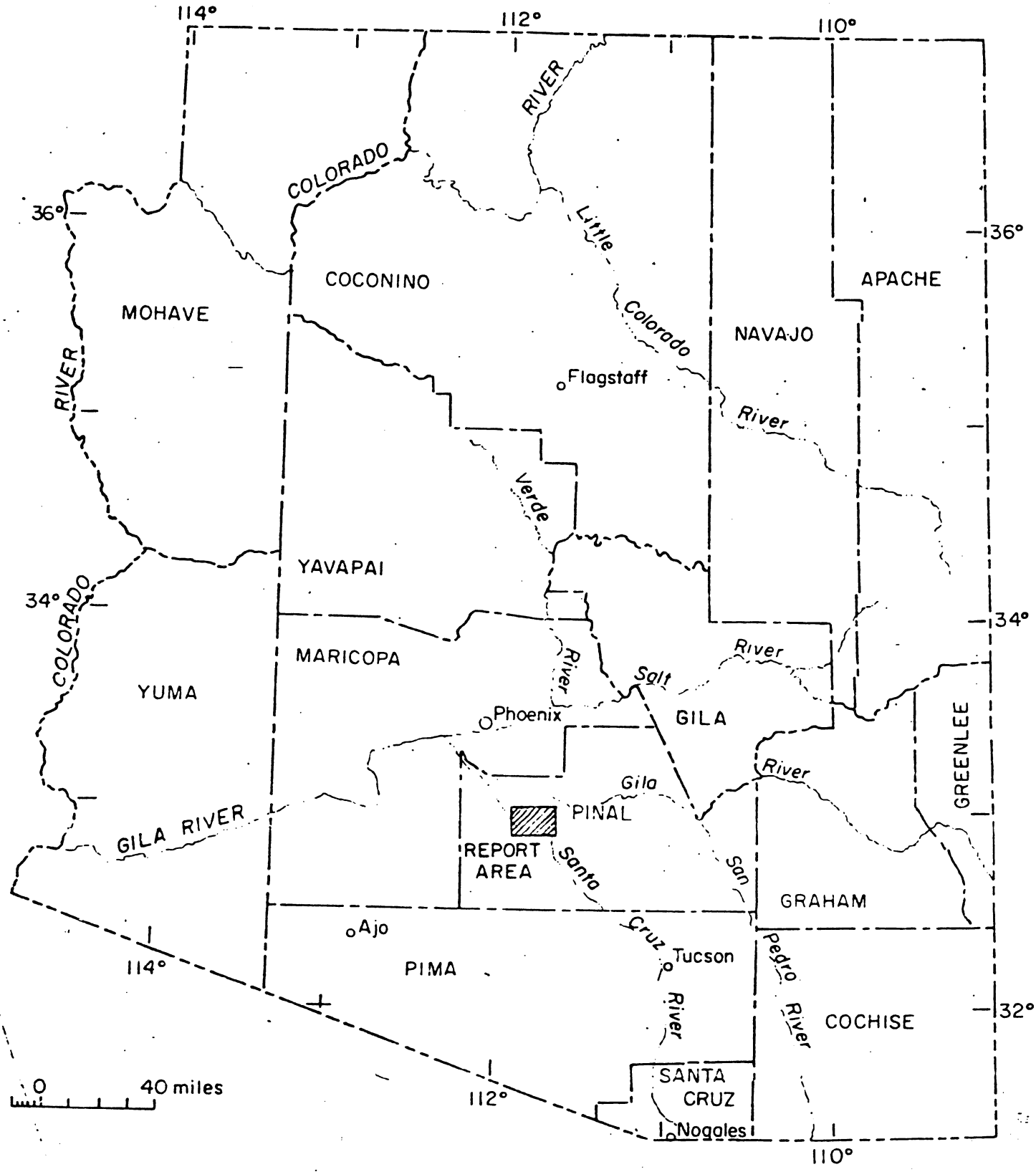


FIGURE 1.--INDEX MAP OF ARIZONA SHOWING LOCATION OF AREA DISCUSSED IN THIS REPORT.

Physiography

As mentioned in the introduction to this section the Sacaton Unit is within the Basin and Range Province. The area is more specifically categorized as the Sonoran Desert Section of the Basin and Range Province, and is characterized by broad, level valley plains, gently sloping pediments or fans and widely separated mountain ranges. Isolated buttes occur within the valley plain, and are indicative of major controlling features in the hydrologic regime. Fans, pediments or eroded rock surfaces ranging in nature from semi-planar to hill-contour type, originate along the mountain fronts, slope gently outward and grade into or disappear beneath the valley alluvium.

Elevations in the area range from a high of 2,800 feet above sea level in the Sacaton Mountains to a low of approximately 1,320 feet above sea level near the banks of the North Branch of the Santa Cruz River. Due to the arid climate in the region of the study area, development of rich soil profiles is very limited. The soil profiles on the valley plain adjacent to the Santa Cruz Wash are deep, medium textured to very fine grained or silty soils. On the fans and pediments deep coarse grained to gravely soils predominate. The soils in the areas immediately adjacent to the Sacaton Unit are Typic Torrifluvents-Antho Valencia Series to the northwest, Typic Paleorthids-Coolidge-Cavelt Series to the north, on the flank of the Sacaton Mountains, and Typic Natragids-Casa Grande Series to the east and south of the mine site. The results of more detailed investigation of soils in the mine site, indicates these soils are Typic Natragids-Casa Grande Series. These soils originated from old, mixed alluvium and are classifed as a coarse loam in texture (66% sand, 17% silt and 17% clay). Chemical analyses of soils on the mine site indicate very low levels of available plant nutrients.

The flora of the area is also controlled by the arid climate, and is commonly characterized as desert scrub vegetation. Dominant genera in the mine area include Atriplex (salt brush), Ephedra (mormon tea), Prosopis (mesquite), Cercidium (palo verde), Baccharis (desert broom) and Larrea (creosote). Important grasses found in the mine area include Bracharia (sand hill grass) and Sphaerlcea (globe mallow). In most of the lower Santa Cruz Valley, the Sacaton Mine area included, cover density is relatively sparse ranging from 10 to 15 percent. Localized areas adjacent to surface waters or shallow groundwater often support stands of Tamarix (salt cedar) and Prosopis with cover densitites ranging from 75 to 100 percent.

The principal drainage feature in the vicinity of the Sacaton Unit is the Santa Cruz River. The entire Santa Cruz River Basin includes approximately 9,210 square miles in Arizona, and 400 square miles in Mexico. For purposes of resource management, the Santa Cruz Basin is generally divided into an upper and a lower basin. The Upper Santa Cruz Basin consists of the area from the headwaters of the Santa Cruz River to the Rillito narrows near Tucson. The Lower Santa Cruz Basin consists of the balance of the drainage area, from the Rillito narrows to the confluence with the Gila River, approximately 35 miles northwest of the Sacaton Unit. Given the large areal extent of the Santa Cruz River Basin, the basin characteristics differ significantly from one reach of the river to another making it difficult to develop basin characteristics to describe the basin as a whole. The Sacaton Mine Unit is within a reach of the Santa Cruz River between the gaging station at Cortaro, and the gaging station at Laveen. The area drained between these stations is approximately 5,000 square miles including the area drained by Brawley Wash and Santa Rosa Wash, the only major tributaries to the Santa Cruz River below below Cortaro. The upper reaches of Brawley Wash are drained by Altar Wash which drains the east flank of the Baboquivari Mountains, and the west slope of the Cerro Colorado and the Sierrita Mountains. Santa Rosa Wash heads in the north Comobabi Mountains. Unit runoff at Santa Rosa Wash near Sells is 7.8 acre-feet per square mile, and for the Santa Cruz Wash near Laveen, 1.8 acre feet per square mile. The valley in the vicinity of the report area is drained by the North Branch of the Santa Cruz River. In this reach, the river retains a braided bed character, typical of desert streams, and is neither perennial nor entrenched.

Climate

Arizona's climate pattern is characterized as a biseasonal regime, composed of periods of winter precipitation followed by spring drought; and summer precipitation followed by fall drought. Generally the spring drought is associated with high temperatures, at times ranging up to 120° F, and is the more severe of the drought periods.

Arizona's biseasonal precipitation events come from northwesterly directions in the winter months and from southerly directions in the summer months. The summer precipitation is characteristically local as opposed to widespread. These storms are convectional in nature and usually very intense, frequently causing local flooding. The source of these storms is moist tropical air either from the Gulf of Mexico or the Gulf of California, which rises rapidly, cools and condenses as it travels over hot, mountainous terrain.

The summer rainfall season ranges from mid-June to mid-October, though summer storms usually do not begin before the middle of July. April, May and June are characteristically the driest months of the year.

Winter precipitation events are associated with westerly winds which often bring Polar Pacific air moisture into the state. The same processes of heating of the air mass which rises, cools and condenses, take place during winter storms but to a lesser degree due to cooler winter temperatures. Accordingly, winter storms are not as intense as summer storms, but are of a vast areal extent frequently covering the entire state for several days. The past several winters have brought an anomalously high number of these frontal systems through Arizona resulting in widespread flooding of major proportion.

Temperatures around the State of Arizona are controlled largely by differences in elevation. The state is divided roughly in half by the northwesterly to southeasterly trending Mogollon Rim, with the southwestern portion of the state experiencing higher temperatures associated with the lower elevations of this area while the higher northeastern half of the state experiences cooler temperatures,

Climatic data in the vicinity of the Sacaton Unit are available from two sources; a National Oceanic and Atmospheric Administration weather station located in the town of Casa Grande, and a weather station operated at the Sacaton Unit. Temperature and precipitation measurements at the Casa Grande station cover a period of 80 years, beginning in 1899. Determinations of sunshine, wind, relative humidity, and evaporation have not been made at this station.

The average precipitation at Casa Grande for the ten year period 1970 through 1979 is 8.6 inches as shown on Table 1 and Figure 2. Mean monthly precipitation for the same period indicates the annual precipitation is distributed roughly in accordance to the biseasonal pattern described earlier. The absence of a conspicuous fall drought period is attributed to unseasonably wet falls in the years 1972 and 1978 (see Fig. 2). The annual spring drought during the months of April, May, and June is well doucmented (see Fig. 2). Summer precipitation occurs primarily in the month of August (mean monthly precipitation 1.89 inches) with roughly equal amounts occurring in the months of July and September. Winter precipitation events are fairly evenly distributed throughout the winter months.

Temperature extremes are very evident at the Casa Grande station, with temperatures ranging from 117° F to 19° F. The average January temperature is approximately 49° F, and the average July temperature is 95° F. Approximately 150 days a year temperatures exceed 90° F, and an average

TABLE 1

CLIMATOLOGICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1970			
January	0.00	0.00	77.0	25.0	67.5	36.7
February	0.23	0.23	84.0	29.0	75.3	42.5
March	1.64	0.81	85.0	34.0	75.6	44.2
April	0.11	0.06	92.0	38.0	81.5	46.2
May	0.00	0.00	113.0	44.0	97.2	60.9
June	0.02	0.02	116.0	55.0	103.9	69.5
July	0.83	0.75	113.0	56.0	107.3	77.3
August	1.43	1.36	110.0	69.0	104.2	77.4
September	1.79	0.84	110.0	47.0	95.5	65.7
October	0.00	0.00	96.0	38.0	85.5	51.5
November	0.04	0.04	88.0	36.0	78.1	44.4
December	0.38	0.13	79.0	31.0	65.4	37.3
			1971			
January	0.00	0.00	86.0	19.0	69.9	33.7
February	0.32	0.24	86.0	31.0	72.6	38.4
March	0.00	0.00	96.0	27.0	82.2	43.2
April	0.17	0.17	97.0	41.0	85.2	48.6
May	0.00	0.00	100.0	39.0	92.5	54.6
June	0.00	0.00	110.0	49.0	102.9	66.7
July	0.80	0.72	113.0	61.0	107.7	77.2
August	6.22	2.60	106.0	-	100.8	71.9
September	1.80	0.82	108.0	51.0	98.8	66.3

TABLE 1
(cont.)
CLIMATOLOGICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1971 (cont.)			
October	1.11	0.60	97.0	29.0	82.8	51.7
November	T	T	88.0	33.0	74.7	41.2
December	0.49	0.20	-	28.0	-	-
			1972			
January	0.00	0.00	78.0	23.0	68.3	33.4
February	0.00	0.00	89.0	25.0	77.0	38.5
March	0.00	0.00	101.0	33.0	77.0	38.5
April	0.00	0.00	96.0	40.0	88.0	48.9
May	0.34	0.29	101.0	49.0	94.6	57.8
June	0.68	0.29	113.0	54.0	102.0	70.1
July	0.49	0.44	114.0	61.0	108.2	78.2
August	3.99	1.72	110.0	67.0	103.0	73.3
September	0.00	0.00	107.0	48.0	99.6	66.1
October	3.70	1.84	106.0	43.0	84.9	58.7
November	1.75	0.88	89.0	32.0	71.1	41.3
December	1.10	-	-	-	-	-
			1973			
January	0.04	0.04	77.0	28.0	63.8	36.2
February	1.80	0.68	79.0	31.0	68.0	42.9
March	2.62	0.589	79.0	35.0	68.5	42.3

TABLE 1
(cont.)
CLIMATOLOGICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1973 (cont.)			
April	0.00	0.00	98.0	39.0	82.4	50.0
May	0.12	0.12	105.0	46.0	96.3	60.4
June	0.12	0.12	115.0	57.0	104.2	68.2
July	0.15	0.07	114.0	66.0	106.5	77.2
August	0.15	0.10	111.0	70.0	105.7	76.6
September	0.00	0.00	108.0	53.0	101.4	64.6
October	0.00	0.00	101.0	38.0	92.3	50.0
November	1.14	0.45	88.0	30.0	75.5	39.7
December	0.00	0.00	83.0	25.0	70.1	32.7
			1974			
January	0.61	0.23	77.0	22.0	65.8	34.9
February	T	T	85.0	24.0	71.9	33.5
March	0.75	0.34	90.0	30.0	78.7	43.9
April	0.00	0.00	95.0	38.0	87.1	46.8
May	0.00	0.00	110.0	44.0	97.2	56.8
June	0.00	0.00	115.0	55.0	108.5	69.1
July	2.98	1.44	111.0	64.0	103.3	72.7
August	1.21	1.03	107.0	59.0	103.0	68.8
September	0.40	0.31	107.0	62.0	97.2	68.3
October	1.49	0.69	102.0	48.0	88.6	60.5
November	0.02	0.03	-	-	-	-
December	0.20	0.17	73.0	15.0	61.7	31.0

TABLE 1
(cont.)
CLIMATOLOGICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1975			
January	0.08	0.04	79.0	20.0	66.1	32.1
February	0.65	0.40	80.0	26.0	67.9	33.5
March	0.85	-	-	-	-	-
April	0.60	0.38	91.0	35.0	78.7	42.4
May	0.00	0.00	103.0	36.0	91.9	51.4
June	0.00	0.00	109.0	55.0	103.4	61.6
July	0.15	0.08	111.0	62.0	104.7	74.5
August	0.21	0.15	113.0	59.0	105.5	71.3
September	0.66	-	-	-	-	-
October	0.00	0.00	101.0	31.0	90.1	48.4
November	1.19	0.68	93.0	29.0	76.8	38.7
December	0.70	0.65	78.0	27.0	65.1	35.9
			1976			
January	0.00	0.00	82.0	19.0	68.5	34.2
February	0.31	0.30	86.0	31.0	74.0	42.9
March	0.52	0.37	87.0	32.0	75.3	40.9
April	0.52	0.47	95.0	38.0	83.8	47.0
May	0.30	0.30	110.0	58.4	98.0	58.4
June	0.03	0.03	114.0	53.0	105.0	63.5
July	0.71	0.42	114.0	68.0	105.2	75.8
August	0.91	0.33	113.0	59.0	104.0	68.8
September	1.91	1.59	101.0	53.0	93.3	62.9

TABLE 1
(cont.)
CLIMATOLOGICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1976 (cont.)			
October	0.20	0.12	96.0	37.0	83.1	51.1
November	0.73	0.73	87.0	23.0	74.3	39.6
December	0.42	0.30	76.0	21.0	65.7	31.0
			1977			
January	1.27	0.58	74.0	23.0	61.0	35.1
February	0.01	0.01	82.0	24.0	71.9	33.2
March	0.54	0.34	88.0	24.0	72.2	36.6
April	0.07	0.06	97.0	31.0	86.9	45.7
May	0.01	0.01	106.0	40.0	88.7	50.7
June	0.03	0.03	114.0	55.0	105.2	65.9
July	0.56	0.36	111.0	69.0	106.2	77.1
August	0.19	0.19	112.0	67.0	104.9	76.3
September	1.06	0.59	109.0	55.0	99.1	68.9
October	0.99	0.47	101.0	45.0	90.0	57.9
November	0.14	0.14	87.0	34.0	76.7	41.6
December	0.94	-	-	-	-	-
			1978			
January	1.63	0.69	75.0	27.0	65.6	39.5
February	2.23	1.28	80.0	29.0	69.8	40.0
March	2.35	-	-	-	-	-

TABLE 1
(cont.)
CLIMATOLOTICAL DATA
CASA GRANDE STATION

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1978 (cont.)			
April	0.40	-	-	-	-	-
May	0.03	-	-	-	-	-
June	0.19	0.19	115.0	48.0	109.3	64.8
July	0.16	0.12	116.0	58.0	109.7	73.5
August	1.30	-	-	-	-	-
September	0.05	-	-	-	-	-
October	1.23	-	-	-	-	-
November	2.46	-	-	-	-	-
December	3.15	-	-	-	-	-
			1979			
January	3.01	1.05	71.0	21.0	59.8	36.0
February	0.22	0.12	81.0	28.0	70.0	35.6
March	1.88	0.86	87.0	30.0	74.9	39.7
April	0.10	0.10	98.0	29.0	88.6	45.4
May	0.64	0.49	107.0	42.0	95.2	57.4
June	0.22	0.22	119.0	53.0	106.9	65.2
July	0.62	0.29	117.0	59.0	109.5	71.7
August	3.25	1.59	110.0	57.0	102.8	68.2
September	T	T	110.0	59.0	103.2	67.1
October	0.05	0.05	105.0	35.0	93.7	52.0
November	T	T	86.0	22.0	75.0	36.9
December	0.13	0.06	83.0	26.0	72.0	36.6

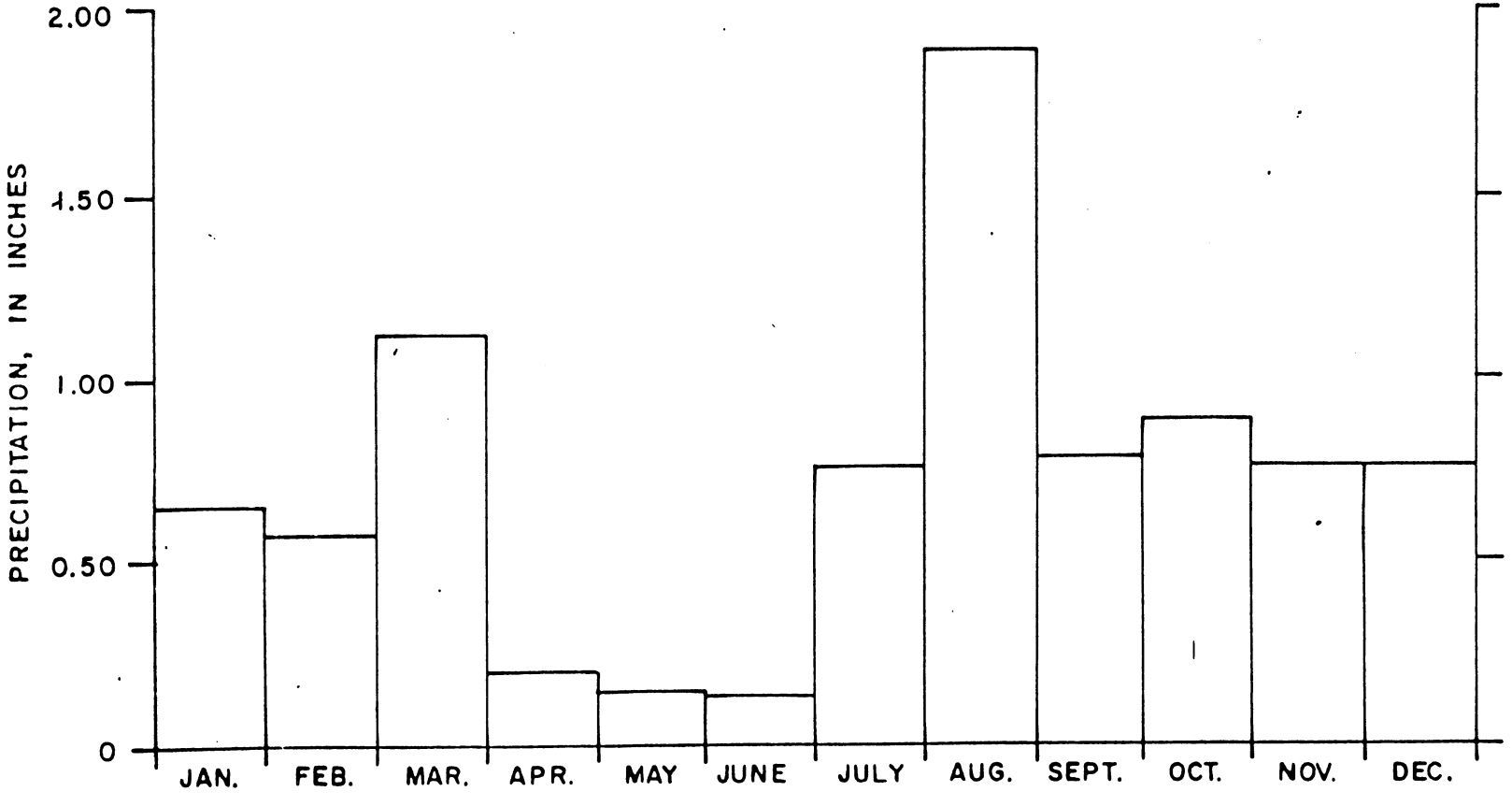


FIGURE 2.-- MEAN MONTHLY PRECIPITATION IN INCHES, CASA GRANDE STATION. PERIOD 1970 THRU 1979.

of 10 days per year of freezing temperatures are recorded at the Casa Grande Station. The area around Casa Grande is subject to periodic dry winds and intense solar radiation. Exact measurements of these parameters are not available. The annual potential evaporation is approximately 120 inches, and the growing season ranges from 300 to 340 days per year.

The average precipitation at the Sacaton Mine for the seven year period 1973 through 1979 is 7.8 inches as shown on Table 2 and Figure 3. Mean monthly precipitation for the same period reflects the same biseasonal distribution evident at the Casa Grande station, with slightly more precipitation occurring during the winter months. The period of record available for the Sacaton Mine station is not sufficiently long to develop correlations between the two stations.

The temperature data for the Sacaton unit indicates the same extremes in data as the Casa Grande station. Generally the extremes and average high and low temperature at the Sacaton Mine station are a few degrees cooler than the Casa Grande station. This is due primarily to the slightly higher elevation of the Sacaton unit.

Table 3 is a comparison of annual total precipitation for the two stations. While the stations are less than 5 miles apart the variability of rainfall distribution is quite evident based on the comparisons of annual totals. The similarity in totals for the years 1977 and 1978 is a result of extensive winter precipitation during these two years. These storms are generally of a very uniform character and precipitation from such events is usually quite uniform barring any extremes in elevation.

TABLE 2

CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1972			
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	-	-	-	-	-	-
June	-	-	-	-	-	-
July	-	-	-	-	-	-
August	-	-	-	-	-	-
September	0.17	0.13	102	56	96.5	66.4
October	2.97	0.91	102	34	80.7	51.2
November	1.49	0.75	82	32	67.0	39.9
December	0.82	0.38	73	27	59.5	34.3
			1973			
January	0.03	0.02	74	26	62.7	34.7
February	1.28	0.88	74	32	64.9	41.1
March	1.54	0.45	75	35	65.0	41.0
April	0.01	0.01	98	38	79.4	48.3
May	0.09	0.09	107	52	93.8	62.8
June	0.05	0.03	114	60	104.5	73.1

TABLE 2
(cont.)
CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1973 (cont.)			
July	0.34	0.14	113	70	104.8	78.0
August	0.09	0.05	110	69	104.3	76.4
September	0.00	0.00	108	60	99.3	67.5
October	0.00	0.00	99	45	89.4	55.0
November	0.83	0.37	88	32	74.7	43.6
December	0.00	0.00	80	29	68.9	37.1
			1974			
January	0.77	0.32	76	35	63.5	37.8
February	0.01	0.01	81	30	71.0	38.0
March	0.58	0.17	88	35	77.1	47.0
April	0.00	0.00	43	43	84.2	53.2
May	0.00	0.00	108	48	94.1	62.2
June	0.00	0.00	116	65	106.3	75.2
July	1.83	0.71	110	69	103.4	76.6
August	1.67	0.74	107	68	103.0	74.4
September	0.61	0.40	106	65	97.2	71.7
October	1.43	0.53	101	43	87.4	62.1
November	0.07	0.07	87	34	76.4	45.1
December	0.37	0.20	74	20	61.9	36.0

TABLE 2
(cont.)
CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1975			
January	0.04	0.02	82	22	66.5	37.6
February	0.78	0.56	81	27	68.6	39.1
March	1.18	0.95	85	32	73.1	44.9
April	0.61	0.28	89	40	78.5	48.1
May	0.00	0.00	105	46	90.8	58.9
June	0.00	0.00	109	63	101.7	70.2
July	0.85	0.70	110	74	104.6	79.1
August	0.15	0.12	113	71	105.0	71.0
September	0.33	0.28	107	63	99.6	71.7
October	0.71	0.70	100	40	89.1	56.6
November	0.95	0.68	93	33	75.6	46.9
December	0.61	0.51	80	31	66.7	40.7
			1976			
January	0.01	0.01	86	25	68.0	39.5
February	0.66	0.35	83	40	73.6	47.4
March	0.39	0.31	89	33	74.6	47.4
April	0.48	0.25	94	38	81.9	53.1
May	0.42	0.26	103	54	93.9	64.1
June	0.00	0.00	113	64	103.4	72.8
July	1.30	0.55	113	73	103.1	78.2

TABLE 2
(cont.)
CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1976 (cont.)			
August	1.02	0.39	109	72	102.9	76.4
September	1.95	0.90	103	60	94.0	70.0
October	0.06	0.03	94	45	83.4	56.5
November	1.06	0.88	86	26	75.3	48.7
December	0.50	0.48	74	30	65.1	40.2
			1977			
January	1.09	0.28	74	20	63.9	40.9
February	0.01	0.01	85	28	73.9	41.5
March	0.45	0.18	86	30	72.4	43.5
April	0.07	0.07	95	38	85.2	54.4
May	0102	0.02	106	48	88..1	59.3
June	0.00	0.00	112	68	103.7	75.0
July	1.32	0.74	110	73	104.6	80.3
August	0.27	0.21	110	73	103.9	79.0
September	0.40	0.22	108	64	98.1	73.1
October	0.92	0.45	102	52	89.7	63.4
November	0.08	0.08	86	42	77.2	49.8
December	1.21	0.72	78	38	69.3	45.6

TABLE 2
(cont.)
CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1978			
January	1.97	0.54	74	31	63.0	43.3
February	2.29	1.46	79	34	66.3	44.3
March	2.46	1.27	88	41	75.7	51.2
April	0.37	0.20	92	37	83.1	52.5
May	0.47	0.46	105	50	91.7	61.8
June	0.01	0.01	113	63	105.8	73.7
July	0.47	0.41	114	70	106.5	79.7
August	0.93	0.87	106	68	102.9	76.3
September	0.03	0.03	104	53	97.5	72.3
October	1.16	0.40	101	52	90.0	63.8
November	1.85	0.58	87	36	70.8	47.3
December	3.87	2.05	75	20	60.7	39.0
			1979			
January	2.76	1.28	68	26	57.9	37.8
February	0.38	0.14	76	29	68.9	40.2
March	1.49	0.83	81	36	71.0	44.5
April	0.00	0.00	97	40	85.1	52.6
May	0.50	0.41	102	51	89.7	63.6
June	0.34	0.34	114	60	102.6	72.4
July	0.78	0.29	112	68	106.2	77.9

T BLE 2
(cont.)
CLIMATOLOGICAL DATA
SACATON MINE

Month	Precipitation (inches) Total	Greatest Day	Temperature (°F) Extreme Max.	Extreme Min.	Average Max.	Average Min.
			1979 (cont.)			
August	0.79	0.45	108	64	101.3	74.4
September	0.03	0.03	111	68	103.0	75.9
October	T	T	102	42	91.7	60.6
November	0.02	0.01	83	25	73.1	42.8
December	0.10	0.10	81	33	69.9	41.7

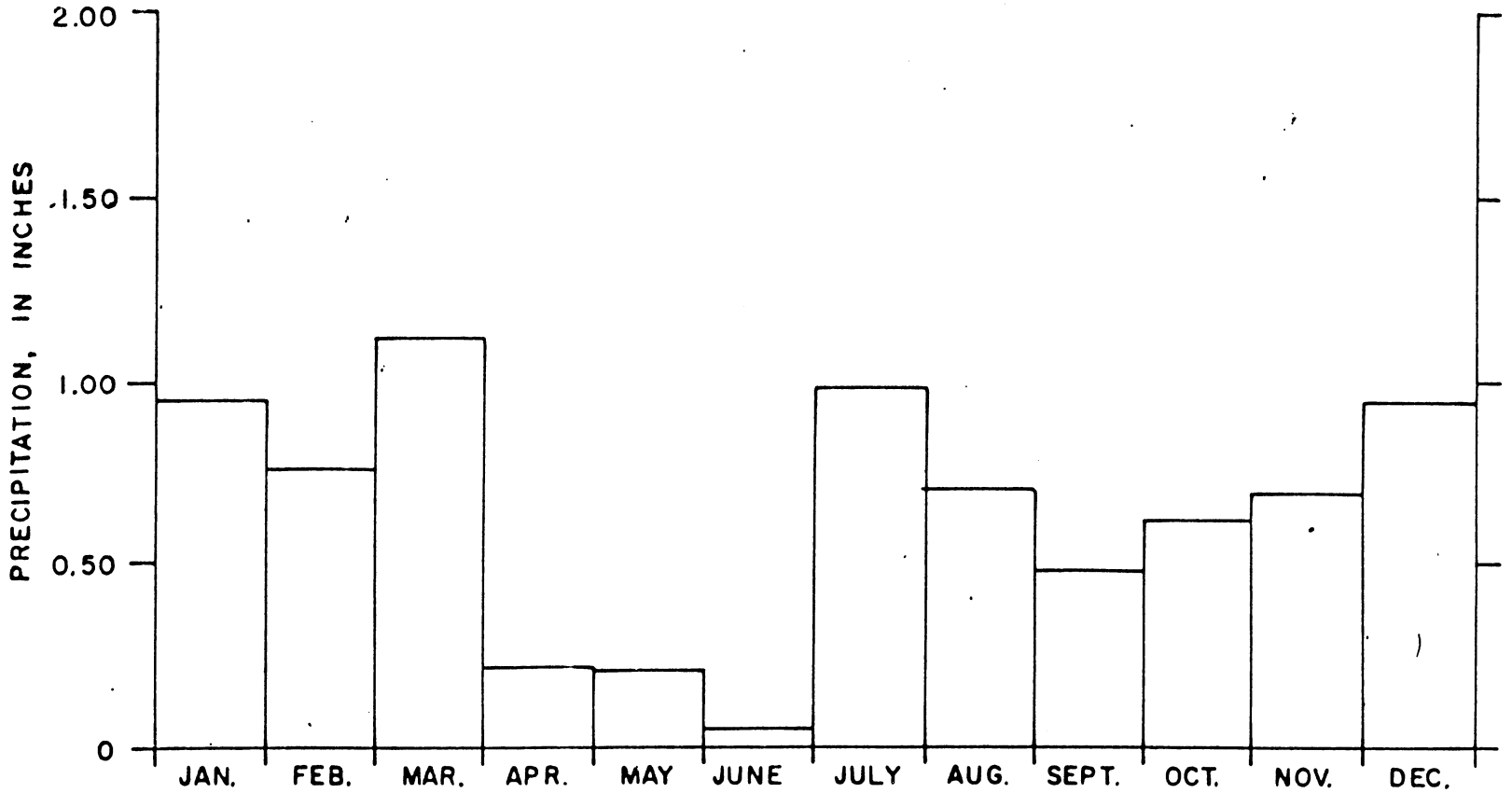


FIGURE 3.-- MEAN MONTHLY PRECIPITATION IN INCHES, SACATON MINE. PERIOD 1970 THRU 1979.

TABLE 3

COMPARISON OF TOTAL ANNUAL PRECIPITATION AT CASA GRANDE AND SACATON MINE

Casa Grande		Sacaton Mine	
Year	Annual Precipitation (inches)	Year	Annual Precipitation (inches)
1970	6.47	1970	--
1971	10.91	1971	--
1972	12.05	1972	--
1973	6.14	1973	4.26
1974	7.66	1974	7.34
1975	5.09	1975	6.21
1976	6.56	1976	7.85
1977	5.81	1977	5.84
1978	15.18	1978	15.88
1979	10.12	1979	7.21

GEOLOGY

Regional

The geologic phenomenon controlling the structure and origin of the Basin and Range Province are extremely complex. The core of most of the prominent mountain ranges which characterize the province are made up of metamorphic and igneous crystalline rock of Older Precambrian age. During this era, the existing sedimentary and igneous rocks were compressed into close folds in a northeast trending geosynclinal trough, and metamorphosed into schist and gneiss. Coincident or subsequent to these events these rocks were invaded by granitic intrusions. Evidence of these three Precambrian rocks is widespread throughout the Sacaton and Casa Grande Mountains. Samples of light colored granite from Sacaton Peak contain 60 percent orthoclase, 2 percent oligoclase, 30 percent quartz, and 5 percent biotite. North of Sacaton Peak dark granites contain 35 percent orthoclase, 25 percent oligoclase, 15 percent quartz, 10 percent biotite and 3 percent horneblende. Analyses of gneiss in the study area indicate these rocks contain 33 percent orthoclase, 10 percent oligoclase, 50 percent quartz, 4 percent biotite and 1 percent pyroxene (Wilson, 1969).[1/] South of the Sacaton Unit in the Casa Grande Mountains, the Pinal Schist as identified by Blacet (1978) is described as medium to coarse grained, medium light to dark greenish gray quartz-biotite-muscovite schist containing 25 percent hornblende, and 5 percent subhedral to euhedral garnets 0.2 to 0.7 centimeter in diameter. Chlorite and epidote are the major constituents of the schist.

While the areal extent of the geosynclinal trough is not known, it is fairly evident that the development of this trough covered a period of millions of years during which alternating periods of volcanic activity and sedimentation continued to form Older Precambrian rocks. Total thickness of these rocks during Precambrian times are estimated by some to have exceeded 10 miles. The depositional environment of these rocks may have been marine or nonmarine or a combination of both. The intrusion of large plutonics of granitic composition occurred toward the end of the Older Precambrian era during a structural deformation of major proportions known as the Mazatzal Revolution. Successive generations of uplift during the Mazatzal Revolution gave rise to high mountain ranges which influenced subsequent geologic history.

Between the Older Precambrian and the Younger Precambrian eras a period of intense erosional activity continuing for approximately 100 million years wore most of the uplifted ragnes down to peneplains. This activity covered most of the State except the area known as Mazatal Land

---

1/ See "References Cited" at end of report.

which covered most of what is now Maricopa and Gila Counties. The Younger Precambrian activity resulted in continued geosynclinal warping and the marine deposition of the Apache group, none of which were evident in the Sacaton Area.

The pre Paleozoic interval again was largely characterized by an extensive erosional period which leveled much of the Younger Precambrian rock. During this interval humid conditions prevailed, accelerating chemical weathering and erosion by running water. Locally a thickness of 15,000 feet of material was removed during this period. Only the resistant quartzite of the Mazatzal area survived this interval.

During the Paleozoic era continuing uplift of the Mazatzal and Defiance areas accelerated the development of the Cordilleran geosyncline to the northwest, and the Sonoran geosyncline to the southwest. The Cambrian system in southern Arizona includes the Troy quartzite, the Bolsa quartzite and the Abrigo limestone. These units are predominantly marine calcareous deposits, and can be identified in the Vekol Mountains southwest of the study area. The Devonian epoch is represented by the Martin limestone, also present in the Vekol Mountains. During this period the study area was inundated by an epicontinental sea which extended northwestward to, but did not include, the Mazatzal-Defiance areas. Thick sedimentation of the Sonoran and Cordilleran geosynclines occurred during this time.

From the Mississipian through the Permian epochs, continued uplift of the Mazatzal-Defiance areas and continued development of the Cordilleran and Sonoran geosynclines resulted in marine limestone deposits in southern Arizona. In the study area clastics and red beds of deltaic, floodplain and dune origin were extensively deposited.

Evidence of the Triassic and Jurassic epochs of Mesozoic Era are not apparent in the vicinity of the Sacaton Unit. Areas of southern Arizona experienced strong crustal deformations and subsequent invasion by granitic and monzonitic magmas, and andesite volcanic eruptions were a prominent feature of this period in the extreme southeastern portion of Arizona. Sharp uplift of what is now the area occuppied by the Mogollon Rim and resultant changes of drainage patterns led to the deposition of the red beds of northern Arizona. The late Cretaceous period was characterized by seas advancing and retreating from the northwest as far as Pinal and Graham Counties. Units deposited in the study area during this period include nonmarine shales and sandstones, evidence of which can be found in the Vekol Mountains. Large scale crustal deformations and subsequent intrusion of volcanics near northeastern Pinal County are thought to have deposited rhyolite and andesite beds as great as 1,500 feet thick.

The interval between the Cretaceous and Tertiary period is commonly referred to as the Laramide Revolution, a period of deformation, uplift and igneous activity. Evidence indicates Laramide deformations were very intense in the Basin and Range Province. In the desert regions broad open folds of northwest trend developed in Laramide times. Major intrusives ranging from granitic to dioritic in composition invaded many deep seated structural features throughout the Basin and Range Province. The Three Peaks Monzonite, which outcrops in the vicinity of the Sacaton Unit is of Laramide age.

The Cenozoic era included extensive distribution of volcanic activity and minor intrusives. Activities of this era included structural movement, volcanic and igneous activity, erosion and sedimentation. Activity during the Miocene epoch is thought to have developed the Basin and Range topography. The Pliocene epoch included complex changes in drainage patterns due to structural movement and minor volcanic activity. The activities created diversions and blocked existing water courses which were subsequently filled with sediments ranging from hundreds to thousands of feet in thickness. Igneous activity of the late Cenozoic era occur prominently in the Vekol and Sawtooth Mountains southwest and south of Casa Grande. Minor intrusives of this era include dikes and plugs of basaltic composition, such as those found in the Picacho area.

Structural activity of this period is evident by elevated fault blocks and adjacent depressed basins which characterize the Basin and Range Province. The valley fill materials in the study area are composed of conglomerates, sand and gravel deposits of Tertiary age overlying gravel, sand and silts of Quaternary age.

Local Geology

As described by Cummings (1978) the discovery of the Sacaton ore body resulted from the examination of a leached granitic outcrop cut by several monzonite porhyry dikes, located south of the Sacaton Mountains. The character of the outcrop was indicative of original sulfides in the vicinity containing approximately 2 percent pyrite by volume and traces of chalcocite. Subsequent exploration programs delineated two zones of ore grade copper mineralization separated by the Sacaton Fault, a steep dipping normal fault. The present open pit operation, which began in 1974 is currently mining the west ore body on the up-thrown side of the Sacaton fault. Future plans call for block and cave mining of the east ore body. Calculation of the ore reserves indicated approximately 33 million tons of an average grade of 0.76 percent copper.

Pinal Schist and Oracle Granite of Precambrian age and the Three Peaks Monzonite of Laramide age outcrop in the area of the Sacaton ore body. The remainder of the area is blanketed by Quaternary alluvium which covers both ore bodies. Monzonites and quartz-monzonites of Laramide age intrude the Oracle Granite within the ore bodies. The porphyrys include large amorphous dike-like intrusive masses, thin well defined dikes, as well as mixed and monolithic breccias. Fragments of granite and the porphyrys make up an irregular pre-mineral breccia located in the center of the west ore body.

Extensive hydrothermal alteration is evident in pre-mineral rocks located in and around the ore zones. Principle minerals of the hydrothermal alteration include sericite, quartz, biotite, chlorite, and undifferentiated clays. The zones of strongest alteration are concomitant with the most concentrated sulfide mineralization.

Evidence of hypogene sulfide mineralization including pyrite, chalcopyrite and molybdenite occurs in breccia cavity fillings, veinlets and disseminations. Mineralization occurs in all pre-mineral rock types. Hypogene sulfide content varies from 1.5 percent to 4.0 percent by volume with the higher hypogene mineralization occurring in curved zones overlain by ore grade supergene mineralization. The copper content of this zone averages 0.40 percent as chalcopyrite with the pyrite to chalcopyrite ratio between 1:1 and 1:3.

Supergene sulfide mineralization including chalcocite and covellite are present as replacements of chalcopyrite and pyrite. The supergene mineralization is irregular in thickness and in grade in the west ore body, varying in thickness from 50 to 500 feet. The irregularity in configuration and continuity is largely due to post-enrichment oxidation and leaching. Significant quantities of chalcocite found in the supergene mineralization were oxidized and fixed in place as oxide copper minerals, or leached from the area.

HYDROLOGY

This chapter is intended to provide the reader with a brief description of the regional hydrologic conditions in the Lower Santa Cruz River Basin. Due to the prevailing arid climate, the occurrence of surface water is limited to brief flow events following seasonal precipitation events. Accordingly, the section on surface water will be limited to a short description of drainage features, and some of the more significant flow events. Subsequent portions of this chapter will provide a more detailed description of the groundwater hydrology in the area, and the influences of various activities upon this sytem. Finally a portion of this chapter will present the relationship between the Sacaton Mine Unit and hydrologic parameters related to the mine operation.

Surface Water

For the purposes of this report the discussion of surface water resources is limited to the lower portion of the Santa Cruz Basin rather than the basin as a whole. The separation between the Upper and Lower Basins of the Santa Cruz River is generally considered to be the area known as the Rillito Narrows northwest of Tucson. This area is convienently delineated by the gaging stations on the Santa Cruz River at Cortaro, and near Laveen. The drainage area of the Lower Santa Cruz Basin between these gages is approximately 5,100 square miles including the areas drained by the major tributaries of this reach, Brawley and Santa Rosa Washes. The Santa Rosa Wash drainage is bounded by the Vekol Mountains on the west, the North Comobabi Mountains on the south and the Sierra de Santa Rosa and the Sawtooth Mountains on the east. The confluence of Santa Rosa Wash and the Santa Cruz River is approximately 1 mile east of Stanfield. The Brawley Wash tributary drains the Avra and Altar Valleys which are bounded by the Silver Bell, Roskruge, and Baboquivari Mountains on the west, the Pozo Verde and San Luis Mountains on the south, and Las Guijas, Cerro Colorado, Sierrita and Tucson Mountains on the east. The confluence of Brawley Wash and the Santa Cruz River is located apprpximately 6 miles southwest of the town of Red Rock.

The Lower Santa Cruz Basin as described above contains two gaging stations with continuous recording gages, one on Santa Rosa Wash and one on the Santa Cruz River near Laveen. Partial records are available for the Brawley Wash tributary but are generally of poor quality.

The gage on Santa Rosa Wash is located in Section 2, Township 9 South, Range 4 East approximately 3 miles south of Vaiva Vo on the Papago

Indian Reservation. Records for this station are generally good. The ephemeral nature of this water course is well documented by the surface water records as shown on Table 4. The majority of the flow events occur in the months of July, August, and September, coincident with the summer precipitation season. Mean monthly discharge of Santa Rosa Wash shows excellent correlation with the biseasonal distribution of rainfall as shown on Figure 4.

Floods of major proportion are relatively infrequent on Santa Rosa Wash. During the 24 year period of record for the gaging station only two flood events with peak discharges of 10,000 cfs or greater have occurred, one on November 1957 with a peak discharge of 10,000 cfs, and one in September 1962 with a peak discharge of 53,100 cfs. Subsequent frequency analysis of Santa Rosa Wash flood events by the Corps of Engineers indicate the September 1962 flood event was in excess of a 200 year flood. In response to the September 1962 flood the Corps of Engineers constructed Tat Momolikot Dam to provide flood protection as well as irrigation and recreation facilities. Subsequent flow events have been too infrequent to provide sufficient volumes of water to satisfy planned agricultural and recreation needs.

The gaging station on the Santa Cruz River near Laveen is located in Section 29, Township 2 South, Range 2 East, 9 miles south of Laveen. Excellent records covering the period 1948 through 1977 are available for this station. Examination of available data indicate flow events similar in distribution to those of Santa Rosa Wash. Due to the alluvial character of the basin through which the lower Santa Cruz River flows, mean annual discharge of this station is not significantly higher than that at Santa Rosa Wash in spite of large differences in drainage areas. This is due in great measure to the rapid infiltration of flow events along the lower Santa Cruz River, and due in part to flatter gradients, lower elevations, and differences in basin characteristics between the two washes. Mean annual discharge of the Santa Cruz River near Laveen for the period 1948 through 1977 is approximately 16 cfs. Mean monthly discharge values for this period indicate the majority of runoff events occur during the period July through September, and during the winter months of December and January as shown on Table 5, and Fig. 5. These periods are preceded by intervals of little or no flow. The distribution of runoff events for this station also shows excellent correlation with the biseasonal precipitation pattern of the region.

Records of annual peak discharge on the Santa Cruz River near Laveen show no peak above 10,000 cfs during the period of observations made at this gage. The greatest peak discharge occurred September 1962, remnants of attenuated flows of the Santa Rosa Wash flood event of the same period. In spite of thousands of square miles of drainage area above the Laveen gage, the relatively low runoff potential is not unusual. As indicated previously the basin characteristics controlling the magnitude of floods

TABLE 4

MEAN DISCHARGE OF SANTA ROSA WASH NEAR VAIVA VO, ARIZONA
(Values in cubic feet per second)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean for Cal. Yr.
1955	1.9	0	0	0	0	0	129.0	156.0	0.9	0.3	0	0	24.4
1956	8.5	0	0	0	0	1.6	15.7	0	0	0	0	0	2.2
1957	0	0	0	0	0	0	13.6	4.4	0	84.4	150.0	0	21.0
1958	0	92.3	39.5	1.9	0	0	69.3	25.2	0.1	5.1	0	0	19.1
1959	0	0	0	0.1	0	0	66.9	81.7	0	24.4	2.6	33.2	17.7
1960	8.4	0	0	0	0	0	11.2	6.8	10.0	0	0	0.5	3.1
1961	0	0	0	0	0	0	28.7	29.4	29.4	0	0	1.0	7.4
1962	0.2	0	0	0	0	4.8	0.7	0	838.0	0	1.9	1.6	69.6
1963	0	1.4	0	0	0	0	2.9	111.0	27.8	12.6	11.3	0	14.1
1964	0	0	0.3	0	0	0	101.0	224.0	7.5	0.7	0	0	28.2
1965	0	3.2	0	0	0	0	1.9	10.8	4.5	0	0	89.1	9.3
1966	0	56.4	0	0	0	0	0.9	53.7	55.7	5.7	0	0	14.0
1967	0	0	0	0	0	4.7	6.0	29.6	4.4	10.7	0	69.3	7.2
1968	0	0.5	5.6	0	0	0	139.0	119.0	142.0	0.2	0	0.8	3.1
1969	0	0	0	0	0	0	1.2	17.3	7.2	0	0.1	0	2.2
1970	0	0	1.0	0	0	0	9.0	48.1	6.6	0	0	0	5.5
1971	0	0	0	0	0	0	11.2	236.0	23.9	1.9	0	0	23.1
1972	0	0	0	0	0.8	4.4	0	16.2	0	38.6	5.3	0	5.5
1973	0	0	0.5	0	0	0	0.2	0.1	0	0	0	0	0.1
1974	0	0	0	0	0	0	0.1	1.2	0	0.3	0	0	0.1
1975	0	0	0	0	0	0	2.3	0.5	0	0	0.1	0	0.2
1976	0	0	0	0.1	0.1	0	0.6	0.7	0.7	0	0.2	0	0.2
1977	0	0	0	0	0	0	1.2	0	0	0.1	0	0.1	0.1
1978	0.1	0.2	0.2	0	0	0	0	0	0				

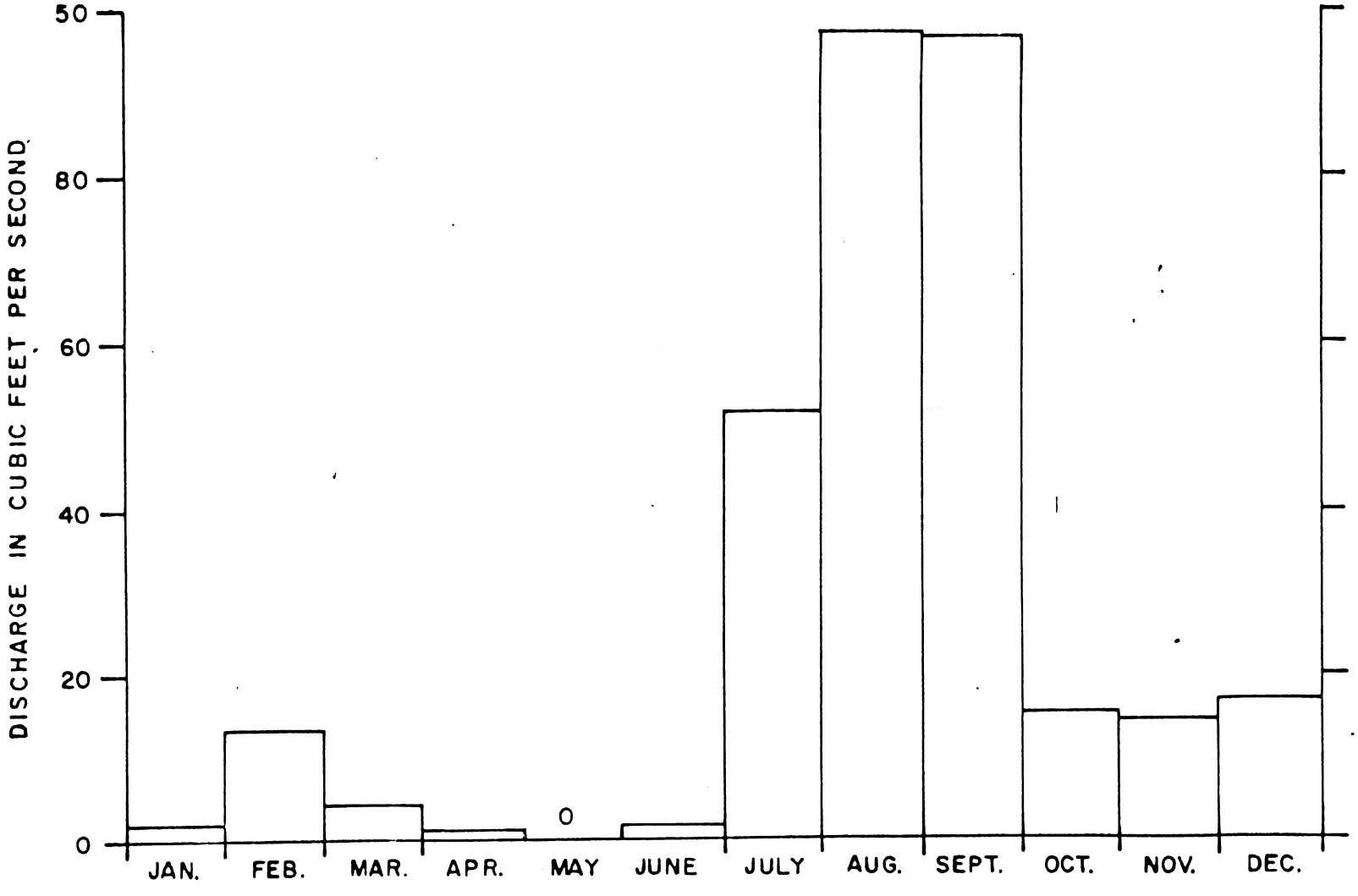


FIGURE 4.-- MEAN MONTHLY DISCHARGE, SANTA ROSA WASH NEAR VAIVA VO, ARIZONA. (CFS) PERIOD 1955 . THRU 1977.

TABLE 5

MEAN DISCHARGE OF SANTA CRUZ RIVER NEAR LAVEEN, ARIZONA, 1948-1978
(Values in cubic feet per second)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean for Cal. Yr.
1948	1.0	1.6	2.5	2.7	1.7	0.8	2.2	30.5	3.0	0.2	0.2	0.6	4.0
1949	1.3	1.3	2.2	3.0	0.9	5.9	10.1	29.5	119.0	0.4	0.2	0.9	14.4
1950	1.5	4.0	2.9	2.4	0.7	0.4	16.4	44.1	2.8	0.3	2.6	16.0	6.4
1951	6.9	9.0	3.1	4.7	5.3	5.1	28.0	501.0	10.8	0.1	0.1	0	10.8
1952	120.0	13.2	3.4	1.1	0.6	0	6.9	28.6	0.3	0.4	60.2	2.6	19.1
1953	4.1	8.5	18.9	20.6	11.4	9.2	41.6	14.4	8.7	0	0	0	4.5
1954	0	0	46.5	2.3	0	0	97.5	644.0	38.4	0	0.4	0.2	70.4
1965	0.7	0.2	0	0	0	0	249.0	895.0	2.6	0	0	0.3	97.5
1956	1.7	0.4	0	0	0	0.1	0	0	0	0	0	0	0.2
1957	8.0	0	0.2	0	0	0	1.5	9.7	0	0.9	17.5	0	3.2
1958	0	3.8	5.1	0.3	0	0.7	6.0	92.4	38.1	0	0	0	13.9
1959	0	0.2	1.2	0.2	0.2	0.1	11.4	205.0	0.7	10.5	25.7	102.0	20.1
1960	165.0	0	0	0	0	0	0	0	0.1	0	0	0	14.0
1961	0	0	0	0	0	0	2.9	37.4	19.2	0	0	0.6	2.9
1962	2.5	0.8	1.0	0.1	0	0.9	1.5	2.0	286.0	0	0	0	1.2
1963	0	49.4	0	0	0	0	0	110.0	3.3	0	0	0	13.4
1964	0	0	0	0	0	0	9,4	103.0	70.9	0.5	0	0	15.4
1965	0	3.1	0	0	0	0	0	0	0	0	0	498.0	42.6

TABLE 5
(continued)
MEAN DISCHARGE OF SANTA CRUZ RIVER NEAR LAVEEN, ARIZONA, 1948-1978

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean for Cal. Yr.
1966	43.4	50.1	0	0	0	0	0	23.5	65.4	0	0	0	14.9
1967	0	0	0	0	0	0	0	0	16.8	1.9	0	331.0	29.6
1968	0.4	77.2	15.0	0	0	0	0	0	0	0.4	6.4	1.8	4.9
1969	1.5	0.9	0	0	0	0	0.3	0.2	0	0	0	0	0.2
1970	0.5	0.4	2.7	0	0	0	5.3	13.9	62.8	0.7	0	0	7.2
1971	0.1	0	0	0	0	0	0	413.0	53.4	3.2	1.9	0.3	39.9
1972	0.4	0	0	0	0	0	0	4.4	0	118.0	6.3	3.5	11.2
1973	0.2	24.6	42.8	0.5	0	0	0	0	0	0	0	0	2.2
1974	0	0	0	0	0	3.3	55.5	73.5	32.2	1.0	0.6	0	0.6
1975	0	2.7	0.3	0.1	0	0	4.8	0	1.7	0	0.7	0	0.9
1976	0	0	0	0.2	0.1	0	3.1	8.3	22.4	2.8	0	0	3.1
1977	0.2	0	0	0	0	0	0	2.5	0	123.0	0.2	0.9	10.8
1978	65.1	75.2	95.1	0.5	0	0	4.8	1.5	0				

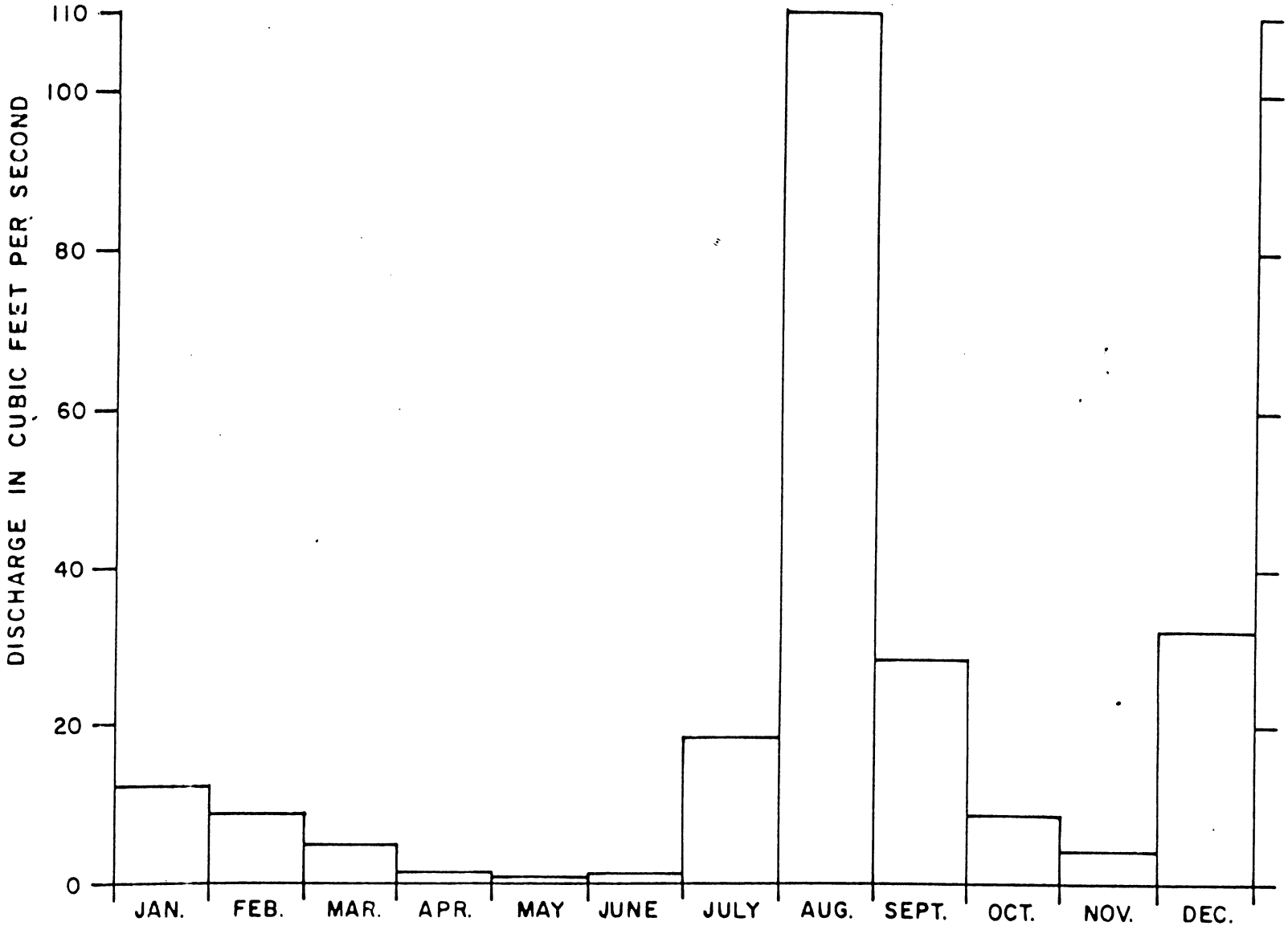


FIGURE 5.-- MEAN MONTHLY DISCHARGE, SANTA CRUZ RIVER NEAR LAVEEN, ARIZONA. (CFS) PERIOD 1948 THRU 1977.

generally are not conducive to large peak discharges.

Rather sketchy records of stream flow data are available for the Brawley Wash tributary of the Santa Cruz River. The upper reach of Brawley Wash, known as Altar Wash was gaged during the period 1966 through September 1975. The gage is located in Section 27, Township 18 South, Range 9 East approximately 18 miles south of Three Points. During the period of record, the reported mean annual discharge was 7.5 cfs. The maximum discharge reported was 22,000 cfs on September 4, 1970.

Since the early 1920's the use of groundwater in the Lower Santa Cruz Basin, primarily for irrigation, has had profound effect on the surface water regime of this area. Prior to large overdrafts of groundwater reserves portions of the lower Santa Cruz were perennial, sustained by shallow groundwater. The extensive use of groundwater in western Pinal County in effect serves as diversions of flows of the Santa Cruz River. In addition to substantially depleting surface water flows in the basin, the surface water records identify extensive periods where flows in the river near Laveen are composed of drainage and wasteway return from upstream fields irrigated with groundwater.

Groundwater Hydrology

Description of Groundwater System

The groundwater system under discussion has an areal extent of over 1,600 square miles, with an estimated 1,500 irrigation wells located within the system. The boundaries of this system include the Picacho Mountains on the east, the Silver Bell, Saw Tooth and Table Top Mountains on the on the south, the Palo Verde Mountains and Haley Hills on the west, and the Gila River to the north. Following the format proposed by Hardt and Cattany (1965) the groundwater system is divided into 4 subareas, the Stanfield-Maricopa area, the Casa Grande-Florence area, the Gila River area, and the Eloy area, which conform to the geographical feature for which they are named.

As described in previous portions of this report, the area, except for isolated mountains, is covered by unconsolidated alluvial materials. These alluvial deposits are in turn underlain by consolidated alaluvium, and crystalline rock. Generally the crystalline rocks are not considered water bearing, and the consolidated alluvium, commonly a con-

glomerate, is relatively impermeable, and well yields are extremely poor where this unit does yield water. The unconsolidated materials are therefore the main storage reservoir of groundwater within the area described above. Rocks other than the unconsolidated water bearing sediments including the tightly cemented sedimentary rocks, crystalline metamorphic and igneous rocks are generally termed hydrologic bedrock.

System Boundaries

The isolated mountain ranges which roughly define the outer boundaries of the study area also serve as boundaries of the hydrologic system. Descriptions of regional geology indicate Precambrian crystalline rocks mostly granite, schist and gneiss constitute approximately 75 percent of the mountain boundaries. The remaining portions of these boundaries are composed of intrusive rocks of Mesozoic age; volcanic flows, and dikes ranging in compostion from rhyolites to basalts of Tertiary age; and tightly cemented sandstones and conglomerates of Cretaceous age.

The appearance of these hydrologic bedrock features at land surface coupled with detailed information from drilling logs has led to fairly reliable delination of subsurface hydrologic boundaries. Northwest of Casa Grande approximately 2 miles, an outcrop of reddish brown conglomerate serves as an indication of shallow bedrock, which is confirmed by similar materials identified in drilling cuttings from nearby wells.

The correlation of similar data throughout the study area show that the western portion of the lower Santa Cruz Basin within the Casa Grande-Florence area is divided by a shallow ridge of bedrock which trends north-south from the Sacaton Mountains to the Silver Reef Mountains. The ridge located 2 to 5 miles west of Casa Grande, is as shallow as 200 feet below land surface in some locations. East of the Casa Grande Ridge the surface of the hydrologic bedrock slopes eastward approximately 250 feet per mile to an estimated depth of 2,500 feet below land surface in the vicinity of Picacho Reservoir. This deep trough of alluvium extends southward beyond Eloy, where the thickness of the alluvial deposits decreases due to the presence of another shallow bedrock ridge between Picacho Peak and the Silver Reef Mountains. The eastern limit of this trough is defined by the Picacho Mountains, and by shallow subsurface hydrologic bedrock extending north to the town of Florence. The approximate northern limit of this feature is the Gila River where the hydrologic bedrock surface ranges from 400 to 600 feet below land surface.

West of the Casa Grande Ridge the surface of the hydrologic bedrock unit slopes steeply westward, where in the vicinity of the Stanfield-Maricopa area depth to bedrock exceeds 2,000 feet. The long axis of this trough trends northwest from Stanfield to the Salt River. Bedrock along the margins of this

trough include the Haley Hills, Palo Verde and Sierra Estrella Mountains on the west flank of the trough, the Casa Grande Ridge and Sacaton Mountains on the east, and the Vaiva Hills, Table Top Mountains, and the Silver Reef Mountains to the south.

Description of Aquifer Units

The saturated unconsolidated alluvial materials which store the majority of the basin groundwater supply constitute the aquifer system in Western Pinal County. Descriptions of aquifer materials, and geohydrologic units within the extensive heterogeneous aquifers are generally made on the basis of the size of the materials and its permeability. Following this format, the permeable deposits of the study area have been identified by Hardt and Cattany (1965), using information from driller's logs. These permeable alluvial deposits are divided into four categories and include from oldest to youngest; the local gravel unit, the lower sand and gravel unit, the silt and clay unit, and the upper sand and gravel units. Except for the silt and clay unit, the remaining sediments are major water yielding units. The silt and clay unit stores large volumes of water but the ability of this unit to transmit water to wells is generally poor. It is however, important due to its great areal extent and thickness and because locally it serves as a confining layer which renders artesian characteristics to the underlying units.

Local Gravel Unit

The local gravel unit is identified only in the southern portion of the sediment filled trough west of the Casa Grande Ridge. This unit is present as a fan shaped deposit extending northward from the Vaiva Hills and Tat Momoli Mountains for approximately 20 miles, and westward from the Casa Grande Ridge for approximately 12 miles. The deposit widens and thins toward the center of the trough, and ranges in thickness from 0 to 1,000 feet. Materials which make up this unit are primarily coarse to medium sands and gravels with minor amounts of clay. In some areas within this unit the materials are tightly cemented, which reduces its productivity.

Lower Sand and Gravel Unit

The lower sand and gravel unit is possibly similar in age, and stratigraphically equivalent to the local gravel unit. This unit is a heterogeneous mixture of gravel, sand, and clay ranging in thickness from 0 to 500 feet. This unit has been identified in both troughs on either side of the Casa Grande Ridge but is absent on the Ridge itself. The top of the lower sand and gravel unit varies from 300 to 1,000 feet below land surface in the western basin, and from 300 to 2,000 feet below land surface in the eastern basin. Gen-

the troughs, and thins toward the margins. In areas where the lower sand and gravel unit is overlain by the silt and clay unit, it exhibits semi-artesian to artesian characteristics. In areas where it is not overlain by the clay unit the contact between the lower sand and gravel unit and the upper sand and gravel unit is indistinguishable. As in the lower gravel unit, this unit is locally cemented and exhibits poor water-yielding characteristics.

Silt and Clay Unit

The silt and clay unit ranges in composition from fine silty sand to silty clay. The unit was deposited in a fluvial and/or lacustrine environment, dominated by the ancestral Santa Cruz River. The silt and clay unit is also separated in areal extent by the Casa Grande Ridge. East of the Ridge the largest deposit of this unit underlies almost the entire east basin of the Eloy-Casa Grande area. In this area the silt and clay unit ranges in depth from 200 to 600 feet below land surface, with the greater depths occurring primarily on the southeast margin of the basin in the vicinity of Eloy. The thickness of this unit varies from 200 feet along the margins of the trough, to in excess of 1,600 feet in the center of the basin south of Coolidge. West of the Casa Grande Ridge the silt and clay unit is evident in the areas coincident with the deepest portions of the trough underlying the Standfield-Maricopa area. Generally the deposit of silt and clay is located at depth in the center of this area, approximately 400 feet below land surface, and shallower toward the margins of the basin, averaging 200 feet below land surface in these areas. The thickness of the silt and clay unit in this part of the basin varies from 200 feet in the margin areas to 800 feet in the center of the basin. This unit of the aquifer is saturated in most parts of the study area and yields inappreciable amounts of water to wells, from thin lenses of sands and gravels.

Upper Sand and Gravel

This unit is evident at land surface through most of the Lower Santa Cruz Basin and is made up of Quaternary alluvium. Extremes in thickness range from 50 to 600 feet, with average thickness in the range of 300 to 400 feet. The sediments of this unit while indistinguishable from the lower sand and gravel unit, are less indurated than the lower sediments, and are therefore higher in average permeability. Continued overdraft of groundwater in western Pinal County, primarily from the upper sand and gravel unit has caused declines of the static water level that exceed a rate of 10 feet per year in some portions of the basin. Substantial portions of the upper unit have been dewatered, and in some areas, the entire thickness of the upper sand and gravel unit. This continuing rate of decline has resulted in the abandonment of numerous shallow wells completed in the upper unit, and eventually will require increased dependence on the deeper sediments.

History of Deposition

As described in the section on regional geology, the rock sequence in the study area represents a complex series of geological phenomenon. To a minor extent, present land forms were influenced by strong crustal deformations during the Paleozoic and Mesozoic eras. More significant in establishing the present land forms of the Basin and Range Province was extensive tectonic activity during late Tertiary time. The majority of the mountain ranges present in the province were uplifted by extensive block faulting. Subsequent to this structural deformation, the broad intermountain valleys were filled with alluvial debris derived from the mountain ranges.

The lower sand and gravel unit represents the oldest alluvial deposits of this period, deposited largely by streams and sheet runoff from nearby ranges. The deposit grades in texture from large boulders and coarser grained materials near the mountains and the Casa Grande Ridge to generally finer deposits near the center of the basin. Near the flattened land surfaces away from the elevated features of the basin, grading of the deposits became more pronounced both vertically and laterally. Extensive deposition of the lower sand and gravel unit is thought to have been deposited during the same time. Subsequent to the deposition of the lower sand and gravel unit, previously formed topographic highs were accentuated by additional differential uplift, altering the course of the Santa Cruz River. Alteration of the rivers course resulted in the formation of a lacustrine environment in the eastern depression of the basin. The formation of the lacustrine environment developed from components of both the Gila and Santa Cruz Rivers, which deposited the fine materials of the silt and clay unit. The deposition of the silt and clay unit in the western depression occurred after locally eroded and locally deposited sediments built up to a level sufficiently high to allow the Santa Cruz River to flow westward over the ridge and establish a lacustrine environment in the western depression. Filling of the western depression with the silt and clay unit and deposition of the upper sand and gravel unit over the entire basin, established the course of the Santa Cruz River as it exists today.

Movement of Groundwater

The direction of movement of groundwater is controlled primarily by the force of gravity which regulates the altitude of the groundwater surface, and to a lesser extent by the hydraulic character of the sediments. Following the establishment of the course of the Santa Cruz River elevation differences in the basin were also well established. Inflow to the basin occurred from three primary directions, essentially as it does today. Underflow from central Pinal County in the vicinity of the Picacho Mountains moved generally northwestward toward Coolidge and the Gila River. Surface and groundwater movement from the Gila River area moves through the basin between

the Sacaton Mountains and the Santan Mountains. Shallow bedrock features forced most of the groundwater flow to the surface in this area creating a perennial flow in the Gila River, even in times of deficient surface water supply.

Underflow from the Marana area entered the lower basin between the Silver Bell Mountains and Picacho Peak. The occurrence of relatively shallow hydrologic bedrock in the area formed a constricted channel which forced groundwater flows upward, establishing a relatively shallow water table. The western depression of the Lower Santa Cruz Basin was recharged primarily from surface waters and underflow from Vekol Wash and Santa Rosa Wash.

The primary avenue of outflow from the area occurred along the alluvial channels where the Gila and Santa Cruz Rivers exit the area near Laveen. In addition to surface and groundwater flows exiting these areas, the lack of man induced groundwater withdrawals sustained shallow groundwater tables and surface water flows which were subject to large losses due to evaporation.

Analysis of Regional Aquifer Network

The previous description of aquifer boundaries, materials and the depositional history of the system requires further detailed discussion in order to establish the physical controls which govern the system. Included in these controls are variables which control the ability of the aquifer to transmit and store water. On a regional basis the application of analytical techniques used to develop these variables is not feasible due to the areal extent of the system and the changing character of the system over this area. However, alternative techniques based on historic well data, including driller's logs, discharge-drawdown relationships; and records of groundwater withdrawal provides sufficient information to develop reasonable estimates of aquifer parameters.

Hydrologic Parameters

The aquifer parameters used to characterize a groundwater system include the measurements of porosity, the coefficients of storage, permeability and transmissibility. The porosity of geologic materials is a measure of the interstitial space of the rock, where water is stored. The coefficient of storage is a measure of an aquifers ability to take into or release water from storage per unit volume, and unit change of water level elevation. The coefficient of permeability is a determination of ability of a unit thickness of the

aquifer to transmit water, and the coefficient of transmissibility is a measure of the aquifers ability to transmit water through its entire thickness. The parameters are determined through detailed laboratory and field analytical techniques. Reasonable estimates of these factors can be developed from available data as described below. In the Lower Santa Cruz Basin, the primary source of this data has been drilling records from individual wells which range from poor to good in accuracy and reliability of data. The greatest limitation in evaluating aquifer parameters using indirect methods is the quality of the available data.

Specific Capacity

The evaluation of the regional aquifer systems has relied for the most part on analysis of the specific capacities of wells in the basin. The term specific capacity is used to describe the relationship of well discharge to well drawdown, and is expressed in terms of gallons per minute of production per foot of drawdown in the well. Several complicating factors other than hydrologic character of the aquifer are reflected in the determination of specific capacities, including well depth, well construction techniques, well efficiency and pumping regime. The figures derived using this method are therefore only relative indicators of aquifer conditions, and are not as reliable as data developed from direct methods. Locally, detailed information derived by direct methods is available which can be used to evaluate the accuracy of the determinations of aquifer parameters developed from indirect methods.

Initial studies of the regional aquifer parameters were conducted by Hardt and Cattany in 1965, based on the analysis of data from approximately 540 wells drilled between 1945 and 1950. Results of this study indicate a range in specific capacities of greater than two orders of magnitude. Wells with specific capacities in excess of 25 gpm/ft occurred extensively along the margins of the Gila River, and in the area lying between Coolidge and Casa Grande. In the southern portion of the eastern depression the area extending northeast from Eloy toward the Picacho Mountains, and the area between the Silver Bell Mountains and Picacho Peak trending northwesterly along the Santa Cruz contained high specific capacities. West of the Casa Grande Ridge the areas of high specific capacities included the area around Stanfield extending south along the alignment of the Santa Rosa Wash, and the area around Vekol Wash out to Maricopa.

Estimates of coefficients of transmissibilities in the area based on specific capacity data were made using an empirical factor developed by Hardt and Cattany. On the basis of studies done in similar areas, the specific capacity multiplied by this factor provides estimates of aquifer transmissibilities. The calculated range of transmissibilities based on the data from the period 1945 to 1950, extended from 5,000 to 300,000 gallons per day per foot. The calculated transmissibilities ranged from 7,000 to 300,000

gpd per foot in the vicinity of Eloy; from 5,000 to 270,000 gpd per foot in the Stanfield and Maricopa area; from 8,000 to 180,000 gpd per foot in the Florence-Casa Grande area; and from 37,000 to 245,000 gpd per foot in the Gila River area.

The withdrawal of groundwater at rates which exceed the natural rate of recharge to the aquifer system has resulted in substantial dewatering of the upper sediments in the basin. As the depth to water increases in the region the estimated regional transmissibilities decrease due to the lower transmissibilities of the deeper sediments, and the decrease in saturated thickness. The magnitude of this change through recent years has not been determined.

Storage Coefficient

Indirect determination of storage characteristics of aquifer materials can be estimated by evaluating the approximate volume of sediments dewatered as a result of groundwater withdrawals divided by the estimated volume of water withdrawn. Using data for the period 1942 through 1960, the apparent storage coefficients as calculated by Hardt and Cattany were 0.19 for the Stanfield-Maricopa area and 0.21 for the Eloy area. Since 1960 water levels continued to decline at rates approaching 15 feet per year in some areas. Data published recently by Konieczki and English (1979) show that declines of 400 feet and greater have occurred over large portions of the western basin in the Stanfield-Maricopa area since 1923. Declines in the vicinity of the Casa Grande Ridge during this interval have generally been less than 50 feet. In the Eloy area delines during this period range from 150 feet in the area southeast of the Casa Grande Mountains to over 350 feet near the Silver Bell Mountains.

In the Casa Grande-Florence area the apparent storage coefficient calculated by Hardt and Cattany for the period 1942 through 1960 was 0.31. This figure is considered high due to a greater component of recharge in the area. In addition to recharge from irrigation returns, an estimated 200,000 acre-feet of water is imported to this area from the Gila River. Transport of this water is through unlined canals which contribute significantly to the recharge of the system. Declines in these areas are generally lower than in other portions of the basin as a result of less demand on the groundwater system and greater recharge by surface water imports. Since 1923 declines in this area have ranged from 150 to 200 feet.

As with the determination of the coefficient of transmissibility, the coefficient of storage will decrease as water levels continue to decline. The calculation of updated apparent storage coefficient is beyond the scope of this report.

Development of Groundwater

Prior to 1923, virtually no irrigation wells were used in western Pinal County, and the Lower Santa Cruz Basin. Subsequent to this time, extensive development of groundwater resources for irrigation purposes has has profound effect on the groundwater regime.

History of Groundwater Development for Irrigation

The first irrigation wells drilled in the Lower Santa Cruz Basin were located in the area near Toltec, and were drilled in approximately 1914. Additional development of groundwater resources in this area continued through roughly 1918, but were abandoned shortly thereafter due to the high costs resulting from the poor efficiency of pumping equipment (Turner, et al 1943).

Based on Turner the irrigated area in Pinal County as of 1919 totaled 28,647 acres, and the total number of irrigation wells was 136. In the ten year interval from 1919 to 1929 the total irrigated area increased to 37,044 acres, and the number of irrigation wells increased to 203. The following ten year period marked a phenomenal change in the rate of agricultural expansion, with total irrigated acreage increasing to 117,556 acres, with a total of 446 irrigation wells in the area. During World War II the demand for agricultural products resulted in a large increase in irrigated acreage, and by 1942 total irrigated area was estimated as 170,000 acres (Hardt and Cattany, 1965).

The increased use of groundwater for irrigation and the related declines in water table elevation resulted in the enactment of institutional constraints designed to restrict irrigation withdrawals. Under the groundwater code enacted in 1948, areas of rapid groundwater decline were subject to the regulation of area under cultivation, and groundwater withdrawal. Areas subject to these constraints were known as critical areas. In 1949 the Eloy area was declared critical, and in 1951 the Casa Grande-Florence area, and the Stanfield-Maricopa area were declared critical.

Annual Production of Groundwater

During the interval of intensive agricultural production from 1942 to 1952, a total of 7,300,000 acre feet of groundwater was withdrawn from the Lower Santa Cruz Basin. Toward the end of this time interval the rate of annual groundwater withdrawal exceeded 1,000,000 acre feet, and has remained

essentially constant. Through 1976 total withdrawal of groundwater from the Lower Santa Cruz Basin has amounted to 38,521,000 acre-feet (Konieczki & English, 1979). Annual withdrawals for the period 1915 through 1976 are given in Table 6.

Changes in Groundwater Movement

Prior to the extensive development of the groundwater resources in the Lower Santa Cruz Basin the natural path of movement of groundwater into the area was between Picacho Peak and the Silver Bell Mountains. Under native conditions the water table gradient in this area was approximately 15 feet per mile. The general direction of movement was north and northwestward to the Sacaton Mountains, a distance of approximately 30 miles during which the water table gradient flattened to just under 10 feet per mile. The Sacaton Mountains functioning as a barrier diverted a portion of this underflow westward over the Casa Grande Ridge toward the Stanfield-Maricopa area, and a portion of the underflow northward toward the Gila River. The westerly component of the underflow developed a steeper gradient, approximately 20 feet per mile, as it crossed the ridge area flowing toward Stanfield. The movement in this western portion of the basin is generally northward from Stanfield to Maricopa at a gradient of approximately 5 feet per mile. The component of flow diverted toward the Gila River moves northward past Coolidge to join the underflow of the Gila River which flows in a northwesterly direction.

The extensive overdraft of groundwater in the Lower Santa Cruz Basin has significantly altered the direction of movement of groundwater. Inflow to the eastern portion of the basin is still largely through the Silver Bell Mountains and Picacho Peak, but the gradient now approaches 40 feet per mile as opposed to the former 15 feet per mile. No throughflow from this portion of the basin reaches the western portion of the basin. The development of a large cone of depression with an approximate center near the town of Picacho has effectively reversed the direction of groundwater movement in this part of the basin. Groundwater flow to the Casa Grande Ridge area is primarily from the Casa Grande Mountain area, and the flow from the ridge area is to the west toward Stanfield and to a lesser extent to the northeast toward the Sacaton Mountains. Water table declines in the western portion of the basin near Stanfield have caused the water table gradient west of the Casa Grande Ridge to steepen to gradients approaching 100 feet per mile. In addition the northerly direction of groundwater movement, from the Maricopa area toward the Gila River has reversed, and subsurface flow from the Gila River area now flows south into this area.

TABLE 6

ESTIMATED GROUNDWATER PUMPAGE IN THE LOWER SANTA CRUZ AREA

(In acre-feet)

Year	Groundwater Pumpage (ac-ft)	Year	Groundwater Pumpage (ac-ft)
1915	82,000	1945	610,000
1916	83,000	1946	660,000
1917	84,000	1947	700,000
1918	85,000	1948	950,000
1919	86,000	1949	1,100,000
1920	88,000	1950	1,000,000
1921	90,000	1951	1,030,000
1922	93,000	1952	950,000
1923	96,000	1953	1,400,000
1924	99,000	1954	1,200,000
1925	101,000	1955	1,200,000
1926	104,000	1956	1,100,000
1927	106,000	1957	1,100,000
1928	109,000	1958	1,200,000
1929	111,000	1959	1,200,000
1930	135,000	1960	1,100,000
1931	160,000	1961	1,150,000
1932	185,000	1962	1,050,000
1933	210,000	1963	1,000,000
1934	235,000	1964	1,150,000
1935	260,000	1965	910,000
1936	285,000	1966	915,000
1937	305,000	1967	1,120,000
1938	325,000	1968	910,000
1939	352,000	1969	1,043,000
1940	372,000	1970	890,000
1941	421,000	1971	819,000
1942	500,000	1972	798,000
1943	515,000	1973	990,000
1944	530,000	1974	1,130,000
		1975	973,000
		1976	966,000
Total			38,521,000

Declines and Water Level Fluctuations

The cumulative effect of withdrawal of groundwater for irrigation purposes has created deep depressions in the regional water table. The two major areas of decline correspond to the eastern and western portions of the Lower Santa Cruz Basin, as discussed in previous sections of this report. In the Stanfield-Maricopa area, where declines have been greatest the average annual rate of decline ranged from approximately 2 feet per year along the western margin of the Casa Grande Ridge to over 8 feet per year near the center of the west basin. The rapid development of agricultural production and subsequent increase in groundwater use over the past twenty years, have resulted in short term decline rates which approach 15 feet per year.

Water levels over the Casa Grande Ridge have shown little decline in the past 50 years of groundwater use. In this vicinity the poor quality water associated with the shallow hydrologic bedrock feature has not been subject to the intense pumpage experienced on either side of the ridge. Since 1923 the water table over the ridge has declined approximately 50 feet, or slightly less than 1 foot per year. A large percentage of this decline can be attributed to the movement of groundwater from the ridge area to the east and west caused by the expanding cones of depression in these areas.

Groundwater declines in the Casa Grande-Florence area and the Eloy area have not been as high as in the western portion of the basin due to a comparitively higher rate of recharge in this area. In addition to recharge from underflow of the Santa Cruz River and the Gila River, seepage from Picacho Reservoir and the Casa Grande-Florence Canal serve as recharge mechanisms in the eastern portions of the basin. In the Eloy area the rate of water table decline since 1923 ranges from approximately 3.5 feet per year to 5.5 feet per year. Along the margins of the Casa Grande-Florence Canal and in the area where the Santa Cruz River enters the basin the rate of decline since 1923 has generally been less than 3.0 feet per year.

Along the margins of the Gila River the rate of decline of the groundwater table during this interval have generally been less than 2.0 feet per year owing to the large volume of underflow along the river.

The calculated rate of declines indicated above are representative of long term changes in the water table elevations and are developed from water level measurements taken during the winter months when pumping is generally stopped. Short term or seasonal changes in water levels can fluctuate as much as 30 to 60 feet between the height of the irrigation season and the winter months.

Quality of Groundwater

While adequate chemical analyses of groundwater in the Lower Santa Cruz Basin were not available until 1941, the rapid and successful expansion of agricultural production was indicative of excellent quality water. Initial detailed geochemical studies of the area, performed largely by the U. S. Geological Survey, indicated the presence of excellent quality of water in the eastern and western portions of the study area, and a zone of more highly mineralized water associated with the hydrologic bedrock feature of the Casa Grande Ridge. The total dissolved solids content of the water in several of the wells overlying the ridge area exceeded 4,000 ppm (parts per million) compared to total dissolved solids content ranging from 300 to 800 ppm for water from wells in the surrounding area. Deep seated structural features along the Casa Grande Ridge may be a source of deeper saline groundwater.

Correlation of Water Quality With Aquifer Units

Most of the irrigation wells in the Lower Santa Cruz Basin are perforated over a fairly large interval allowing the wells to penetrate several water bearing strata. Groundwater samples obtained from wells completed in this fashion represent a composite sampling of several geohydrologic units, and do not provide sufficient data to develop correlations of water quality and aquifer units. The character of water produced from the upper sand and gravel unit can be fairly well established by samples taken from wells which penetrate only this unit. The water associated with this unit is generally very good. The TDS (total dissolved solids) content of water produced from this zone ranges from 300 to 500 ppm. Measurements of specific conductance obtained by Kister and Hardt (1966) indicate groundwater from the upper sand and gravel unit usually does not exceed 1,500 micromhos per centimeter at 25° C.

Underlying the upper sand and gravel unit, is an extensive sequence of impermeable silt and clay beds identified as the silt and clay unit. Contained within this unit are areas of evaporite deposits which contribute large quantities of dissolved salts to the groundwater. Groundwater in contact with , or along the margin of these evaporite deposits range in specific conductance value from 10,000 to 30,000 micromhos. Detailed analyses of waters in these zones reveal high sulfate and chloride contents, indicating the presence of gypsum and salt beds in the silt and clay unit.

The lower sand and gravel unit which underlies the silt and clay unit appears to contain water similar in character to that found in the upper sand and gravel unit. Locally this unit contains sufficient artesian pressure to

cause the upward flow of good quality water in wells which penetrate the lower sand and gravel unit and the silt and clay unit. This upward movement of deeper waters tends to mask the presence of poorer quality water from the silt and clay unit.

In local areas portions of the hydrologic bedrock also contain appreciable amounts of water in storage. One such area includes the Gasline conglomerate which in part makes up the feature previously referred to as the Casa Grande Ridge. Groundwater associated with this ridge is known to be extremely poor quality, often exceeding 10,000 ppm TDS. The source of this poor quality water is possibly underlying saline water associated with the crystalline rocks in the area. Table-7 contains data from chemical analyses of samples from a well tapping the conglomerate in the Casa Grande Ridge, and from a bedrock seep in the ASARCO Sacaton Pit.

Changes in Water Quality

Changes in water quality can be related directly to the withdrawal of groundwater causing the migration of mineralized water, and to the percolation of saline irrigation returns.

As mentioned in a previous section of this chapter, the withdrawal of vast quantities of groundwater in the Lower Santa Cruz Basin has caused substantial alteration to the direction of groundwater movement. The expanding cones of depression in the vicinities of Stanfield and near Coolidge have resulted in highly mineralized water from the Casa Grande Ridge migrating toward these areas. Locally the dewatering of the upper sand and gravel has resulted in a proportionally greater volume of water to be pumped from the silt and clay unit in wells which penetrate both these units. The long term effect of this phenomenon has been the gradual increase of the total dissolved solids content of certain wells.

The quality of irrigation water is subject to the effects of evaporation and transpiration, which causes the concentration of dissolved minerals in the soil. Repeated application of irrigation water results in the development of saline soil which is potentially damaging to the crop. Current irrigation practices call for the application of excess quantities of irrigation water to leach this salt buildup downward below the plant root zone. This practice results in the percolation of saline waters downward toward the water table, causing an increase in the TDS of the waters contained in the aquifer. In the areas of the Lower Santa Cruz Basin where declines have dropped the water table substantially, the effect of percolating

TABLE 7

ANALYSES OF CASA GRANDE RIDGE WATER AND BEDROCK WATER

(Analyzed by B C Laboratories. In parts per million.)

Constituent	Well (D-6-5) 12 ccb Ridge Water	ASARCO Sacaton Pit 790' Level
Calcium	190	470
Magnesium	44	87
Sodium	1,050	1,750
Potassium	10	92
Carbonate	0	0
Bicarbonate	462	0
Sulfate	1,430	2,432
Chloride	719	2,100
Nitrate	95	159.5
Boron	0.11	2.9
Fluoride	4.5	4.4
TDS @ 180° F	4,514	7,827
Specific conductance (micromhos @ 25° C)	5,900	10,830
pH	7.9	3.8
Date Sampled	09-19-72	07-10-79

irrigation returns has not yet materialized due to the great depths of unsaturated sediments through which these waters must travel. Locally where declines have not been excessive, the effect of these returns is noticeable in the form of high nitrate concentrations, and elevated concentrations of pesticides and certain trace metals.

Description of Sacaton Unit Hydrology

Surface Water

Prior to development of the mine facilities the area now occupied by the mine was crossed by a few poorly developed drainage courses. The area drained by these features included approximately 3.5 square miles on the southern flank of the Sacaton Mountains. Given the small area drained by these features, and the low regional precipitation, these drainage features provide no dependable source of surface water, and very little flood potential. These features have been diverted around the mine facilities.

Flood Potential

The nearest surface water feature in the vicinity of the Sacaton Unit is the North Branch of the Santa Cruz Wash. This portion of the river is not considered by the U. S. Geological Survey to be subject to major flooding. The nearest surface water feature which is subject to major flooding is the main stem of the Santa Cruz River located approximately 2.5 miles southwest of the Sacaton property. The differences in elevation between the Sacaton Unit and the 100-year flood boundary in this area are sufficient to preclude the possibility of flood damage to the Sacaton Unit during a 100-year flood event.

Groundwater

The following section of this chapter will describe the groundwater hydrology of the Sacaton Unit as it relates to the production, use, and disposal of the mine water supply. The relative scarcity and the high cost of groundwater in the Lower Santa Cruz Basin requires the efficient use of these resources during the mining and milling processes.

Mine Water Supply

Location

The location of the Sacaton Unit precluded the development of a water supply for the unit on the mine property. The mine is located at the northern limit of the hydrologic bedrock unit previously referred to as the Casa Grande Ridge. The only occurrence of groundwater in the vicinity of the mine property, is the highly mineralized waters found in association with the Casa Grande Ridge. The quality of this water did not meet the quality standards necessary for the milling process. To develop the necessary volume of good quality water to meet supply needs ASARCO purchased a total of 1,560 acres located in Sections 27, 28, 33, and 34, Township 5 South, Range 6 East. All of Section 33 and all but the northwest quarter of Section 28, a total of 1,120 acres was being cultivated at the time of purchase. Sections 27 and 34 were not irrigated.

Annual Water Production

The initial mining plan of the Sacaton Mine required a water system capacity of 2,500 gpm to be operational 80 percent of the time, at an average rate of 2,000 gpm. The bulk of this water would be pumped from the water wells during the initial years of milling, and would be supplemented by reclaim water from the tailing pond, and drainage from the mine pit. To date the average pumping rate at the Sacaton Unit has been approximately 1,550 gpm (205 ac-ft per month). Annually this is equivalent to the withdrawal of 2,460 acre-feet.

When the farm property purchased as a water supply was in operation, the annual pumping requirement of the farm was 4 acre-feet per acre. For the total area cultivated annual groundwater withdrawal amounted to 4,480 acre-feet, approximately twice the volume of water required for the mine operation on an annual basis.

Regional Effect of Mine Withdrawal

Prior to the purchase of the farm as a water supply, the average annual rate of water level decline in the area was 6.11 feet per year (Halpenny and Greene, 1972). In spite of the reduction of groundwater withdrawal from the farm, the annual rate of water level decline in the ASARCO supply wells did not decrease. The rate of decline is controlled primarily by the base regional groundwater pumpage which has not shown much reduction. As of 1978

the average annual decline in water level in the ASARCO supply wells had in fact increased to an average rate approaching 15 feet per year.

Mine Water Consumption

Generally the consumptive use of water in mining operations is calculated in terms of gallons of water required per ton of ore milled. Based on a milling rate of 9,000 tons per day the calculated requirement for make-up water is 250 gallons per ton.

The principal components in water consumption are water use for dust control and losses by evaporation from holding tanks and ponds. The estimated net consumptive use of the makeup water in the milling and mining operation is approximately 25 gallons per ton of ore milled or 10 percent of the makeup water requirement. The remaining 90 percent of the makeup water is utilized for disposal of the mine tailings by sluicing them through a pipeline to the tailing pond.

Mine Water Disposal

Utilizing an average of 90 percent of the total production of makeup water to deliver tailings to the ponds, the annual delivery of water to the tailings pond area amounts to 2,100 acre-feet per year. Approximately 1,173 acre feet of water per year is reclaimed from the tailings pond area. The balance of the water delivered to the tailings pond is subject to evaporation, retention in the tailings and seepage. Approximately 75 percent of the water delivered to the tailings pond is accounted for by the processes of evaporation and retention, the remaining 25 percent is attributed to seepage.

Infiltration From Tailing Pond Area

The previous discussion indicates approximately 25 percent of the water delivered to the tailings ponds may exit the pond area as seepage. Based on available data, this is equivalent to approximately 230 acre feet per year or approximately 146 gpm. Of this volume of water moving downward, an undetermined percentage is retained in the interstices of the vadose zone, the remainder migrates downward at an estimated rate of 50 to 100 feet per year.

Quality of Tailings Pond Water

Analysis of tailings pond reclaim water as shown on Table 8, indicates the concentration of several constituents during the milling process. The causes of this concentration of constituents are fairly easily determined by analysis of the milling process.

During the milling process burnt lime is added. Portions of this calcium are precipitated as calcium carbonate in pipelines and tanks, but an overall increase in the calcium content does take place. The magnesium content of the makeup water is generally higher than the pond water magnesium content due to the deposition of the magnesium as scale during the milling process. The bicarbonate content of the water decreases as ti passes through the mill due to the presence of metallic sulfides and sulfates in the ore. The dissolution of various minerals containing chloride and fluoride, causes an increase in the concentration of these constituents in the mill process water.

Direction of Groundwater Movement

Prior to the development of groundwater resources in the Lower Santa Cruz Basin, the lack of recharge along the northern portion of the Casa Grande Ridge near the Sacaton Unit resulted in virtually no groundwater movement in this area. The lack of gradient contributing to this effect has since been altered due to extensive groundwater withdrawals southwest and west of the mine area. The vast cones of depression in these areas have created a gradient to the west from the mine area. Studies by previous authors (Kister and Hardt, 1966) have indicated that the western front of highly mineralized water on the Casa Grande Ridge is migrating in a southwesterly direction at a rate of approximately 100 feet per year. There are no known wells within a one mile radius of the tailing pond, but if a well is hypothetically situated a distance of one mile down gradient from the ponds, and the migration of decant water could be identified at this point, the rate of migration calculated above would require in excess of fifty years for pond seepage to reach the well.

It is difficult to predict the result of groundwater use or future groundwater movement in the vicinity of the Sacaton Unit. Anticipated effects in the area include a gradual flattening of the westerly gradient from the Casa Grand Grande Ridge due to a decrease in pumpage in the western basin. Large tracts of farm land are being abandoned in this area due to the lack of water. This decrease in pumpage coupled with future imports of surface water from the Central Arizona Project will cause a slow long term recovery of water levels which in turn will reduce groundwater gradients and slow the migration

TABLE 8

ANALYSIS OF TAILING POND DECANT WATER
(Analyzed by B C Laboratories)

Constituent	ppm
Calcium	140.0
Magnesium	2.4
Sodium	435.0
Potassium	110.0
Carbonate	0
Bicarbonate	34.7
Chloride	306.2
Sulfate	920.0
Nitrate	< 0.5
Boron	0.6
Fluoride	15.6
Specific conductance (micromhos @ 25° C)	2,920
Total dissolved solids @ 180° F	2,040
pH	7.5

of water from the Casa Grande Ridge. Future development of the underground workings at theSacaton Unit will require pumping for mine drainage which is anticipated to flatten the westerly gradient to an even greater extent. The extent of this flattening is anticipated to be sufficient to cause an eastward gradient to develop on the water table beneath the tailings ponds. Accordingly, seepage from the tailings ponds would migrate eastward to the mine drainage works in the shaft and pit, effectively capturing potential seepage. To the south of the pond area, the elevation of the water table along the Casa Grande Ridge is higher than beneath the pond and southward movement of groundwater cannot occur.

Tailing Pond Monitor System

In a voluntary effort to provide environmental safeguards, and to insure that the mine operation did not adversely degrade local water quality a program to monitor potential seepage from the tailings pond was designed and implemented prior to the actual use of the ponds.

Location of Monitor Well

The tailings pond monitor well is located at the southwest corner of the tailings pond. The well was sited just below the perimeter of the tailings impoundment. The site was selected because it lies downgradient from the impoundment, normal to the primary component of groundwater flow.

Monitor Well Construction

The well was drilled during the summer of 1973 using the cable tool method to a total depth of 400 feet. The well was cased with 8-5/8-inch steel casing with 3/16 by 3 inch machine cut perforations from 155 to 400 feet. A total of 9 perforations per foot of casing provide a perforated area of slightly more than 5 square inches per foot of perforated casing. Twenty feet of 12-3/4-inch blank surface casing was set and cemented at the land surface. Table 9 is a copy of the log provided by the driller, Don Butz Drilling Co. Table 10 is a copy of a geologic log prepared by the ASARCO field geologist who examined the cuttings.

Following completion of drilling the well was swabbed and bailed with the drilling rig to remove loose materials from the well bore. The well was subsequently developed with a submersible pump. A 24-hour pumping test was conducted beginning August 21, 1973 to develop data on water quality and

TABLE 9

DRILLER'S LOG
SACATON MONITOR WELL

Material	From (ft)	To (ft)
Sandy clay	0	145
Clay and boulders	145	215
Conglomerate	215	400
TOTAL DEPTH		400

TABLE 10

FIELD GEOLOGIC LOG
SACATON MONITOR WELL

Depth (ft)	Interval (ft)	Description and/or Remarks
0-110	110	Qal: Gravel, light reddish brown, clayey silt. Clasts appear to be 100% Three Peaks Monzonite (Laramide). Fine to medium grained biotite monzonite w/ 10% biotite, some chloritic alteration and traces of sphene (?). 1-2% disseminated magnetite.
110-135	25	Qal: As above w/1-3% of clast material showing FeOx stain.
135-400	265	Gasline conglomerate (Gila): Fine cuttings are greenish gray in color; slightly clayey sand and silt. Coarse cuttings appear to be mostly pre-Cambrian granite with minor schist; possibly some Three Peaks Monzonite with minor dark green fine-grained porphyry.

aquifer characteristics. The well discharge ranged from 30 to 60 gpm, and the final specific capacity was 0.4 gpm per foot of drawdown. Based on the specific capacity data the transmissibility of the materials underlying the pond is extremely low, in the range of 700 gpd per foot. The vertical permeability of these materials is estimated to be in the range of 10^{-4} to 10^{-5} centimeters per second.

Sample Withdrawal

Preliminary water quality data of the native groundwater underlying the pond area were obtained by measurements of specific conductance. During the original pumping test field measurements of specific conductance were determined until the value remained effectively constant. Samples were collected at that time for more detailed analysis. The results of these determinations will be discussed in following sections of this chapter.

Following the removal of the pump, the monitor well was equipped with an air lift system which has remained in the well permanently. The air lift system was chosen as the sample withdrawal method due to the low cost, and low maintenance features of the system. Prior to subsequent sampling, an air compressor is connected to the system and the well is pumped for a minimum of 24 hours.

Frequency of Sampling

Beginning in mid-1975 the monitor well has been sampled biannually. Generally the samplings are conducted at the beginning of each calendar year, in January or February, and again in June or July.

Constituents Analyzed

In addition to measurement of specific conductance and temperature which are determined in the field at the time of sample collection, the samples from the monitor well are shipped to B C Laboratories, Bakersfield, California for more detailed chemical analysis. The constituents analyzed in the laboratory include the following:

Calcium	Sulfate
Magnesium	Nitrate
Sodium	Boron
Potassium	Fluoride
Carbonate	Specific Conductance
Bicarbonate	Total Dissolved solids @ 180° F
Chloride	pH

Results of Sampling Program

The results of analyses of samples from the monitor well are presented in Table 11. The first column of values listed in this table are representative of the quality of the naturally occurring groundwater underlying the pond area. This sample was collected prior to the use of the tailings pond, and reflects conditions uninfluenced by potential pond seepage. Results of this analysis indicate the predominant ions are sodium (1,114 ppm), sulfate (1,213 ppm), chloride (634 ppm), and bicarbonate (553 ppm). The fluoride content was 10 ppm, and total dissolved solids at 180° F was 3,080 ppm. Comparison with the values on the analyses of Casa Grande Ridge water and bedrock water (see Table 7), and with samples from other wells completed in the Gasline conglomerate along the Casa Grande Ridge indicates the results of this sample are very representative of water along the ridge.

The results of the biannual sampling indicates an overall improvement in water quality. Comparison of latest available analyses with the original analysis shows a decrease of 290 ppm in the sodium content, a decrease of 415 ppm in the bicarbonate, a 198 ppm decrease in chloride and the TDS content decreased from over 3,000 ppm to approximately 2,450 ppm, a decrease of 550 ppm. With the exception of fluoride and nitrate all values analyzed show improvement in quality.

The water quality of the pond reclaim water is in fact of better quality than the native groundwater (see Table 8), and seepage from the pond area would serve to improve local groundwater. The gradual improvement in water quality in the pond area is anticipated to continue at a very slow rate due to the comparatively small input from the pond area compared to the large volume of water stored in the conglomerate.

The existing monitor well is properly sited with respect to the position of the tailings pond. The data show that the monitor well is functioning satisfactorily as a means of evaluating the effect of pond seepage. Construction of additional monitor wells would not, in our opinion, add sufficient new or more detailed information relating to pond seepage. Accordingly, construction of additional monitor wells is not considered to be warranted.

TABLE 11

ANALYSES OF SAMPLES FROM SACATON MONITOR WELL

Date	08-22-73	08-12-75	01-08-76	08-05-76	01-06-77	07-15-77	01-18-78	08-09-78	01-23-79	07-10-79	01-31-80	08-05-8
Calcium	28.0	58	36	23	30.2	23.8	19.5	33.0	30.0	19.5	21	19.9
Magnesium	11.3	12.3	8.0	4.1	5.3	5.6	6.0	7.8	6.0	6.0	5.0	3.6
Sodium	1,140	1,430	1,140	780	870	780	810	950	880	750	850	710.0
Potassium	14.5	5.5	7.0	1.8	1.9	1.7	1.7	4.5	1.0	1.2	1.0	0.7
Carbonate	0	0	0	23.0	14.5	12.8	8.5	8.5	0	0	0	0
Bicarbonate	553.3	367.2	230.6	176.7	187.1	149.0	153.3	152.5	159.4	157.7	137.7	145.5
Chloride	633.7	672.6	555.8	371.7	375.2	404.3	439.7	552.2	481.9	385.5	435.4	303.4
Sulfate	1,213	1,945	1,560	1,001	1,204	1,007	1,017	1,199	1,250	970	1,140	1,025.0
Nitrate	1.86	43.6	13.9	27	36.3	21.7	19.5	22.2	17.3	23.9	31.9	31.0
Boron	3.0	7.02	4.1	3.62	1.6	1.3	1.7	2.1	4.6	1.0	.97	-
Fluoride	10.0	5.4	18.5	2.2	5.2	18.9	16.5	8.0	14.4	15.6	16.2	15.0
Specific Conductance, Micromhos @ 25°C	5,200	6,700	5,100	3,600	3,900	3,900	3,910	4,100	4,000	3,670	4,020	3,400
Total Dissolved Solids @ 180°F	3,080	4,117	3,057	2,463	2,387	2,397	2,543	2,750	2,487	2,323	2,447	2,083
pH	7.7	8.1	8.2	8.2	8.3	8.4	8.3	8.2	8.0	8.1	7.8	8.1

REFERENCES CITED

Blacet, P. M., 1978, Preliminary reconnaissance bedrock geologic map of the Casa Grande Mountains quadrangle, Pinal County, Arizona: U. S. Geological Survey Open-File Report 78-547

Cummings, R. R., 1978, The Sacaton porphyry copper deposit: Geological Society of America Cordilleran Section Annual Meeting, Special Paper No. 2, p.83

Halpenny, L. C., and Greene, D. K., 1972, History of ground-water development in Casa Grande area and effect of proposed Sacaton Project upon hydrology of surrounding region: Water Development Corporation consulting report, December 1972, 32 p.

Hardt, W. F., and Cattany, R. E., 1965, Description and analysis of the geo-hydrologic system in western Pinal County, Arizona: U. S. Geological Survey Open-File Report, 92 p.

Kister, L. B., and Hardt, W. F., 1966, Salinity of the ground water in western Pinal County, Arizona: U. S. Geological Survey Water-Supply Paper 1819-E, 21 p.

Konieczki, A. D., and English, C. S., 1979, Maps showing ground-water conditions in the Lower Santa Cruz area, Pinal, Pima, and Maricopa Counties, Arizona - 1977: U. S. Geological Survey Open-File Report

Turner, S. F., and others, 1943, Groundwater resources of the Santa Cruz basin, Arizona: U. S. Geological Survey Open-File Report, 84 p.

Wilson, E. D., 1969, Mineral deposits of the Gila River Indian Reservation, Arizona: Arizona Bureau of Mines Bulletin 179, 34 p.

REFERENCE	ITEM
1820-C-9	Description of location and type of devices for monitoring and control of surface and subsurface drainage

Refer to the Water Development Corporation report, page 4-28. The report is also under Reference 1820-C-9.

REFERENCE	ITEM
1820-C-9	Description of location and type of devices for monitoring and control of leachate percolation

Does not apply.

REFERENCE	ITEM
1820-C-9	Description of location and type of devices for monitoring and control of gas generation

Does not apply.

REFERENCE	ITEM
1820-C-9	Description of location and type of devices for monitoring and control of air pollution emissions

Does not apply.

REFERENCE	ITEM
1820-C-9	Topographic map indicating all known wells, bodies of surface water, 100 year flood plains and active fault zones

Refer to the attached drawing marked 1820-C-9(A).

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CASA GRANDE WEST QUADRANGLE
ARIZONA—PINAL CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CASA GRANDE 15' QUADRANGLE

SACATON PROPERTY BOUNDARY
MONITOR WELL
1 MILE
100-YEAR FLOOD BOUNDARY
FLOOD PRONE AREA
SHAFT WELLS
Tailing Pond
Sacaton Plant Site
Open Pit
East Dump
Dirt Dump
Dirt Dump
South Dump (Rock)
Gravel Pit
Dry Well 1347
Dry Well 1358
Water Tank
Sewage Disposal
Landing Strip
Athletic Fields
GOLF COURSE
FRANCISCO GRANDE
CASA GRANDE MUNICIPAL AIRPORT
Rodeo Grounds
Mormon Battalion Historical Monument
Three Point Airport
Burgess Peak
Trailer Park
Drive-in Theater
Jr High Sch
Substation
Water Tank
Water Tank
Well 1415
Well 1386
Well 1372
Well 1376
Well 1358
Well 1377
Well 1333
Well 1337
Well 1352
Well 1356
Well 1361
Well 1371
Well 1382
Well 1369
Wells 1381
Wells 1389
Wells 1351
Wells 1341
Wells 1389
BM 1338
BM 1345
BM 1340
BM 1337
BM 1341
BM 1341
BM 1344
BM 1350
BM 1375
BM 1388
BM 1460
BM 1449
BM 1415
BM 1386
BM 1398
SACATON MOUNTAINS
GILA RIVER INDIAN RESERVATION BOUNDARY
DESERT VISTA DRIVE
HOPI DRIVE
WEST VAL VISTA ROAD
VAL VISTA BLVD
ROAD
BIANCO ROAD
BURRIS ROAD
ETHINGTON ROAD
CASA GRANDE CANAL
SOUTHERN PACIFIC
MARICOPA 11 MI.
MARICOPA 13 MI.
3 MI.-CASA GRANDE 3 MI.
North Branch Santa Cruz Wash
Santa Cruz Wash
CANDLESTICK DRIVE
CLAYTON ROAD
COTTONWOOD LANE
KORTSEN ROAD
RODEO ROAD
MC MURRAY BLVD
FLORENCE BLVD
CASA GRANDE
PHOENIX 47 MI.
16 MI. TO ARIZ. 87
COOLIDGE 18 MI.
TOLTEC 9.8 MI.
TUCSON 65 MI.
ELEVEN MILE CORNER 11 MI.
COOLIDGE 20 MI.
GILA BEND 49 MI.
STANFIELD 5 MI.
CHUICHU 9.4 MI
(DOUBLE PEAK) 3649 IV SW
3649 IV NW (STANFIELD)
3649 I NW (CASA GRANDE EAST)
3649 I SW (CASA GRANDE MTS.)
3650 III SW (SACATON BUTTE)
3650 III SE (GILA BUTTE SE)
3650 II (SACATON 1:62 500)
(CHUICHU) 3649 IV SE

111°52'30" 33°00' 111°45' 32°52'30"
719000m E. 420 50' 422 423 425 R. 5 E. 47'30" 540 000 FEET R. 6 E. 428000m E.
3651 000m N. 3651 3650 3649 3648 3647 57'30" 3646 3645 3644 3643 55' 3642 3641 3640 3639 000m N. 3638
T. 5 S. T. 6 S.
720 000 FEET 690 000 FEET 520 000 FEET

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1965

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Red tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence lines

A portion of the southwest quarter of this map lies within a subsidence area
Vertical control based on latest available adjustment

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
GN MN 0°27' EAST 13½° 240 MILS 8 MILS

SCALE 1:24000
1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ARIZONA
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
State Route

ASARCO SACATON UNIT
CASA GRANDE WEST, ARIZ.
NE/4 CASA GRANDE 15' QUADRANGLE
N3252.5—W11145/7.5

1965

AMS 3649 IV NE—SERIES V898

1820-C-9(A)

INTERIOR—GEOLOGICAL SURVEY WASHINGTON D C—1967

REFERENCE ITEM

1820-D-1 Education, training and work experience of supervisory and management personnel

Mill Superintendent

B.S., Metallurgical Engineering
1 year as metallurgist
1 year as leach plant metallurgist
1½ years as concentrator shift supervisor
2 years as mill superintendent
4 years as assistant mill superintendent
1 year as mill superintendent at present location

Assistant Mill Superintendent

B.S., Metallurgical Engineering
1½ years smelter operating experience
2 years as metallurgist
1½ years as concentrator shift foreman
1½ years as chief metallurgist
1 year as assistant mill superintendent

Mill Shift Foremen (4)

(1) B.S., Metallurgical Engineering
1½ years metallurgist
2 years concentrator shift foreman

(1) High School Diploma
5 years operations experience including 1 year supervisory
1½ years concentrator shift foreman

(1) High School Diploma
5½ years operations experience
7 years concentrator shift foreman

(1) High School Diploma
8½ years operations experience
7 years concentrator shift foreman

REFERENCE	ITEM
1820-D-2	Description of hazardous waste accepted for storage, treatment or disposal, including volume, concentration, hazardous qualities, operational procedures and rate of acceptance.

Please refer to ASARCO Incorporated position paper.

REFERENCE	ITEM
1820-D-3	Copy of applicant's performance bonds, insurance and policies, and other relevant information indicating financial responsibility

Refer to the attached ASARCO Incorporated Umbrella Liability Insurance Policy.

DECLARATIONS
UMBRELLA LIABILITY

POLICY NO.
BE 132 45 92
RIN 132 45 58

Member Companies
of
American International Group

☒ AMERICAN HOME ASSURANCE COMPANY

☐ NATIONAL UNION FIRE INSURANCE COMPANY OF PITTSBURGH, PA.

102 Maiden Lane, New York, N.Y. 10005
(Executive Offices)

ITEM 1. Name of Insured / Address (Street, Town or State)

Asarco, Incorporated
120 Broadway
New York, New York 10005

This Declaration page, with policy provisions and endorsements, if any, issued to form a part thereof, completes the above numbered Umbrella Liability Policy.

ITEM 2. Policy Period

From: March 15, 1980 To: March 15, 1981

(12:01) A.M. Standard Time at the address of the Insured stated above)

ITEM 3. Limit of Liability

The limit of the Company's liability shall be as stated herein subject to all the terms of this policy having reference thereto

(A) $ 3,000,000 Single Limit any one occurrence Personal Injury or Property Damage or Advertising Liability or any combination thereof.

in excess of

(1) the amount recoverable under the underlying insurance as set out in the attached Schedule A.

or

(2) $ 2,500,000 annual aggregate all occurrence ultimate net loss in respect of ~~each occurrence~~ not covered by said underlying insurance.

(B) $ 3,000,000 in the aggregate for the policy period or each annual period in accordance with the "Limit of Liability—Retained Limit" Section of the policy.

ITEM 4. Premium Computation

Rating Basis	Estimated Exposure	Rate	Estimated Premium
			500,000

Deposit Premium	Minimum Premium	Audit Period
$ 500,000.	$ 500,000	FLAT

Producer: (Name and Address)

Samuel Metzger Insurance
120 Broadway
New York, New York 10005

Date of Issue March 24, 1980 Countersigned by _____ (Licensed Resident Agent)

Policy Text Form No. 23022 (5/77)

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of Policy No. BE 132 45 92 issued to Asarco, Incorporated

By American Home Assurance Company

SCHEDULE OF UNDERLYING INSURANCE

GENERAL LIABILITY

UNIT	DESCRIPTION OF INSURANCE	INSURANCE COMPANY	PREMIUM
Federated Genco Ltd. (Canada)	C$500,000.C.S.L. - General Liability including products	Royal-Globe	$20,000.
ASARCO Incorporated Buchans, Newfoundland	C$300,000. B.I. - General Liability 50,000. P.D. including products	Continental Insurance	3,500.
Lac D'Amiante du Quebec	C$500,000. C.S.L. - General Liability Only	Allstate of Canada	24,000.
Corporacion Minera Nor Peru,S.A.	$2,000,000. C.S.L. - General Liability	El Pacifico	23,000.
Enthone, Inc.	$ 500,000. C.S.L. - Product Liability	Pine Top Ins.Co.Ltd. etal	55,000.
Asarco Exploration Cos.	$ 500,000. C.S.L. - Includes supplementary auto,	Granite State (A.I.U.)	5,300.

AUTOMOBILE LIABILITY

U.S. Operations	$ 500,000 C.S.L.	Federal	130,000.
Canadian Operations	C $ 300,000. C.S.L.	Federal	19,000.
Corporacion Minera Nor Peru	$ 50,000. C.S.L.	El Pacifico	6,000.

UNIT	DESCRIPTION OF INSURAN	INSURANCE COMPANY	PREMIUM
MISCELLANEOUS LIABILITY			
Aircraft Liability			
1) Lockheed Jetstar	$50,000,000. C.S.L.	A.A.U.	$28,000.
2) DeHavilland Beaver	10,000,000. C.S.L.	Lloyds, London etal	Unknown*
3) Non-owned Aircraft Liability	5,000,000. C.S.L.	I.N.A.	2,750.
Protection and Indemnity American Limestone Co.	1,000,000.	Northwestern National	25,000.
EMPLOYER'S LIABILITY			
Underground Mines	1,000,000.	General Re	N/A
All other operations	500,000.	Various	N/A

* The DeHavilland Beaver is leased by Asarco to Labroador Airways, Ltd., which has named Asarco as an additional insured on its policy, and furnished Asarco with a certificate of insurance.

Justin Barker
AUTHORIZED REPRESENTATIVE

ENDORSEMENT #2

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated
by American Home Assurance Company

The definition of Insured is extended to include the interest of any partner or member of any venture managed by the Named Insured, but only with respect to liability arising out of the operations of the Named Insured.

3/24/80:lml

Authorized Representative

ENDORSEMENT #3

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of policy No. BE 132 45 92 issued to Asarco, Incorporated by American Home Assurance Company

It is understood and agreed that exclusion F shall not apply to watercraft operated by the Insured in connection with the dredging operations conducted on non-navigable waterways wholly within company owned or leased premises known as the Manchester Unit, Ocean County, NJ.

It is also agreed that Exclusion (F) (ii) concerning Personal Injury and Property Damage arising from owned or rented aircraft is hereby deleted from the policy.

3/24/80

Authorized Representative

ENDORSEMENT #4

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that exclusion (G) does not apply to the liability of any employee arising out of his responsibility for the occupational safety and health of any employee and any Insured covered by this policy.

3/24/80:lml

Authorized Representative

ENDORSEMENT #5

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of policy No. BE 132 45 92 issued to Asarco, Incorporated

by American Home Assurance Company

It is understood and agreed that this policy does not cover punitive or exemplary damages, or clean up costs.

3/24/80:lml

Authorized Representative

ENDORSEMENT #6

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that Insuring Agreement II, Defense Settlement and Supplementary Payments, is amended to provide that Defense costs shall be reimbursed to the Company by the Insured, until the annual aggregate deductible, as defined in Definition (I) Ultimate Net Loss, is exceeded.

3/24/80

Authorized Representative

ENDORSEMENT #7

This endorsement, effective 12:01 A.M. March 15, 1980
policy No. BE 132 45 92 issued to Asarco, Incorporated forms a part of

American Home Assurance Company

It is hereby agreed that any coverage provided by the Geominerals Insurance Company Limited, a subsidiary of Asarco, shall not be considered as "other insurance' under this insurance program and that any losses paid for claims occurring during this policy period by that subsidiary will be considered as applied towards the satisfaction of the annual aggregate deductible where no underlying insurance cover is provided.

Authorized Representative

Member Companies
of
American International Group

☐ AMERICAN HOME ASSURANCE COMPANY
☐ NATIONAL UNION FIRE INSURANCE COMPANY OF PITTSBURGH, PA.

(Executive Offices)
102 Maiden Lane, New York, N.Y. 10005

COMMERCIAL LIABILITY UMBRELLA POLICY

In consideration of the payment of the premium, and in reliance upon the statements in the Declarations made a part hereof and subject to the limits of liability, exclusions, conditions and other terms of this policy, the Company agrees with the insured named in the Declarations as follows:

INSURING AGREEMENTS

I. COVERAGE. To pay on behalf of the Insured that portion of the ultimate net loss in excess of the retained limit as hereinafter defined, which the Insured shall become legally obligated to pay as damages for liability imposed upon the Insured by law, or liability assumed by the Insured under contract because of (i) personal injury, (ii) property damage, or (iii) advertising liability, as defined herein caused by an occurrence.

II. DEFENSE, SETTLEMENT, SUPPLEMENTARY PAYMENTS. (The provisions of this Insuring Agreement apply solely to occurrences covered under this policy but not covered by any underlying policies listed in the Schedule of Underlying Insurance or any other underlying insurance providing coverage to the Insured, whether collectible or not. This Insuring Agreement shall also apply to occurrences not covered by any underlying insurance due to exhaustion of any aggregate limits by reason of any losses paid thereunder.)

The Company shall:

(a) defend any suit against the Insured alleging liability insured under the provisions of this policy and seeking recovery for damages on account thereof even if such suit is groundless, false or fraudulent, but the Company shall have the right to make such investigation and negotiation and settlement of any claim or suit as may be deemed expedient by the Company;

(b) pay all premiums on bonds to release attachments for an amount not in excess of the applicable limit of liability of this policy, all premiums on appeal bonds required in any such defended suit, but without any obligation to apply for or furnish such bonds, all costs taxed against the Insured in any such suit, all expenses incurred by the Company and all interest accruing after entry of judgment until the Company has paid, tendered or deposited in court that part of the judgment as does not exceed the limit of the Company's liability thereon;

(c) reimburse the Insured for all reasonable expenses incurred at the Company's request, (including actual loss of wages or salary, but not loss of other income, not to exceed $75 per day) because of his attendance at hearings or trials at such request.

The Company agrees to pay the amounts incurred under this Insurance Agreement II, except in settlement of claims and suits, in addition to the limit of liability stated in the Declarations, and such defense and supplementary payments shall not be included as part of the ultimate net loss, as defined in the policy.

The Insured shall promptly reimburse the Company (excepting Defense Costs) for any amount of ultimate net loss paid on behalf of the Insured within the retained limit specified in Item 3(A-2) of the Declarations.

Insuring Agreement I and II shall cease to apply after the applicable limits of the Company's liability has been exhausted by payment of judgments or settlements.

LIMIT OF LIABILITY – RETAINED LIMIT

(A) The Company shall be liable only for that portion of the ultimate net loss excess of the Insured's retained limit defined as either:

(1) the total of the applicable limits of the underlying policies listed in the Schedule of Underlying Insurance hereof, and the applicable limits of any other underlying insurance providing coverage to the insured; or

(2) the amount stated in Item 3(A-2) of the Declarations as the result of any one occurrence not covered by such underlying policies or insurance;

and then up to an amount not exceeding the amount as stated in Item 3(A) of the Declarations as the result of any one occurrence.

(B) In the event of reduction or exhaustion of the aggregate limits of liability under said underlying insurance by reason of losses paid thereunder during this policy period, this policy shall, subject to its terms and conditions and the limit of liability stated in Items 3(A) and 3(B) of the Declarations:

(1) in the event of reductions, pay excess of the reduced underlying insurance, or

(2) in the event of exhaustion of the limits of liability, continue in force as underlying insurance.

(C) There is no limit to the number of occurrences during the policy period for which claims may be made, except that the Company's total limit of liability arising out of the Products Hazard or the Completed Operations Hazard or both combined shall not exceed the amount stated in Item 3(B) of the Declarations as respects all occurrences during each annual period commencing with the effective or anniversary date of this policy.

In those cases where the underlying insurance listed in the Schedule of Underlying Insurance Policies contains coverage(s), which are subject to an Aggregate Limit of Liability for all insured damages, the Company's liability shall likewise be limited to the amount stated in Item 3(B) of the Declarations with respect to all occurrences during each annual period while this policy is in force commencing from its effective date. The umbrella policy aggregate limit, so amended, shall apply separately to each underlying insurance coverage which carries an aggregate limit in the policy of underlying insurance.

(D) For the purpose of determining the limit of the Company's liability, all personal injury and property damage arising out of continuous or repeated exposure to substantially the same general conditions shall be considered as arising out of one occurrence. With respect to Advertising Liability, all damages involving the same injurious material or act, regardless of the frequency or repetition thereof, the number and kind of media used and the number of claimants shall be deemed to arise out of one occurrence.

EXCLUSIONS

This policy shall not apply:

(A) to any obligation for which the Insured or any carrier as his insurer may be held liable under any Worker's Compensation, Occupational Disease, Unemployment Compensation, or Disability Benefits Law, or under any similar law;

(B) to any obligation which the Insured may be liable under any "no fault benefits" or "uninsured motorists" law;

(C) to the loss of use of tangible property which has not been physically injured or destroyed, resulting from:

(i) a delay in or lack of performance by or on behalf of the Insured of any contract or agreement, or

(ii) the failure of the Insured's products or work performed by or on behalf of the Insured to meet the level of performance, quality, fitness or durability warranted or represented by the Insured; but this exclusion does not apply to loss of use of other tangible property resulting from the sudden and accidental physical injury to or destruction of the Insured's products or work performed by or on behalf of the Insured after such products or work have been put to use by any person or organization other than an Insured.

(D) to Property Damage to:

(i) the Insured's products arising out of such products or any part of such products;

(ii) work performed by or on behalf of the Insured arising out of the work or any portion thereof, or out of material, parts or equipment furnished in connection therewith;

(iii) property owned by the Insured;

(iv) aircraft or watercraft rented to, used by or in the care, custody or control of the Insured;

(E) to damages claimed for the withdrawal, inspection, repair, replacement or loss of use of the Insured's products or work completed by or for the Insured or of any property of which such products or work form a part, if such product, work or property are withdrawn from the market or from use by anyone because of any known or suspected defect or deficiency therein;

(F) to Personal Injury or Property Damage arising out of the ownership, maintenance, operation, use, loading or unloading of:

(i) any watercraft, except to the extent that coverage is provided by a policy listed in the Schedule of Underlying Insurance; or

(ii) any aircraft owned by the Insured or rented to the Insured without a crew.

(G) to liability of any employee with respect to Personal Injury to another employee of the same employer injured in the course of such employment unless insurance therefore is provided by a policy listed in the Schedule of Underlying Insurance and then not for broader coverage than is afforded to such employee by that policy;

(ii) for infringement of trade-mark or trade name;

(iii) for incorrect description of any article or commodity;

(iv) for mistake in advertised prices;

(I) (a) under Coverages 1 (i) and 1 (ii) to injury, sickness, disease, death or destruction:

(i) with respect to which an Insured under the policy is also an Insured under a nuclear energy liability policy issued by Nuclear Energy Liability-Property Insurance Association, Mutual Atomic Energy Liability Underwriters or Nuclear Insurance Association of Canada, or would be an Insured under any such policy but for its termination upon exhaustion of its limit of liability; or

(ii) resulting from the hazardous properties of nuclear material and with respect to which (1) any person or organization is required to maintain financial protection pursuant to the Atomic Energy Act of 1954, or any law amendatory thereof, or (2) the Insured is, or had this policy not been issued would be, entitled to indemnity from the United States of America or any agency thereof, under any agreement entered into by the United States of America or any agency thereof, with any person or organization.

(b) under any Medical Payments Coverage, or under any Supplementary Payments provision relating to immediate medical or surgical relief for expenses incurred with respect to bodily injury, sickness, disease, or death resulting from hazardous properties of nuclear material and arising out of the operation of a nuclear facility by any person or organization.

(c) under any Liability Coverage, to injury, sickness, disease, death or destruction resulting from the hazardous properties of nuclear material, if:

(i) the nuclear material (1) is at any nuclear facility owned by or operated by or on behalf of, an Insured or (2) has been discharged or dispenses therefrom;

(ii) the nuclear material is contained in spent fuel or waste at any time possessed, handled, used, processed, stored, transported or disposed of by or on behalf of an Insured; or

(iii) the injury, sickness, disease, death, or destruction arises out of the furnishing by an Insured of services, materials, parts or equipment in connection with the planning, construction, maintenance, operating or use of any nuclear facility, but if such facility is located within the United States of America, its territories or possessions of Canada, this exclusion (iii) applies only to injury to or destruction of property at such nuclear facility;

(d) as used in this policy:

— "hazardous properties" include radioactive, toxic or explosive properties;

— "nuclear material" means source material, special nuclear material or by-product material;

— "source material", "special nuclear material" and "by-product material" have meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof;

— "spent fuel" means any fuel element or fuel component, solid or liquid which has been used or exposed to radiation in a nuclear reactor;

— "waste" means any waste material (1) containing by-product material and (2) resulting from the operation by any person or organization of any nuclear facility included within the definition of nuclear facility under paragraph (i) or (ii) thereof;

— "Nuclear Facility" means:

(i) any nuclear reactor,

(ii) any equipment or device designed or used for (1) separating the isotopes of uranium or plutonium, (2) processing or utilizing spent fuel, or (3) handling, processing or packaging wastes,

(iii) any equipment or device used for the processing, fabricating or alloying of special nuclear material if at any time the total amount of such material in the custody of the Insured at the premises where such equipment or device is located consists of or contains more than 25 grams of plutonium or uranium 233 or any combination thereof, or more than 250 grams of uranium 235,

(iv) any structure, basin, excavation, premises or place prepared or used for storage or disposal of waste, and includes the site on which any of the foregoing is located, all operations conducted on such site and all premises used for such operations:

— "Nuclear Reactor" means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of fissionable material;

— with respect to injury to or destruction of property, the word "injury" or "destruction" includes all forms of radioactive contamination of property;

(J) to bodily injury or property damage arising out of the discharge, dispersal, release or escape of smoke, vapors, soot, fumes, acids, alkalis, toxic chemicals, liquids or gases, waste materials or other irritants, contaminants or pollutants into or upon land, the atmosphere or any watercourse or body of water; but this exclusion does not apply if such discharge, dispersal, release or escape is sudden and accidental;

(K) to any liability of the Insured directly or indirectly occasioned by, happening through or in consequence of war, invasion, acts of foreign enemies, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, military or usurped power or confiscation or nationalization or requisition or destruction of or damage to property by or under the order of any government or public or local authority.

POLICY TERRITORY

(A) This policy applies to personal injury, property damage or advertising liability occurring anywhere in the world.

DEFINITIONS

When used in this policy (including endorsements forming a part hereof):

(A) PERSONS INSURED means each of the following to the extent set forth below:

(a) (1) the Named Insured stated in Item 1 of the Declarations and any companies that are subsidiaries or owned or controlled by said Named Insured on the inception date of the policy;

(2) any additional companies that become subsidiaries or owned or controlled companies of said Named Insured providing notice is given to the Company within thirty (30) days thereof;

(b) If the Named Insured is designated in the Declarations as a partnership or joint venture, the partnership or joint venture so designated and any partner or member thereof but only with respect to his liability as such, however, if the Named Insured is a partnership, this policy does not apply to an automobile owned by or registered in the named of a partner thereof. This policy does not apply to Personal Injury, Property Damage or Advertising Liability arising out of the conduct of any partnership or joint venture of which the Insured is a partner or member and which is not designated in this policy as a Named Insured. If the Named Insured is designated in the Declarations as an individual, the person so designated, but only with respect to the conduct of a business of which he is the sole proprietor;

(c) any person, organization, trustee or estate to whom or to which the Named Insured is obligated by virtue of a written contract to provide insurance such as is afforded by this policy, but only with respect to operations by or on behalf of the Named Insured or to the facilities of or used by the Named Insured;

(d) subject to the terms and conditions of this policy, any additional Insured included in the underlying insurance, but only to the extent that insurance is available to such additional Insured under such underlying insurance;

(e) except with respect to ownership, maintenance or use including loading or unloading of any automobiles or aircraft, any partner, executive, officer, director, stockholder or employee of the Named Insured, while acting in his capacity as such and any organization or proprietor with respect to real estate management for the Named Insured;

(f) any person while using any automobile owned by the Named Insured or any automobile loaned to the Named Insured or hired for use in behalf of the Named Insured and any person legally responsible for the use thereof provided the actual use thereof is with the permission of the Named Insured, and any executive officer, director or stockholder of the Named Insured with respect to the use of an automobile or watercraft not owned by the Named Insured in the business of the Named Insured. The insurance with respect to any person or organization other than the Named Insured does not apply under this division (f):

(1) to any person or organization, to any agent or employee thereof, operating an automobile sales agency, repair shop, service station, storage garage or public parking place, with respect to any occurrence arising out of the operation thereof;

(2) with respect to any automobile hired by or loaned to the Named Insured, to the owner or lessee thereof other than the Named Insured, or to any agent or employee of such owner or lessee;

The inclusion or addition hereunder of more than one Insured shall not operate to increase the Company's limit of liability.

(B) PERSONAL INJURY shall mean:

(a) bodily injury, sickness, disease, including death anytime resulting therefrom, shock, fright, mental anguish and mental injury;

(b) false arrest, false imprisonment, wrongful eviction, wrongful detention, malicious prosecution and humiliation;

(c) libel, slander, defamation of character or invasion of right of privacy unless arising out of Advertising Liability; and

(d) assault and battery not committed by or at the direction of the Insured unless committed for the purpose of preventing or eliminating danger to persons or property;

which occurs during the policy period.

(C) PROPERTY DAMAGE shall mean (1) physical injury to or destruction of tangible property, which occurs during the policy period, including loss of use thereof at any time resulting therefrom; or (2) loss of use of tangible property, which has not been physically injured or destroyed provided such loss of use is caused by an occurrence during the policy period.

(D) ADVERTISING LIABILITY shall mean liability for damage because of:

(a) unintentional Libel, Slander or Defamation of Character;

(b) infringement of copyright or title or of slogan;

(c) piracy or unfair competition or idea misappropriation under an implied contract;

(d) invasion of the rights of privacy

cast or telecast and arising out of the Named Insured's advertising activities.

(E) PRODUCTS HAZARD includes Personal Injury and Property Damage arising out of the Insured's products or reliance upon a representation or warranty with respect thereto, but only if the Personal Injury or Property Damage occurs away from premises owned by or rented to the Insured and after physical possession has been relinquished to others.

(F) INSURED'S PRODUCTS means goods or products manufactured, sold, handled or distributed by the Insured or by others trading under his name, including any container thereof (other than a vehicle), but Insured's products shall not include a vending machine or any property other than such container, rented to or located for use of others but not sold.

(G) COMPLETED OPERATIONS HAZARD includes Personal Injury and Property Damage arising out of operations or reliance upon a representation or warranty made at any time with respect thereto, but only if the Personal Injury or Property Damage occurs after such operations have been completed or abandoned and occurs away from premises owned by or rented to the Insured. "Operations" include materials, parts or equipment furnished in connection therewith.

Operations shall be deemed completed at the earliest of the following times:

(a) when all operations to be performed by or on behalf of the Insured under the contract have been completed,

(b) when all operations to be performed by or on behalf of the Insured at the site of the operations have been completed,

(c) when the portion of the work out of which the injury or damage arises has been put to its intended use by any person or organization other than another contractor or sub-contractor engaged in performing operations for a principal as part of the same project.

Operations which may require further service or maintenance work, or correction, repair, or replacement because of any defect or deficiency, but which are otherwise complete, shall be deemed completed.

The Completed Operations Hazard does not include Personal Injury or Property Damage arising out of:

(1) operations in connection with the transportation of property, unless the Personal Injury or Property Damage arises out of a condition in or on a vehicle created by the loading or unloading thereof,

(2) the existence of tools, uninstalled equipment or abandoned or unused materials.

(H) OCCURRENCE – With respect to Personal Injury and Property Damage, the term "Occurrence" means an event, including continuous or repeated exposure to conditions, which result in Personal Injury or Property Damage during the policy period, neither expected nor intended from the standpoint of the Insured. All Personal Injury or Property Damage arising out of the continuous or repeated exposure to substantially the same general conditions shall be considered as arising out of one occurrence.

(I) ULTIMATE NET LOSS – Except as provided in Insuring Agreement II, "Defense", the term "Ultimate Net Loss" shall mean the total sum which the Insured, or any company as its insurer, or both become obligated to pay by reason of personal injury, property damage, or advertising liability claims, either through adjudication or compromise, and shall also include hospital, medical, and funeral charges and all sums paid or payable as salaries, wages, compensation, fees, charges, interest, expenses for doctors, nurses, and investigators and other persons, and for settlement, adjustment, investigation and defense of claims and excluding only the salaries of the Insured or any of the underlying Insurer's permanent employees.

The Company shall not be liable for expenses as aforesaid when such are covered by underlying policies of insurance whether collectible or not.

CONDITIONS

1. **Premium.** The premium for this policy is a flat premium and is not subject to adjustment except that additional premiums may be required for any additional insureds as outlined in Definition (A) "Persons Insured", as provided in Condition 13 "Cancellation", or if this policy is subject to audit adjustment, the premium may be based upon the rating basis as set forth in the Declarations during the policy period. Upon expiration of this policy or its termination during the policy period, or at the end of each policy year, the earned premium shall be computed as specified herein. If the earned premium is more than the advance premium paid, the Insured shall promptly pay the excess to the Company; if less, the Company shall return to the Insured the unearned portion, subject to the annual minimum premium stated in the Declarations for each twelve (12) months of the policy period, and subject further to the policy minimum premium as stated in the Declarations.

2. **Prior Insurance and Non-Cumulation of Liability.** It is agreed, that if any loss is also covered in whole or in part under any other excess policy issued to the Insured prior to the inception date hereof, the Company's limit of liability as stated in Item 3 of the Declarations shall be reduced by any amounts due the Insured on account of any such loss under such prior insurance.

3. **Severability of Interest.** In the event of claims being made by reason of Personal Injuries, Property Damage or Advertising Liability suffered by one Insured herein for which another Insured herein is or may be liable, this policy shall cover such Insured against whom a claim is made or may be made in the same manner as if separate policies had been issued to each Insured herein. Nothing contained herein shall operate to increase the Company's limit of liability as set forth in the Limit of Liability section.

Occurrence covered hereunder involved injuries or damages which, in the event that the Insured should be held liable is likely to involve this policy immediate notice shall be sent to the Company.

5. **Inspection and Audit.** The Company shall be permitted but not obligated to inspect the Insured's property and operations at any time. Neither the Company's right to make inspections nor the making thereof nor any report thereon shall constitute an undertaking, on behalf of or for the benefit of the Insured or others, to determine or warrant that such property or operations are safe. The Company may examine and audit the Insured's books and records at any time during the policy and extensions thereof and within three (3) years after the final termination of this policy, as far as they relate to the subject matter of this insurance.

6. **Maintenance of Underlying Insurance.** The policy or policies referred to in the attached "Schedule of Underlying Insurances", and any renewal or replacement thereof, not more restrictive, shall be maintained by the Insured in full effect during the currency of this policy without alteration of terms or conditions except for any reduction of the aggregate limit or limits contained therein solely by payment of claims. Failure of the Insured to comply with the foregoing shall not invalidate this policy but in the event of such failure, the Company shall only be liable to the same extent as it would have been had the Insured so maintained such policy or policies.

7. **Assistance and Cooperation.** Except as provided by Insuring Agreement II, Defense, the Company shall not be called upon to assume charge of the settlement or defense of any claim made or suit brought or proceedings instituted against the Insured, but the Company shall have the right and shall be given the opportunity to associate with the Insured or the Insured's underlying insurer, or both, in the defense and control of any claim, suit or proceeding relative to any Occurrence where the claim or suit involves, or appears reasonably likely to involve the Company, in which event the Insured, the underlying insurers and the Company shall cooperate in all things in the defense of such claim, suit or proceeding.

8. **Appeals.** In the event the Insured or the Insured's underlying insurer(s) elects not to appeal a judgment in excess of the underlying limits, the Company may elect to make such appeal at its own cost and expense and shall be liable for the taxable costs and disbursements and interest incidental thereto, but in no event shall the liability of the Company, for the ultimate net loss, exceed the amount set forth in Item 3(A) of the Declarations for any one Occurrence plus the cost and expense of such appeal.

9. **Other Insurance.** If other valid and collectible insurance with any other insurer is available to the Insured covering a loss also covered hereunder, this insurance shall be excess of, and shall not contribute with such other insurance. Excess insurance over the Limits of Liability expressed in this policy is permitted without prejudice to this insurance and the existence of such insurance shall not reduce any liability under this policy.

10. **Application of Salvages — Subrogation.** All salvages, recoveries or payments recovered or received subsequent to a loss settlement under this insurance shall be applied as if recovered or received prior to such settlement and all necessary adjustments shall then be made between the Insured and the Company, provided always that nothing in this clause shall be construed or mean that losses under this insurance are not recoverable until the Insured's ultimate net loss has been finally ascertained. Inasmuch as this policy is "Excess Coverage", the Insured's right of recovery against any person or other entity cannot always be exclusively subrogated to the Company. It is therefore understood and agreed that in case of any payment hereunder, the Company shall act in concert with all other interests (including the Insured) concerned, in the exercise of such rights of recovery. The apportioning of any amounts which may be so recovered shall follow the principle that any interests (including the Insured) that shall have paid an amount over and above any payment hereunder, shall first be reimbursed up to the amount paid by them; the Company shall then be reimbursed out of any balance then remaining up to the amount paid hereunder; lastly, the interests (including the Insured) of whom this coverage is excess are entitled to claim the residue, if any. Expense necessary to the recovery of any such amounts shall be apportioned between the interests (including the Insured) concerned, in the ratio of their respective recoveries as finally settled.

11. **Changes.** Notice to or knowledge possessed by any person shall not affect a waiver or change in any part of this policy or stop the Company from asserting any rights under the terms of this policy; nor shall the terms of this policy be waived or changed, except by endorsement issued to form a part hereof, signed by an authorized representative of the Company.

12. **Assignment.** Assignment of interest under this policy shall not bind the Company until its consent is endorsed hereon; if, however, the Insured shall be adjudged bankrupt or insolvent, this policy shall cover the Insured's legal representative as Insured; provided that notice of cancellation addressed to the Insured named in the Declarations and mailed to the address shown in this policy shall be sufficient notice to effect cancellation of this policy.

13. **Cancellation.** This policy may be cancelled by the Insured by surrender thereof to the Company or any of its authorized agents, or by mailing to the Company or any of its authorized agents, written notice stating when thereafter such cancellation shall be effective. The policy may be cancelled by the Company by mailing to the Insured at the address shown in Item 1 of the Declarations, written notice stating when, not less than thirty (30) days thereafter, ten (10) days with respect to cancellation for non-payment of premium, such cancellation shall be effective. Proof of mailing of notice as aforesaid shall be sufficient proof of notice. The time of surrender or the effective date and hour of cancellation stated in the notice shall become the end of the policy period. Delivery of such written notice either by the Insured or by the Company shall be equivalent to mailing. If the Insured cancels, earned premium shall be computed in accordance with the customary short rate table procedure. If the Company cancels, earned premium shall be computed pro rata. In the event of such cancellation, the earned premium shall in no case be less than the annual minimum premium stated in the Declarations, subject to the policy minimum premium also stated in the Declarations.

Premium adjustment may be made at the time cancellation is effected or as soon as practicable thereafter. The check of the Company or its representative mailed or delivered, shall be sufficient tender of any refund due the Insured.

If this policy insures more than one Insured, cancellation may be effected by the first of such Insureds for the account of all Insureds: the notice of cancellation by the Company to such first Insured shall be notice to all Insureds. Payment of any unearned premium to such first Insured shall be for the account of all interests in such payment.

14. Bankruptcy and Insolvency. In the event of the bankruptcy or insolvency of the Insured or any entity comprising the Insured, the Company shall not be relieved thereby of the payment of any claims hereunder because of such bankruptcy or insolvency.

15. First Named Insured. The first Named Insured in Item 1 of the Declarations, shall be responsible for payment of all premiums, and shall act on behalf of all other Insureds with respect to the giving and receiving of notice of cancellation and the receipt of any return premium, that may become payable under this policy.

IN WITNESS WHEREOF, the Company has caused this policy to be executed and attested, but this policy shall not be valid unless countersigned by a duly authorized representative of the Company.

Secretary

President

REFERENCE	ITEM
1821-E-1	Description of communication for summoning external emergency assistance

Plantwide telephones are available to either call directly outside or to call the gate security who relay the information. Mobile units and certain in-plant areas have two-way industrial band radios to contact plant security to summon assistance.

REFERENCE	ITEM
1821-E-1	Description of internal warning and communication system

There are in-plant telephones situated at most operating points within the plant. An intercom system is also installed in the mill department work areas. Industrial band radios are installed in supervisory vehicles as well as several operational vehicles and base areas.

In case of a rupture of the dam, the following sequence of events would take place:

1. Notify mill supervisor (emergency coordinator)
2. Mill feed to be cut off if needed
3. Pit supervisor notified to supply the necessary equipment
4. Move tailings distribution away from rupture area if necessary
5. Berm built as needed to contain spillage as close to tailings dam as possible
6. Dam examined and repaired as needed

REFERENCE	ITEM
1821-E-2	Description of equipment available to emergency response team

Any or all of the following equipment would be available to respond to an emergency:

(2) 12 yd. front end loaders
(1) D-9 caterpillar dozer
(2) D-8 caterpillar dozer
(2) rubber tired dozers
(20) 85 ton Wabco Haul Pak trucks
(2) motor graders
(1) truck crane
(1) 2 yard loader with backhoe
(3) scrapers

REFERENCE	ITEM
1821-E-2	Description of protective clothing and breathing equipment available on-site to emergency response team

Protective clothing and breathing equipment would not be necessary for an emergency response team as no hazardous conditions would exist that would require them.

Dust respirators are given to all employees. Scott air pacs are available within the plantsite.

REFERENCE	ITEM
1821-E-2	Description of procedures established to handle uncontrolled reaction, combustion or explosion

Does not apply.

REFERENCE	ITEM
1821-E-2	Description of procedures established to handle spillage, discharge or disposal in an area not intended for discharge or disposal

Any spillage or accidental discharge outside the tailings disposal site would be cleaned up as required and the clean up disposed of within the facility.

REFERENCE	ITEM
1821-E-2	Description of procedures established to handle degradation of air or water quality standards

The top of the dam is being wetted in approximately six month cycles continuously. This keeps it reasonably dust free.

Water is reclaimed from the dam surface to be reused in the milling operation.

The final banks are covered with conglomerate and revegetated. The vegetation is watered until it can sustain itself naturally.

REFERENCE	ITEM
1821-E-2	Description of procedures established to handle escape of leachates

Does not apply.

REFERENCE	ITEM
1821-E-4	List of emergency agencies, including police, fire, ambulance, hospitals, etc., agreeing to provide emergency services

1. Sacaton Unit ambulance, EMT trained personnel
2. Pinal County Sheriff Department
3. AZTEC Ambulance Service
4. Casa Grande Clinic
5. Hoemako Hospital
6. State Mine Inspector
7. MSHA
8. Casa Grande Fire Department (Paramedic Unit)

REFERENCE	ITEM
1821-E-4	Containment, decontamination and cleanup procedures to be used in emergency situations

Any spills would be contained inside berms. No decontamination will be necessary. The solids would be cleaned up as needed after air-drying.

REFERENCE	ITEM
1821-E-5	Training and qualifications of on-site Emergency Coordinators

The emergency coordinator will be the concentrator shift foreman.

The following training procedure will be followed:

1. Familiarization with design and operation of tailings disposal system
2. Familiarization of facility site
3. Procedure to summon aid
4. Emergency drills
5. Continuous update in status of dam operation; for example, tailings distribution point, roads in service, specific areas to watch during operations

REFERENCE	ITEM
1821-E-5	Contingency plan implementation checklist for emergency situations

Procedure to follow in case of tailings dam rupture:

1. Notify mill supervisor, pit supervisor and all employees in the area
2. Cut fresh ore feed to the mill
3. Move tailings distribution point away from rupture area (if necessary)
4. Pit supervisor is to direct equipment building-containment berm
5. The tailings dam will be examined and repaired as needed

REFERENCE	ITEM
1821-E-5	Training and inspection procedures to be performed by the Emergency Coordinators

Emergency Coordinator training procedure:

1. Instruct new employees in tailings dam area on proper procedures in case of dam failure
2. Instruct new employees in dam area on inspection procedures
3. Conduct emergency drills

Emergency Coordinator inspection procedure:

1. Visual inspection of operating area of dam
2. Visual inspection of decant tower and area
3. Visual inspection of reclaim pond area
4. Visual inspection of entire tailings dam

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-1	Description of the proposed final elevation

The final tailings dam elevation is expected to be at 1490 feet above sea level, sloping to 1481 feet in the center of the dam. The highest point of the dam will be approximately 100 feet above the base elevation.

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-2	Procedure for the physical inspection, monitoring and supervision to prevent air and/or water pollution

The dam would be covered with top soil and revegetated. Physical inspection would be done by employees retained after revegetation to maintain the irrigation system. At the time the vegetation would become self-sustaining, the irrigation would be discontinued.

FACILITY CLOSURE AND POST CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-3	Procedure for access control and maintenance of posted warning signs

Existing fences of barbed wire would be maintained with the existing no trespassing signs (posted approximately every 500 feet). Gates would remain locked.

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-4	Estimated cost of all closure procedures

The estimated cost to cover the tailings dam top and sides with soil is $1,240,000.

The estimated cost to revegetate the tailings dam top and slopes and install drip irrigation is $525,400.

The estimated cost to maintain the vegetation until it can be sustained naturally is $153,550 yearly. It is estimated this will take two years to accomplish.

The total estimated cost of all closure procedures is $2,072,500.

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-5	Description of performance bonds, insurance carriers and policies indicating financial responsibility for claims resulting from post-closure discharges

Refer to the attached ASARCO Incorporated Umbrella Liability Insurance Policy.

DECLARATIONS
UMBRELLA LIABILITY

POLICY NO.
BE 132 45 92
RIN 132 45 58

Member Companies
of
American International Group

☒ AMERICAN HOME ASSURANCE COMPANY

☐ NATIONAL UNION FIRE INSURANCE COMPANY OF PITTSBURGH, PA.

102 Maiden Lane, New York, N.Y. 10005
(Executive Offices)

ITEM 1.
Name of Insured
Address (Street, Town or State)

Asarco, Incorporated
120 Broadway
New York, New York 10005

This Declaration page, with policy provisions and endorsements, if any, issued to form a part thereof, completes the above numbered Umbrella Liability Policy.

ITEM 2.
Policy Period

From: March 15, 1980 To: March 15, 1981

(12:01) A.M. Standard Time at the address of the Insured stated above)

ITEM 3.
Limit of Liability

The limit of the Company's liability shall be as stated herein subject to all the terms of this policy having reference thereto

(A) $ 3,000,000 Single Limit any one occurrence Personal Injury or Property Damage or Advertising Liability or any combination thereof.

in excess of

(1) the amount recoverable under the underlying insurance as set out in the attached Schedule A.

(2) $ 2,500,000 annual or aggregate all occurrence ultimate net loss in respect of ~~each occurrence~~ not covered by said underlying insurance.

(B) $ 3,000,000 in the aggregate for the policy period or each annual period in accordance with the "Limit of Liability—Retained Limit" Section of the policy.

ITEM 4.
Premium Computation

Rating Basis	Estimated Exposure	Rate	Estimated Premium
			500,000

Deposit Premium	Minimum Premium	Audit Period
$ 500,000.	$ 500,000	FLAT

Producer:
(Name and Address)

Samuel Metzger Insurance
120 Broadway
New York, New York 10005

Date of Issue March 24 1980 Countersigned by [signature] (Licensed Resident Agent)

Policy Text Form No. 23022 (5/77)

This endorsement, effective 12:01 A.M. Mr h 15, 1980 forms a part of Policy No. BE 132 45 92 issued to Asarco, Incorporated

By American Home Assurance Company

SCHEDULE OF UNDERLYING INSURANCE

GENERAL LIABILITY

UNIT	DESCRIPTION OF INSURANCE	INSURANCE COMPANY	PREMIUM
ederated Genco Ltd. (Canada)	C$500,000.C.S.L. - General Liability including products	Royal-Globe	$20,000.
SARCO Incorporated uchans, Newfoundland	C$300,000. B.I. - General Liability 50,000. P.D. including products	Continental Insurance	3,500.
ac D'Amiante du Quebec	C$500,000. C.S.L. - General Liability Only	Allstate of Canada	24,000.
orporacion Minera Nor Peru,S.A.	$2,000,000. C.S.L. - General Liability	El Pacifico	23,000.
nthone, Inc.	$ 500,000. C.S.L. - Product Liability	Pine Top Ins.Co.Ltd. etal	55,000.
sarco Exploration Cos.	$ 500,000. C.S.L. - Includes supplementary auto,	Granite State (A.I.U.)	5,300.

AUTOMOBILE LIABILITY

U.S. Operations	$ 500,000 C.S.L.	Federal	130,000.
Canadian Operations	C $ 300,000. C.S.L.	Federal	19,000.
Corporacion Minera Nor Peru	$ 50,000. C.S.L.	El Pacifico	6,000.

UNIT	DESCRIPTION OF INSURAN	INSURANCE COMPANY	PREMIUM
MISCELLANEOUS LIABILITY			
Aircraft Liability			
1) Lockheed Jetstar	$50,000,000. C.S.L.	A.A.U.	$28,000.
2) DeHavilland Beaver	10,000,000. C.S.L.	Lloyds, London etal	Unknown*
3) Non-owned Aircraft Liability	5,000,000. C.S.L.	I.N.A.	2,750.
Protection and Indemnity American Limestone Co.	1,000,000.	Northwestern National	25,000.
EMPLOYER'S LIABILITY			
Underground Mines	1,000,000.	General Re	N/A
All other operations	500,000.	Various	N/A

* The DeHavilland Beaver is leased by Asarco to Labroador Airways, Ltd., which has named Asarco as an additional insured on its policy, and furnished Asarco with a certificate of insurance.

AUTHORIZED REPRESENTATIVE

ENDORSEMENT #2

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated

by American Home Assurance Company

The definition of Insured is extended to include the interest of any partner or member of any venture managed by the Named Insured, but only with respect to liability arising out of the operations of the Named Insured.

3/24/80:lml

Authorized Representative

ENDORSEMENT #3

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of

policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that exclusion F shall not apply to watercraft operated by the Insured in connection with the dredging operations conducted on non-navigable waterways wholly within company owned or leased premises known as the Manchester Unit, Ocean County, NJ.

It is also agreed that Exclusion (F) (ii) concerning Personal Injury and Property Damage arising from owned or rented aircraft is hereby deleted from the policy.

3/24/80

Authorized Representative

ENDORSEMENT #4

This endorsement, effective 12:01 A. M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that exclusion (G) does not apply to the liability of any employee arising out of his responsibility for the occupational safety and health of any employee and any Insured covered by this policy.

3/24/80:lml

Authorized Representative

ENDORSEMENT #5

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of
policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that this policy does not cover punitive or exemplary damages, or clean up costs.

3/24/80:lml

Authorized Representative

ENDORSEMENT #6

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of
Policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is understood and agreed that Insuring Agreement II, Defense Settlement and Supplementary Payments, is amended to provide that Defense costs shall be reimbursed to the Company by the Insured, until the annual aggregate deductible, as defined in Definition (I) Ultimate Net Loss, is exceeded.

3/24/80

Authorized Representative

ENDORSEMENT #7

This endorsement, effective 12:01 A.M. March 15, 1980 forms a part of policy No. BE 132 45 92 issued to Asarco, Incorporated

American Home Assurance Company

It is hereby agreed that any coverage provided by the Geominerals Insurance Company Limited, a subsidiary of Asarco, shall not be considered as "other insurance' under this insurance program and that any losses paid for claims occurring during this policy period by that subsidiary will be considered as applied towards the satisfaction of the annual aggregate deductible where no underlying insurance cover is provided.

Authorized Representative

Member Companies
of
American International Group

☐ AMERICAN HOME ASSURANCE COMPANY
☐ NATIONAL UNION FIRE INSURANCE COMPANY OF PITTSBURGH, PA.

(Executive Offices)
102 Maiden Lane, New York, N.Y. 10005

COMMERCIAL LIABILITY UMBRELLA POLICY

In consideration of the payment of the premium, and in reliance upon the statements in the Declarations made a part hereof and subject to the limits of liability, exclusions, conditions and other terms of this policy, the Company agrees with the insured named in the Declarations as follows:

INSURING AGREEMENTS

I. COVERAGE. To pay on behalf of the Insured that portion of the ultimate net loss in excess of the retained limit as hereinafter defined, which the Insured shall become legally obligated to pay as damages for liability imposed upon the Insured by law, or liability assumed by the Insured under contract because of (i) personal injury, (ii) property damage, or (iii) advertising liability, as defined herein caused by an occurrence.

II. DEFENSE, SETTLEMENT, SUPPLEMENTARY PAYMENTS. (The provisions of this Insuring Agreement apply solely to occurrences covered under this policy but not covered by any underlying policies listed in the Schedule of Underlying Insurance or any other underlying insurance providing coverage to the Insured, whether collectible or not. This Insuring Agreement shall also apply to occurrences not covered by any underlying insurance due to exhaustion of any aggregate limits by reason of any losses paid thereunder.)

The Company shall:

(a) defend any suit against the Insured alleging liability insured under the provisions of this policy and seeking recovery for damages on account thereof even if such suit is groundless, false or fraudulent, but the Company shall have the right to make such investigation and negotiation and settlement of any claim or suit as may be deemed expedient by the Company;

(b) pay all premiums on bonds to release attachments for an amount not in excess of the applicable limit of liability of this policy, all premiums on appeal bonds required in any such defended suit, but without any obligation to apply for or furnish such bonds, all costs taxed against the Insured in any such suit, all expenses incurred by the Company and all interest accruing after entry of judgment until the Company has paid, tendered or deposited in court that part of the judgment as does not exceed the limit of the Company's liability thereon;

(c) reimburse the Insured for all reasonable expenses incurred at the Company's request, (including actual loss of wages or salary, but not loss of other income, not to exceed $75 per day) because of his attendance at hearings or trials at such request.

The Company agrees to pay the amounts incurred under this Insurance Agreement II, except in settlement of claims and suits, in addition to the limit of liability stated in the Declarations, and such defense and supplementary payments shall not be included as part of the ultimate net loss, as defined in the policy.

The Insured shall promptly reimburse the Company (excepting Defense Costs) for any amount of ultimate net loss paid on behalf of the Insured within the retained limit specified in Item 3(A-2) of the Declarations.

Insuring Agreement I and II shall cease to apply after the applicable limits of the Company's liability has been exhausted by payment of judgments or settlements.

LIMIT OF LIABILITY – RETAINED LIMIT

(A) The Company shall be liable only for that portion of the ultimate net loss excess of the Insured's retained limit defined as either:

(1) the total of the applicable limits of the underlying policies listed in the Schedule of Underlying Insurance hereof, and the applicable limits of any other underlying insurance providing coverage to the insured; or

(2) the amount stated in Item 3(A-2) of the Declarations as the result of any one occurrence not covered by such underlying policies or insurance;

and then up to an amount not exceeding the amount as stated in Item 3(A) of the Declarations as the result of any one occurrence.

(B) In the event of reduction or exhaustion of the aggregate limits of liability under said underlying insurance by reason of losses paid thereunder during this policy period, this policy shall, subject to its terms and conditions and the limit of liability stated in Items 3(A) and 3(B) of the Declarations:

(1) in the event of reductions, pay excess of the reduced underlying insurance, or

(2) in the event of exhaustion of the limits of liability, continue in force as underlying insurance.

(C) There is no limit to the number of occurrences during the policy period for which claims may be made, except that the Company's total limit of liability arising out of the Products Hazard or the Completed Operations Hazard or both combined shall not exceed the amount stated in Item 3(B) of the Declarations as respects all occurrences during each annual period commencing with the effective or anniversary date of this policy.

In those cases where the underlying insurance listed in the Schedule of Underlying Insurance Policies contains coverage(s), which are subject to an Aggregate Limit of Liability for all insured damages, the Company's liability shall likewise be limited to the amount stated in Item 3(B) of the Declarations with respect to all occurrences during each annual period while this policy is in force commencing from its effective date. The umbrella policy aggregate limit, so amended, shall apply separately to each underlying insurance coverage which carries an aggregate limit in the policy of underlying insurance.

(D) For the purpose of determining the limit of the Company's liability, all personal injury and property damage arising out of continuous or repeated exposure to substantially the same general conditions shall be considered as arising out of one occurrence. With respect to Advertising Liability, all damages involving the same injurious material or act, regardless of the frequency or repetition thereof, the number and kind of media used and the number of claimants shall be deemed to arise out of one occurrence.

EXCLUSIONS

This policy shall not apply:

(A) to any obligation for which the Insured or any carrier as his insurer may be held liable under any Worker's Compensation, Occupational Disease, Unemployment Compensation, or Disability Benefits Law, or under any similar law;

(B) to any obligation which the Insured may be liable under any "no fault benefits" or "uninsured motorists" law;

(C) to the loss of use of tangible property which has not been physically injured or destroyed, resulting from:

(i) a delay in or lack of performance by or on behalf of the Insured of any contract or agreement, or

(ii) the failure of the Insured's products or work performed by or on behalf of the Insured to meet the level of performance, quality, fitness or durability warranted or represented by the Insured; but this exclusion does not apply to loss of use of other tangible property resulting from the sudden and accidental physical injury to or destruction of the Insured's products or work performed by or on behalf of the Insured after such products or work have been put to use by any person or organization other than an Insured.

(D) to Property Damage to:

(i) the Insured's products arising out of such products or any part of such products;

(ii) work performed by or on behalf of the Insured arising out of the work or any portion thereof, or out of material, parts or equipment furnished in connection therewith;

(iii) property owned by the Insured;

(iv) aircraft or watercraft rented to, used by or in the care, custody or control of the Insured;

(E) to damages claimed for the withdrawal, inspection, repair, replacement or loss of use of the Insured's products or work completed by or for the Insured or of any property of which such products or work form a part, if such product, work or property are withdrawn from the market or from use by anyone because of any known or suspected defect or deficiency therein;

(F) to Personal Injury or Property Damage arising out of the ownership, maintenance, operation, use, loading or unloading of:

(i) any watercraft, except to the extent that coverage is provided by a policy listed in the Schedule of Underlying Insurance; or

(ii) any aircraft owned by the Insured or rented to the Insured without a crew.

(G) to liability of any employee with respect to Personal Injury to another employee of the same employer injured in the course of such employment unless insurance therefore is provided by a policy listed in the Schedule of Underlying Insurance and then not for broader coverage than is afforded to such employee by that policy;

(ii) for infringement of trade-mark or trade name;

(iii) for incorrect description of any article or commodity;

(iv) for mistake in advertised prices;

(I) (a) under Coverages 1 (i) and 1 (ii) to injury, sickness, disease, death or destruction:

(i) with respect to which an Insured under the policy is also an Insured under a nuclear energy liability policy issued by Nuclear Energy Liability-Property Insurance Association, Mutual Atomic Energy Liability Underwriters or Nuclear Insurance Association of Canada, or would be an Insured under any such policy but for its termination upon exhaustion of its limit of liability; or

(ii) resulting from the hazardous properties of nuclear material and with respect to which (1) any person or organization is required to maintain financial protection pursuant to the Atomic Energy Act of 1954, or any law amendatory thereof, or (2) the Insured is, or had this policy not been issued would be, entitled to indemnity from the United States of America or any agency thereof, under any agreement entered into by the United States of America or any agency thereof, with any person or organization.

(b) under any Medical Payments Coverage, or under any Supplementary Payments provision relating to immediate medical or surgical relief for expenses incurred with respect to bodily injury, sickness, disease, or death resulting from hazardous properties of nuclear material and arising out of the operation of a nuclear facility by any person or organization.

(c) under any Liability Coverage, to injury, sickness, disease, death or destruction resulting from the hazardous properties of nuclear material, if:

(i) the nuclear material (1) is at any nuclear facility owned by or operated by or on behalf of, an Insured or (2) has been discharged or dispenses therefrom;

(ii) the nuclear material is contained in spent fuel or waste at any time possessed, handled, used, processed, stored, transported or disposed of by or on behalf of an Insured; or

(iii) the injury, sickness, disease, death, or destruction arises out of the furnishing by an Insured of services, materials, parts or equipment in connection with the planning, construction, maintenance, operating or use of any nuclear facility, but if such facility is located within the United States of America, its territories or possessions of Canada, this exclusion (iii) applies only to injury to or destruction of property at such nuclear facility;

(d) as used in this policy:

— "hazardous properties" include radioactive, toxic or explosive properties;

— "nuclear material" means source material, special nuclear material or by-product material;

— "source material", "special nuclear material" and "by-product material" have meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof;

— "spent fuel" means any fuel element or fuel component, solid or liquid which has been used or exposed to radiation in a nuclear reactor;

— "waste" means any waste material (1) containing by-product material and (2) resulting from the operation by any person or organization of any nuclear facility included within the definition of nuclear facility under paragraph (i) or (ii) thereof;

— "Nuclear Facility" means:

(i) any nuclear reactor,

(ii) any equipment or device designed or used for (1) separating the isotopes of uranium or plutonium, (2) processing or utilizing spent fuel, or (3) handling, processing or packaging wastes,

(iii) any equipment or device used for the processing, fabricating or alloying of special nuclear material if at any time the total amount of such material in the custody of the Insured at the premises where such equipment or device is located consists of or contains more than 25 grams of plutonium or uranium 233 or any combination thereof, or more than 250 grams of uranium 235,

(iv) any structure, basin, excavation, premises or place prepared or used for storage or disposal of waste, and includes the site on which any of the foregoing is located, all operations conducted on such site and all premises used for such operations:

— "Nuclear Reactor" means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of fissionable material;

— with respect to injury to or destruction of property, the word "injury" or "destruction" includes all forms of radioactive contamination of property;

(J) to bodily injury or property damage arising out of the discharge, dispersal, release or escape of smoke, vapors, soot, fumes, acids, alkalis, toxic chemicals, liquids or gases, waste materials or other irritants, contaminants or pollutants into or upon land, the atmosphere or any watercourse or body of water; but this exclusion does not apply if such discharge, dispersal, release or escape is sudden and accidental;

(K) to any liability of the Insured directly or indirectly occasioned by, happening through or in consequence of war, invasion, acts of foreign enemies, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, military or usurped power or confiscation or nationalization or requisition or destruction of or damage to property by or under the order of any government or public or local authority.

POLICY TERRITORY

(A) This policy applies to personal injury, property damage or advertising liability occurring anywhere in the world.

DEFINITIONS

When used in this policy (including endorsements forming a part hereof):

(A) PERSONS INSURED means each of the following to the extent set forth below:

(a) (1) the Named Insured stated in Item 1 of the Declarations and any companies that are subsidiaries or owned or controlled by said Named Insured on the inception date of the policy;

(2) any additional companies that become subsidiaries or owned or controlled companies of said Named Insured providing notice is given to the Company within thirty (30) days thereof;

(b) If the Named Insured is designated in the Declarations as a partnership or joint venture, the partnership or joint venture so designated and any partner or member thereof but only with respect to his liability as such, however, if the Named Insured is a partnership, this policy does not apply to an automobile owned by or registered in the named of a partner thereof. This policy does not apply to Personal Injury, Property Damage or Advertising Liability arising out of the conduct of any partnership or joint venture of which the Insured is a partner or member and which is not designated in this policy as a Named Insured. If the Named Insured is designated in the Declarations as an individual, the person so designated, but only with respect to the conduct of a business of which he is the sole proprietor;

(c) any person, organization, trustee or estate to whom or to which the Named Insured is obligated by virtue of a written contract to provide insurance such as is afforded by this policy, but only with respect to operations by or on behalf of the Named Insured or to the facilities of or used by the Named Insured;

(d) subject to the terms and conditions of this policy, any additional Insured included in the underlying insurance, but only to the extent that insurance is available to such additional Insured under such underlying insurance;

(e) except with respect to ownership, maintenance or use including loading or unloading of any automobiles or aircraft, any partner, executive, officer, director, stockholder or employee of the Named Insured, while acting in his capacity as such and any organization or proprietor with respect to real estate management for the Named Insured;

(f) any person while using any automobile owned by the Named Insured or any automobile loaned to the Named Insured or hired for use in behalf of the Named Insured and any person legally responsible for the use thereof provided the actual use thereof is with the permission of the Named Insured, and any executive officer, director or stockholder of the Named Insured with respect to the use of an automobile or watercraft not owned by the Named Insured in the business of the Named Insured. The insurance with respect to any person or organization other than the Named Insured does not apply under this division (f):

(1) to any person or organization, to any agent or employee thereof, operating an automobile sales agency, repair shop, service station, storage garage or public parking place, with respect to any occurrence arising out of the operation thereof;

(2) with respect to any automobile hired by or loaned to the Named Insured, to the owner or lessee thereof other than the Named Insured, or to any agent or employee of such owner or lessee;

The inclusion or addition hereunder of more than one Insured shall not operate to increase the Company's limit of liability.

(B) PERSONAL INJURY shall mean:

(a) bodily injury, sickness, disease, including death anytime resulting therefrom, shock, fright, mental anguish and mental injury;

(b) false arrest, false imprisonment, wrongful eviction, wrongful detention, malicious prosecution and humiliation;

(c) libel, slander, defamation of character or invasion of right of privacy unless arising out of Advertising Liability;

and

(d) assault and battery not committed by or at the direction of the Insured unless committed for the purpose of preventing or eliminating danger to persons or property;

which occurs during the policy period.

(C) PROPERTY DAMAGE shall mean (1) physical injury to or destruction of tangible property, which occurs during the policy period, including loss of use thereof at any time resulting therefrom; or (2) loss of use of tangible property, which has not been physically injured or destroyed provided such loss of use is caused by an occurrence during the policy period.

(D) ADVERTISING LIABILITY shall mean liability for damage because of:

(a) unintentional Libel, Slander or Defamation of Character;

(b) infringement of copyright or title or of slogan;

(c) piracy or unfair competition or idea misappropriation under an implied contract;

(d) invasion of the rights of privacy

cast or telecast and arising out of the Named Insured's advertising activities.

(E) PRODUCTS HAZARD includes Personal Injury and Property Damage arising out of the Insured's products or reliance upon a representation or warranty with respect thereto, but only if the Personal Injury or Property Damage occurs away from premises owned by or rented to the Insured and after physical possession has been relinquished to others.

(F) INSURED'S PRODUCTS means goods or products manufactured, sold, handled or distributed by the Insured or by others trading under his name, including any container thereof (other than a vehicle), but Insured's products shall not include a vending machine or any property other than such container, rented to or located for use of others but not sold.

(G) COMPLETED OPERATIONS HAZARD includes Personal Injury and Property Damage arising out of operations or reliance upon a representation or warranty made at any time with respect thereto, but only if the Personal Injury or Property Damage occurs after such operations have been completed or abandoned and occurs away from premises owned by or rented to the Insured. "Operations" include materials, parts or equipment furnished in connection therewith.

Operations shall be deemed completed at the earliest of the following times:

(a) when all operations to be performed by or on behalf of the Insured under the contract have been completed,

(b) when all operations to be performed by or on behalf of the Insured at the site of the operations have been completed,

(c) when the portion of the work out of which the injury or damage arises has been put to its intended use by any person or organization other than another contractor or sub-contractor engaged in performing operations for a principal as part of the same project.

Operations which may require further service or maintenance work, or correction, repair, or replacement because of any defect or deficiency, but which are otherwise complete, shall be deemed completed.

The Completed Operations Hazard does not include Personal Injury or Property Damage arising out of:

(1) operations in connection with the transportation of property, unless the Personal Injury or Property Damage arises out of a condition in or on a vehicle created by the loading or unloading thereof,

(2) the existence of tools, uninstalled equipment or abandoned or unused materials.

(H) OCCURRENCE – With respect to Personal Injury and Property Damage, the term "Occurrence" means an event, including continuous or repeated exposure to conditions, which result in Personal Injury or Property Damage during the policy period, neither expected nor intended from the standpoint of the Insured. All Personal Injury or Property Damage arising out of the continuous or repeated exposure to substantially the same general conditions shall be considered as arising out of one occurrence.

(I) ULTIMATE NET LOSS – Except as provided in Insuring Agreement II, "Defense", the term "Ultimate Net Loss" shall mean the total sum which the Insured, or any company as its insurer, or both become obligated to pay by reason of personal injury, property damage, or advertising liability claims, either through adjudication or compromise, and shall also include hospital, medical, and funeral charges and all sums paid or payable as salaries, wages, compensation, fees, charges, interest, expenses for doctors, nurses, and investigators and other persons, and for settlement, adjustment, investigation and defense of claims and excluding only the salaries of the Insured or any of the underlying Insurer's permanent employees.

The Company shall not be liable for expenses as aforesaid when such are covered by underlying policies of insurance whether collectible or not.

CONDITIONS

1. Premium. The premium for this policy is a flat premium and is not subject to adjustment except that additional premiums may be required for any additional insureds as outlined in Definition (A) "Persons Insured", as provided in Condition 13 "Cancellation", or if this policy is subject to audit adjustment, the premium may be based upon the rating basis as set forth in the Declarations during the policy period. Upon expiration of this policy or its termination during the policy period, or at the end of each policy year, the earned premium shall be computed as specified herein. If the earned premium is more than the advance premium paid, the Insured shall promptly pay the excess to the Company; if less, the Company shall return to the Insured the unearned portion, subject to the annual minimum premium stated in the Declarations for each twelve (12) months of the policy period, and subject further to the policy minimum premium as stated in the Declarations.

2. Prior Insurance and Non-Cumulation of Liability. It is agreed, that if any loss is also covered in whole or in part under any other excess policy issued to the Insured prior to the inception date hereof, the Company's limit of liability as stated in Item 3 of the Declarations shall be reduced by any amounts due the Insured on account of any such loss under such prior insurance.

3. Severability of Interest. In the event of claims being made by reason of Personal Injuries, Property Damage or Advertising Liability suffered by one Insured herein for which another Insured herein is or may be liable, this policy shall cover such Insured against whom a claim is made or may be made in the same manner as if separate policies had been issued to each Insured herein. Nothing contained herein shall operate to increase the Company's limit of liability as set forth in the Limit of Liability section.

Occurrence covered hereunder involved injuries or damages which, in the event that the Insured should be held liable is likely to involve this policy immediate notice shall be sent to the Company.

5. Inspection and Audit. The Company shall be permitted but not obligated to inspect the Insured's property and operations at any time. Neither the Company's right to make inspections nor the making thereof nor any report thereon shall constitute an undertaking, on behalf of or for the benefit of the Insured or others, to determine or warrant that such property or operations are safe. The Company may examine and audit the Insured's books and records at any time during the policy and extensions thereof and within three (3) years after the final termination of this policy, as far as they relate to the subject matter of this insurance.

6. Maintenance of Underlying Insurance. The policy or policies referred to in the attached "Schedule of Underlying Insurances", and any renewal or replacement thereof, not more restrictive, shall be maintained by the Insured in full effect during the currency of this policy without alteration of terms or conditions except for any reduction of the aggregate limit or limits contained therein solely by payment of claims. Failure of the Insured to comply with the foregoing shall not invalidate this policy but in the event of such failure, the Company shall only be liable to the same extent as it would have been had the Insured so maintained such policy or policies.

7. Assistance and Cooperation. Except as provided by Insuring Agreement II, Defense, the Company shall not be called upon to assume charge of the settlement or defense of any claim made or suit brought or proceedings instituted against the Insured, but the Company shall have the right and shall be given the opportunity to associate with the Insured or the Insured's underlying insurer, or both, in the defense and control of any claim, suit or proceeding relative to any Occurrence where the claim or suit involves, or appears reasonably likely to involve the Company, in which event the Insured, the underlying insurers and the Company shall cooperate in all things in the defense of such claim, suit or proceeding.

8. Appeals. In the event the Insured or the Insured's underlying insurer(s) elects not to appeal a judgment in excess of the underlying limits, the Company may elect to make such appeal at its own cost and expense and shall be liable for the taxable costs and disbursements and interest incidental thereto, but in no event shall the liability of the Company, for the ultimate net loss, exceed the amount set forth in Item 3(A) of the Declarations for any one Occurrence plus the cost and expense of such appeal.

9. Other Insurance. If other valid and collectible insurance with any other insurer is available to the Insured covering a loss also covered hereunder, this insurance shall be excess of, and shall not contribute with such other insurance. Excess insurance over the Limits of Liability expressed in this policy is permitted without prejudice to this insurance and the existence of such insurance shall not reduce any liability under this policy.

10. Application of Salvages — Subrogation. All salvages, recoveries or payments recovered or received subsequent to a loss settlement under this insurance shall be applied as if recovered or received prior to such settlement and all necessary adjustments shall then be made between the Insured and the Company, provided always that nothing in this clause shall be construed or mean that losses under this insurance are not recoverable until the Insured's ultimate net loss has been finally ascertained. Inasmuch as this policy is "Excess Coverage", the Insured's right of recovery against any person or other entity cannot always be exclusively subrogated to the Company. It is therefore understood and agreed that in case of any payment hereunder, the Company shall act in concert with all other interests (including the Insured) concerned, in the exercise of such rights of recovery. The apportioning of any amounts which may be so recovered shall follow the principle that any interests (including the Insured) that shall have paid an amount over and above any payment hereunder, shall first be reimbursed up to the amount paid by them; the Company shall then be reimbursed out of any balance then remaining up to the amount paid hereunder; lastly, the interests (including the Insured) of whom this coverage is excess are entitled to claim the residue, if any. Expense necessary to the recovery of any such amounts shall be apportioned between the interests (including the Insured) concerned, in the ratio of their respective recoveries as finally settled.

11. Changes. Notice to or knowledge possessed by any person shall not affect a waiver or change in any part of this policy or stop the Company from asserting any rights under the terms of this policy; nor shall the terms of this policy be waived or changed, except by endorsement issued to form a part hereof, signed by an authorized representative of the Company.

12. Assignment. Assignment of interest under this policy shall not bind the Company until its consent is endorsed hereon; if, however, the Insured shall be adjudged bankrupt or insolvent, this policy shall cover the Insured's legal representative as Insured; provided that notice of cancellation addressed to the Insured named in the Declarations and mailed to the address shown in this policy shall be sufficient notice to effect cancellation of this policy.

13. Cancellation. This policy may be cancelled by the Insured by surrender thereof to the Company or any of its authorized agents, or by mailing to the Company or any of its authorized agents, written notice stating when thereafter such cancellation shall be effective. The policy may be cancelled by the Company by mailing to the Insured at the address shown in Item 1 of the Declarations, written notice stating when, not less than thirty (30) days thereafter, ten (10) days with respect to cancellation for non-payment of premium, such cancellation shall be effective. Proof of mailing of notice as aforesaid shall be sufficient proof of notice. The time of surrender or the effective date and hour of cancellation stated in the notice shall become the end of the policy period. Delivery of such written notice either by the Insured or by the Company shall be equivalent to mailing. If the Insured cancels, earned premium shall be computed in accordance with the customary short rate table procedure. If the Company cancels, earned premium shall be computed pro rata. In the event of such cancellation, the earned premium shall in no case be less than the annual minimum premium stated in the Declarations, subject to the policy minimum premium also stated in the Declarations.

Premium adjustment may be made at the time cancellation is effected or as soon as practicable thereafter. The check of the Company or its representative mailed or delivered, shall be sufficient tender of any refund due the Insured.

If this policy insures more than one Insured, cancellation may be effected by the first of such Insureds for the account of all Insureds: the notice of cancellation by the Company to such first Insured shall be notice to all Insureds. Payment of any unearned premium to such first Insured shall be for the account of all interests in such payment.

sured, the Company shall not be relieved thereby of the payment of any claims hereunder because of such bankruptcy or insolvency.

15. First Named Insured. The first Named Insured in Item 1 of the Declarations, shall be responsible for payment of all premiums, and shall act on behalf of all other Insureds with respect to the giving and receiving of notice of cancellation and the receipt of any return premium, that may become payable under this policy.

.N WITNESS WHEREOF, the Company has caused this policy to be executed and attested, but this policy shall not be valid unless countersigned by a duly authorized representative of the Company.

Secretary

President

FACILITY CLOSURE AND POST-CLOSURE MAINTENANCE PLAN CHECKLIST

REFERENCE	ITEM
1820-E-6	List of future uses of the site or list of uses which would pose a menace to human health or the environment

There would be no menace to human health or the environment, especially after revegetation was completed.

Air Quality Control Measures

Ore from the pit is subject to spray water as it is dumped into the primary crusher to control fugitive dust. A wet dust collector treats dust generated in the primary crushing stage. Additional water sprays are located at the discharge point from the intermediate ore storage conveyor. Wet dust collectors are located at the intermediate ore storage feeders, the secondary crushing building, the screening tower and the fine ore feeders. Additional water sprays are located at the discharge points from the fine ore storage conveyor. All wet scrubber dust collector underflows are pumped to the mill for mineral recovery.

Two 7,000 gallon and one 8,000 gallon water trucks are used to suppress dust generated by vehicles.

PCB

Any and all PCB to be disposed of will be stored at the Mission Unit of ASARCO Incorporated, Sahuarita, Arizona, until such time as an appropriate disposal facility is available within the state of Arizona.

Mineral Oils

Used oil from the plantsite such as engine oil, lubricating oils and hydraulic fluid is stored either in drums or in a buried steel holding tank. Approximately every month this used oil is picked up by a transporter for reprocessing or reuse off the site.

Toxic Substances

Empty barrels which contained liquid toxic substances will be rinsed with diesel fuel. This fuel will be added to the used oil storage tank. The rinsed empty drum will be either returned to the supplier or properly stored onsite.

REFERENCE	ITEM
1821-C-8	Description of methods used to reduce water content
1821-C-8	Description of methods used to reduce water solubility
1821-C-8	Description of methods used to reduce overall toxicity
1821-A-3	Description of methods used to neutralize waste
1821-C-9	Description of methods used to handle reactive and/or explosive wastes
1821-C-9	Description of surface water diversion structure -
1821-C-9	Design of gas venting system
1821-C-9	Design of facilities to assure segregation of incompatible wastes
1821-A-3	Presentation of the economic feasibility of resource recovery as opposed to disposal in a hazardous waste site
1821-A-3	Presentation of the economic feasibility of waste destruction as opposed to disposal in a hazardous waste site

Does not apply.

REFERENCE	ITEM
1821-D-2	Waste and soil analysis
	Calculations supporting application rates
	Signed agreement with Soil Conservation Service regarding cropping requirements

Does not apply.

REFERENCE ITEM

1821-F-1 Sample of waste log

Mill Tailings Disposal Log (example):

Date	Tons	Storage Location	Remarks
August, 1980	334,476	N. loop dam	1448' level

REFERENCE	ITEM
1821-F-2	Sample of summary reports and records

Incident Log

Date	Description

REFERENCE	ITEM
1821-F-3	Sample of Emergency Coordinators logs

Date and Time	Location	Incident	Remarks	By
10-21-80 2:55PM	N. side tailings dam	Drill only	Response by 3:10 PM	KWD (example entry)
10-28-80	thickener & dam	inspection	all OK	KWD (example entry)

REFERENCE	ITEM
1821-F-4	Sample of operating conditions logs

Date	Tons	% Solids	Gallons of Water To Dam	Gallons of Water From Dam
Aug., 1980	334,476	50.7	77,087,202	14,337,200

REFERENCE	ITEM
1821-F-5	Sample of monitoring logs

Monitor Well

Date Sampled	Analysis Mg/Liter							
	As	Ba	Cd	Cr	Pb	Hg	Se	Ag

REFERENCE	ITEM
1821-B-2	Description of flooring or base of storage areas and its resistance to degradation by wastes being stored

The 275 foot diameter tailings thickener has a PVC liner of 30 mils thickness. It is protected by one foot of fine sand and three feet of tailings. The tailings dam area has no flooring involved.

The desert floor prior to deposition of tailings had an average of 125 feet of sand over conglomerate with horizontal and vertical permeabilities of 117 - 196 and 117 feet per year respectively. The sand was covered with fine slimes prior to tailings being deposited.

The monitor well bore log shows the following below ground level:

0 - 145 ft.	sand
145 - 215 ft.	clay and boulders
215 - 400 ft.	conglomerate

The well was terminated at 400 foot depth. Water was first encountered at a depth of 220-230 feet. The static water level is 200 feet.

REFERENCE	ITEM
1821-B-3	Description of protective devices for collection and containment of wastes escaping from storage units

There are none in place.

REFERENCE	ITEM
	Anticipated storage time of wastes

Does not apply.

REFERENCE	ITEM
	Anticipated waste disposition once storage is discontinued

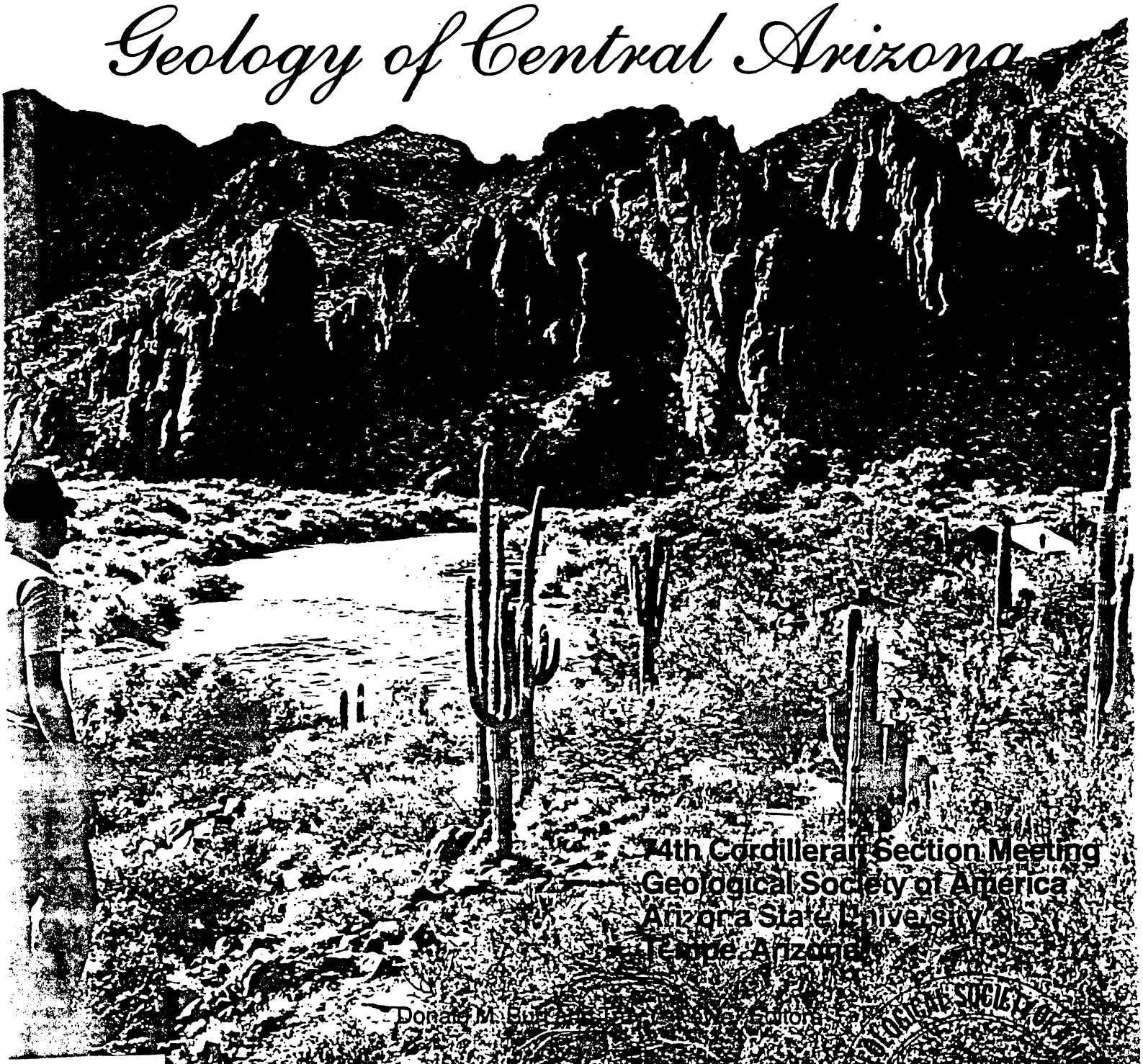
It is not anticipated that the tailings will be disturbed in the future.

REFERENCE	ITEM
	"Current inventory" record keeping procedures

Does not apply.

Guidebook to the Geology of Central Arizona

RECORDS CENTER



74th Cordilleran Section Meeting
Geological Society of America
Arizona State University
Tempe, Arizona

Donald M. Burt and Thomas L. Pewe, Editors

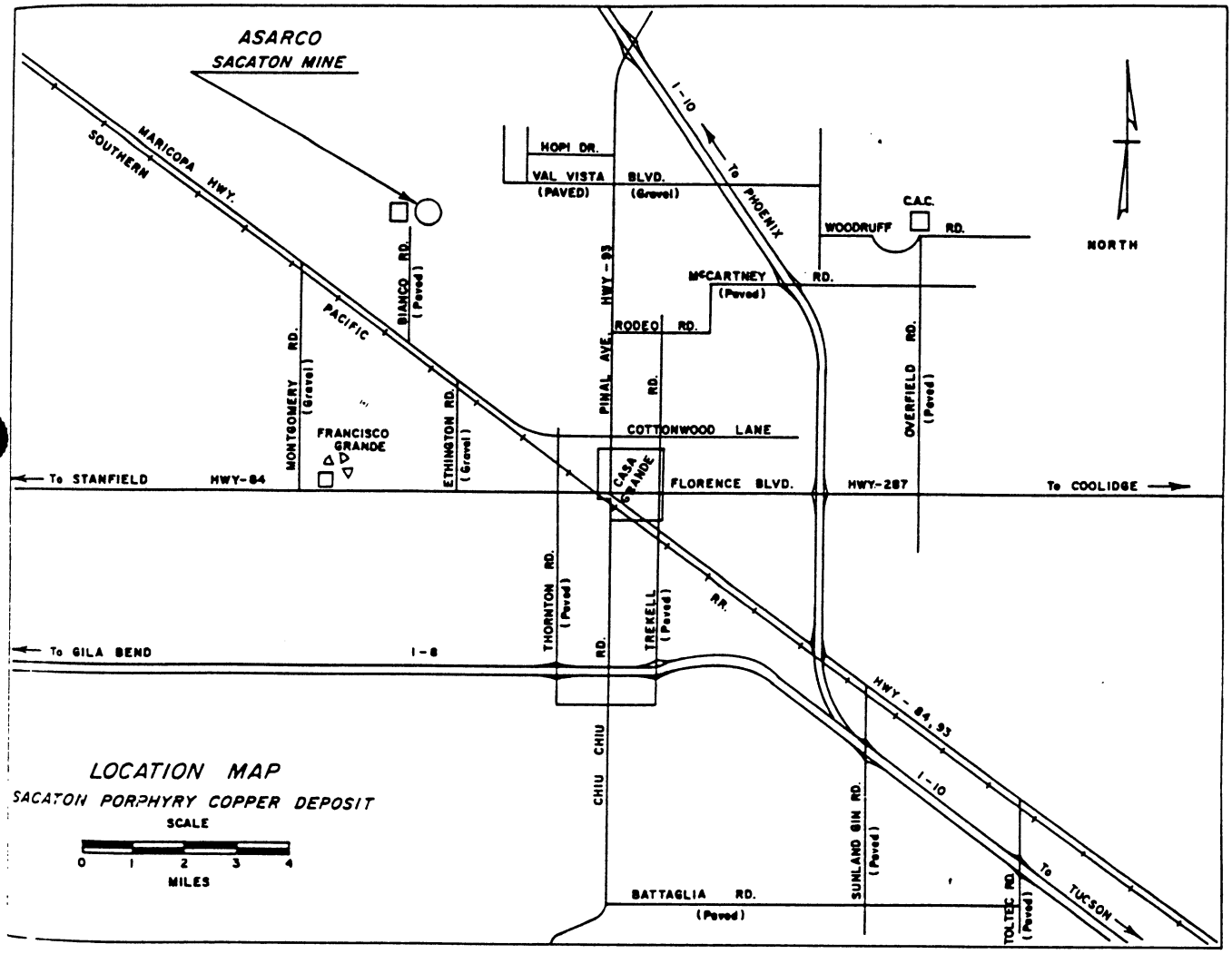
QE
80
G41
1978cs
c.2

Geology and Mineral Technology

THE SACATON PORPHYRY COPPER DEPOSIT

by
Robert B. Cummings
ASARCO, Incorporated
Casa Grande, Arizona

This one-day field trip visits an active open pit copper mine about 35 miles south of Tempe. Boots are recommended; hard hats and safety glasses will be supplied at the mine. Figure 1 is included in place of a road log. The geology of the deposit will be described more completely in an article being prepared for the second porphyry copper volume under the editorship of S. R. Titley (University of Arizona).



The Sacaton copper deposit is located in the west-central portion of Pinal County, Arizona, about 6 miles northwest of Casa Grande and 65 miles northwest of Tucson. The mine is on a gently dipping alluvial plain south of the Sacaton Mountains. Vegetation is sparse and the climate is semiarid. The average altitude in the mine area is 1,450 feet.

Early in 1961 Asarco geologists examined a small outcrop of leached capping south of the Sacaton Mountains. The outcrop forms a low hill, about 300 feet in diameter, which is surrounded by Quaternary alluvium. The closest pre-mineral rocks are found one and one-half miles to the north. The outcrop is composed of granite which is cut by several thin monzonite porphyry dikes. Both rocks contain pervasive phyllic and argillic alteration. The nature of the leached capping suggests the original sulfides were about 2 percent pyrite by volume with traces of chalcocite.

With the altered outcrop as a positive exploration lead a

drilling program was initiated which eventually outlined two zones of ore grade copper mineralization which are separated by a steeply dipping normal fault (the Sacaton Fault). The west ore body, on the up-thrown side of the fault, is presently being mined by open pit methods. Before commencement of mining activities the ore reserves were estimated to be 33.0 million tons at an average grade of 0.76 percent copper with a cutoff of 0.30 percent copper. The east ore body will eventually be mined by block caving methods. Full-scale production in the west ore body started in February, 1974. At the present time the mine is producing approximately 11,000 tons of ore per day.

Outcrops in the vicinity of the Sacaton deposit include Precambrian Pinal Schist and Oracle Granite and the Laramide Three Peaks Monzonite. The ore bodies are completely covered by Quaternary alluvium.

Within the ore bodies Oracle Granite is intruded by monzonite and quartz monzonite porphyries of probable Laramide age. The porphyries occur as mixed breccias, monolithic breccias, large poorly defined dike-like intrusive masses, and thin well-defined dikes. The center of the west ore body is occupied by an irregular pre-mineral breccia in which fragments of granite and the porphyries are intimately mixed.

Pre-mineral rocks occurring in and around the ore bodies exhibit pervasive hydrothermal alteration. The principal alteration minerals include sericite, quartz, undifferentiated clays, biotite, and chlorite. A well-defined zonation of alteration assemblages has not been identified, but the strongest alteration is generally coincident with the most intense sulfide mineralization.

Hypogene sulfide mineralization (as pyrite, chalcopyrite, and molybdenite) occurs in veinlets, disseminations, and breccia cavity fillings. All pre-mineral rock types are mineralized. The total sulfide content varies from 1.5 percent to 4.0 percent by volume. The best hypogene mineralization occurs in an arcuate-shaped zone which underlies ore grade supergene mineralization. Within this zone the copper content averages over 0.40 percent as chalcopyrite and the pyrite to chalcopyrite ratio varies from 1:1 to 3:1.

Supergene sulfides (chalcocite and minor covellite) occur as replacements of chalcopyrite and pyrite. Supergene mineralization in the west ore body is irregular in thickness, configuration, grade, and continuity. The supergene blanket has a gentle to moderate northerly dip and varies in thickness from less than 50 feet on the margins to over 500 feet.

The original supergene blanket was extensively modified and partly destroyed by a period of post-enrichment oxidation and leaching. During this period a significant quantity of chalcocite from the blanket was oxidized. A portion of the oxidized copper was fixed in place as various oxide copper minerals. The remainder was leached and probably flushed out of the mine area.

ASH-1



HEXCEL CHROMIUM DISPOSAL SITE

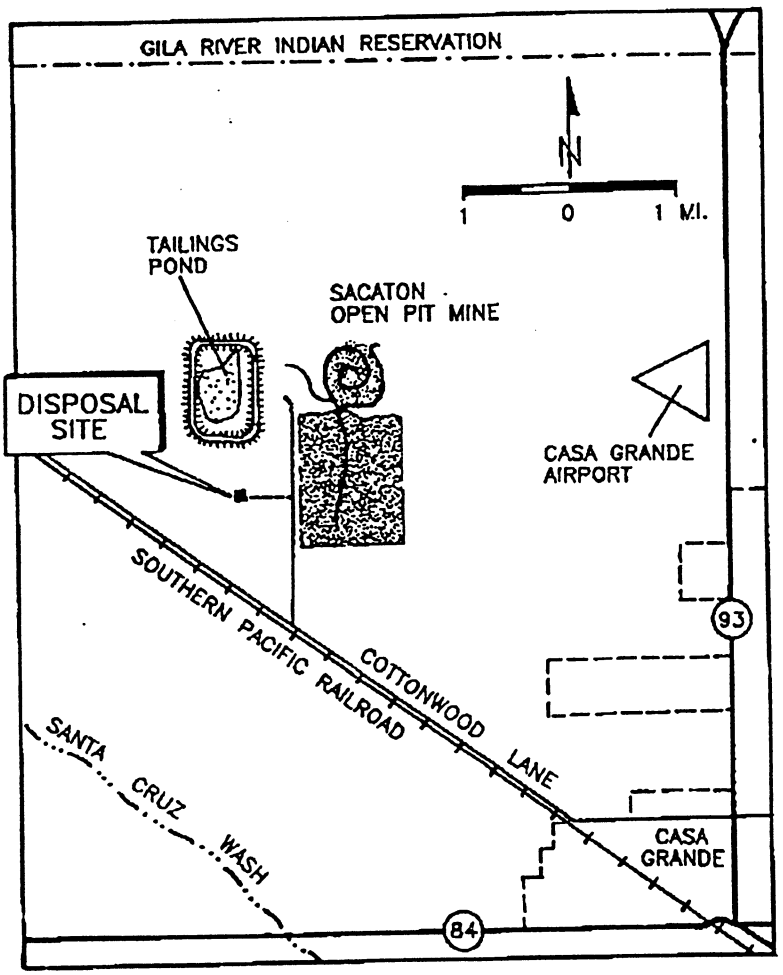
QUESTIONS AND ANSWERS

Arizona Department of Environmental Quality
3033 North Central Avenue
Phoenix, Arizona 85012
(602) 207-2300

WHAT IS THE HEXCEL CHROMIUM DISPOSAL SITE?

Leased by Hexcel Corporation in 1967 from the Arizona State Land Department (ASLD), the site covers roughly one-quarter acre about five miles northwest of Casa Grande. For about two years starting in late 1968, it was used by Hexcel for disposal of chromium-bearing waste mixed with water from industrial processes at the company's manufacturing plant in Casa Grande.

Roughly 6,000 square feet of soil at the site has been contaminated by chromium, a heavy metal, to a maximum depth of 70 feet. Chromium contamination is visible as yellow pigment on areas of the surface soils at the site.



Groundwater at the site also is contaminated, although there is no evidence that the contamination resulted from Hexcel's disposal of industrial waste. Arsenic, nitrates, sodium and sulfates all have been found. Samples also indicate a slightly elevated level of chromium.

Since 1987, the Hexcel Chromium Disposal Site has been under the state's Water Quality Assurance Revolving Fund (WQARF), which supports cleanup efforts across the state. It is now on the WQARF Priority List.

Under supervision of the Arizona Department of Environmental Quality (ADEQ), Hexcel Corporation and ASLD have drawn up plans for remediation at the site.

WHY IS REMEDIATION NECESSARY?

Because soil at the Hexcel site is contaminated, it poses a potential risk to human health and the environment. Remedial action at the site is necessary to eliminate that threat.

As part of the remediation, monitoring of groundwater also will continue.

WHAT IS THE ROLE OF THE PUBLIC IN PLANS FOR THE HEXCEL SITE?

The public is invited to join in the next step in the WQARF process, approval of the Remedial Action Plan (RAP) for the site.

A public comment period on the remedial action plan (RAP) is under way and will extend through March 16, 1993. ADEQ is encouraging members of the public to review the RAP. Comments may be addressed to Project Manager Don Atkinson, 3033 N. Central Avenue, Fifth Floor, Phoenix, Arizona 85012.

For more information about the Hexcel Chromium Disposal Site Remedial Action Plan, see the last page of this fact sheet.

HOW DID THE HEXCEL SITE BECOME CONTAMINATED?

Chromium wastes were disposed of at the site for approximately two years beginning in late 1968. Although no records exist on the disposal activities, the greatest volume of waste is believed to have been generated by rinse water containing approximately .5 percent chromium. Such waste was reportedly transported to the site on an average of one 400- to 600-gallon load per day, seven days per week.

Once every one to two months, a chromium-bearing sulfuric acid solution may have been transported to the site.

WHEN DID WE FIND OUT ABOUT THE CONTAMINATION?

In January 1982, a berm surrounding the site was rebuilt and a new ditch was constructed along the east side to divert surface drainage. In August 1982, soil borings to a depth of 20 feet were drilled around the site and in the centers of the west and east sides of the landfill.

Soil samples were analyzed by ASLD and turned up the contamination.

WHAT DO WE KNOW ABOUT POSSIBLE HEALTH EFFECTS OF SOIL CONTAMINATION AT THE SITE?

Chromium is a heavy metal that can damage living things in low concentrations and tends to accumulate in the food chain. Chromium at the Hexcel site is *environmentally mobile hexavalent chromium,* meaning that it dissolves readily in water to become a pollutant. Some forms of this type of chromium are regarded as carcinogenic.

The Arizona Department of Health Services completed a risk assessment for the site on October 15, 1992. The results of the study indicated that contaminated soil at the site could be of concern.

However, because the Hexcel Chromium Disposal Site is in a remote location and is fenced off, there is very limited potential for exposure to people. Plans are under way as part of the RAP to cap the site and eliminate any risk of exposure.

WHAT HAS BEEN DONE TO TREAT CHROMIUM CONTAMINATION IN SOIL AT THE SITE?

From April 1984 through January 1985, remediation was begun with injection of sulfur dioxide gas into the ground to reduce the hexavalent chromium to *trivalent chromium.* That form of chromium is less soluble, less mobile, and it is not carcinogenic.

Based on chromium analyses before and after the remediation, the process was about 50 percent effective in the treated area.

WHAT STUDIES HAVE BEEN DONE ON GROUNDWATER AT THE SITE?

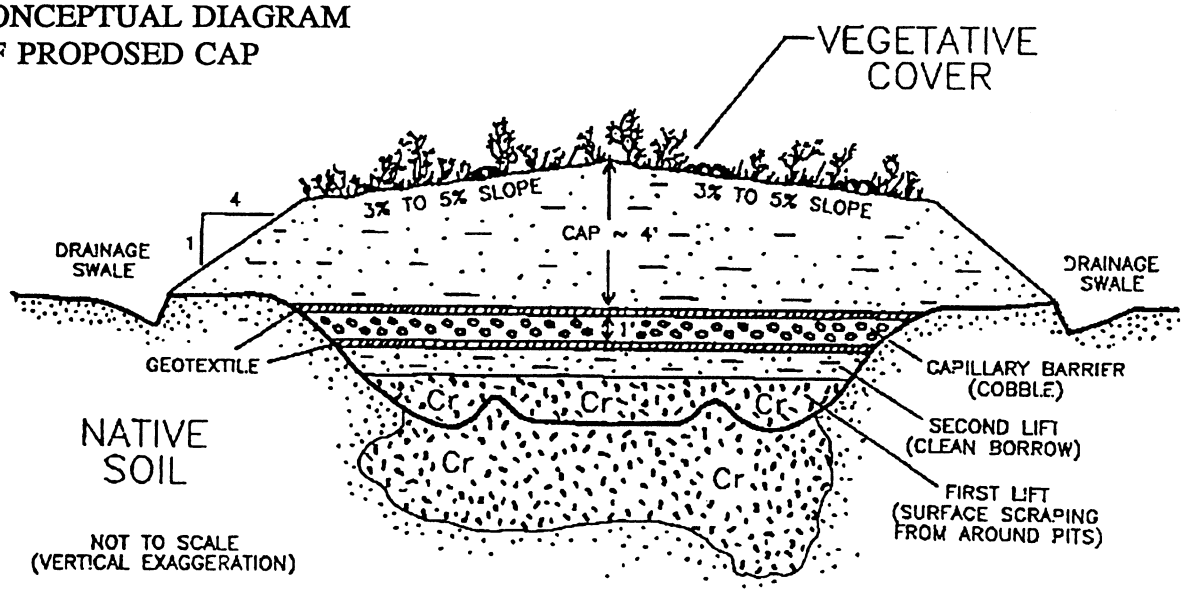
The Arizona Department of Environmental Quality has required installation of three groundwater

monitoring wells. Sampling from the wells has shown no effects from chromium at the site. Results showed chromium concentrations below the federal Maximum Contaminant Level (MCL) for drinking water, while arsenic and selenium exceeded MCLs.

The groundwater tested near the Hexcel Chromium Disposal Site is part of a zone of highly mineralized groundwater that exists around the Sacaton mine area. That water contains high levels of sodium, chloride, sulfate, nitrate and fluoride.

Comparison of upstream and downstream water quality indicates that the poor quality of groundwater near the Hexcel site is not attributable to Hexcel's chromium disposal practices.

CONCEPTUAL DIAGRAM
OF PROPOSED CAP



WHAT REMEDIATION PLANS HAVE BEEN DRAWN UP FOR THE SITE?

As part of the proposed Remedial Action Plan, all surface contamination would be placed in the disposal pits and covered with an earthen cap approximately four to eight feet thick. This would eliminate any possibility of direct contact by people with the contamination, infiltration of water, or the migration of chromium to the surface or to the underground water table.

The RAP also includes construction of surface drainage controls, as well as monitoring of groundwater quality and the performance of the cap.

WHAT IS THE WQARF PROGRAM?

Arizona's Water Quality Assurance Revolving Fund (WQARF) was created by the Legislature under the state Environmental Quality Act of 1986. The WQARF fund was set up to support environmental remediation efforts across the state via fees authorized by the Legislature and other financial sources.

The WQARF fund is used when private money for remediation cannot be found or responsible parties have not been identified. The Hexcel site is one of 24 WQARF Priority List Sites.

WQARF parallels the federal Superfund program, created by Congress in 1980.

The public is encouraged to take an active role during all phases of the WQARF program.

HOW CAN I GET MORE INFORMATION ABOUT THE PROPOSED REMEDIAL ACTION PLAN FOR THE HEXCEL CHROMIUM DISPOSAL SITE?

A copy of the RAP is available for viewing at the following locations:

Arizona Department of Environmental Quality
Information Center, First Floor
3033 N. Central Avenue
Phoenix, Arizona 85012
Phone (602) 207-2202

Casa Grande Public Library
405 East Sixth Street
Casa Grande, Arizona 85222
Phone (602) 421-8690

You can receive information about activities of the Arizona Department of Environmental Quality at the following telephone numbers:

Automated Information Line: (602) 207-4300
General Information: (602) 207-2300
Arizona Toll-Free: (800) 234-5677

The Arizona Department of Environmental Quality shall preserve, protect and enhance the environment and the public health and shall be a leader in the development of public policy to maintain and improve the quality of Arizona's air, land and water resources.

Send Confirmation Report

Name: JetFax M910 ID: 602 4 Dec'98 10:21AM Page 1

Job	Start time	Usage	Phone Number or ID	Type	Pages	Mode	Status
9	12/ 4 10:18AM	2'32"	SCHAFER COLORADO.....	Send.....	7/ 7	EC 96	Completed.....

Total: 2'32" Pages sent: 7 Pages printed: 0

Schafer & Associates

FACSIMILE COVER SHEET

Please deliver the following pages:		Date:	December 4, 1998
To:	Jeff Todd	Phone:	
Firm:	Schafer & Associates, Inc.	Fax:	
From:	Travis LaBlanc	Phone:	(602) 870-7757
Project No.:	228-2	Fax:	(602) 870-1235

Number of pages (including this cover page): 7

A hard copy of this fax will be sent by mail.

If all pages are not received, please call (602) 870-7757

Jeff,

As requested, attached is a copy of ADEQ's "HEXCEL CHROMIUM DISPOSAL SITE – *QUESTIONS AND ANSWERS*" (6 pages total, including cover). I'll put a hard copy of this fax in the mail.

CONFIDENTIALITY NOTICE: This facsimile transmission and the documents accompanying it may contain confidential information which is protected by the attorney-client or attorney work-product privilege. The information is intended only for use by the individual or entity named above. If you are not the intended recipient, any disclosure, copying, distribution or the taking of any action or reliance on the contents of this information is prohibited. If you have received this transmission by error, please IMMEDIATELY notify us by telephone and arrange for the return of the documents.

SCHAFER AND ASSOCIATES, INC.
7220 North 16th Street, Suite E, Phoenix, Arizona 85020
(602) 870-7757

U:\LABLANC\FORMS\FAXCVR.DOC [12/4/98]

WELL INSTALLATION AND GROUNDWATER MONITORING RESULTS AT THE ABANDONED CHROMIUM DISPOSAL SITE CASA GRANDE, ARIZONA

Prepared for:

Hexcel Corporation
11555 Dublin Boulevard
Dublin, California 94568

Prepared by:

Hydro Geo Chem, Inc.
1430 North Sixth Avenue
Tucson, Arizona 85705

Revised October 30, 1992

TABLE OF CONTENTS

Page

I. INTRODUCTION 1

II. LOCATION AND PHYSICAL SETTING 3

III. HYDROGEOLOGIC SETTING 5

IV. GROUNDWATER MONITORING WELL CONSTRUCTION 7

V. SITE LITHOLOGY 14

VI. MONITORING WELL WATER LEVELS AND GROUNDWATER FLOW DIRECTION 16

VII. MONITORING WELL SAMPLING JUNE, 1992 18

Well Purging 18
Sample Collection 19
Results and Analyses 21

VIII. CONCLUSION 24

IX. SUMMARY OF REMEDIAL ACTION PLAN TASKS 25

Tasks Completed to Date 25
Tasks Required to Complete the Remedial Action Plan 28

XI. REFERENCES 30

APPENDIX A: LITHOLOGIC LOGS
APPENDIX B: WATER WELL ANALYSES RESULTS

TABLE OF CONTENTS (CONTINUED)

List of Tables

Table 1	Water Level Elevation Parameters	17
Table 2	Sample Stabilization Parameters	19
Table 3	Analytical Results of June, 1992 Sampling	22
Table 4	Summary of MW-1 Analytical Results	22

List of Figures

Figure 1	Site Location	4
Figure 2	Location of On-site Monitoring Wells and the Subsurface Evaporation Field	8
Figure 3	Monitoring Well Completion Diagram for MW-1	9
Figure 4	Drilling Information and "As-Built" diagram for MW-2	11
Figure 5	Drilling Information and "As-Built" Diagram for MW-3	12
Figure 6	Lithologic cross-section for the Hexcel Chromium Site	15
Figure 7	Water Level Contour Map (at back of report)	
Figure 8	Schedule of Tasks for the Completion of the Remedial Action Plan	28

I. INTRODUCTION

The following groundwater monitoring report is submitted as part of the Remedial Action Plan (RAP) for the Hexcel Abandoned Chromium Disposal Site located near Casa Grande, Arizona. The RAP consists of constructing a permanent cap to contain the wastes on site. The purpose of the groundwater monitoring plan is to satisfy Phase I of the RAP described in detail in the Revised Remedial Action Plan prepared by Hydro Geo Chem, Inc. (HGC) (1992a), for Hexcel Corporation.

The main body of this report describes the construction of the monitoring wells and subsurface evaporation field, the site's lithology, groundwater levels, the flow direction at the site, and the results of the groundwater sampling of the wells.

The report concludes with a summary of tasks comprising the RAP, listing those accomplished (including the groundwater monitoring report) and those remaining to complete the site remedial action.

The current groundwater monitoring plan is described in a work plan submitted on October 15, 1991 (Hydro Geo Chem, 1991c) and revised in a March 4, 1992 letter from Hexcel Corporation to the Arizona Department of Environmental Quality (ADEQ). To fulfill the requirements of the groundwater monitoring plan, two additional monitoring wells were installed, one upgradient and one downgradient of the site, between May 22, 1992 and May 28, 1992 to augment an existing well installed directly west of the impoundments. The three wells were then sampled:

1) To determine if the abandoned chromium surface impoundment is adversely affecting groundwater quality;

2) To determine the direction of groundwater flow in the vicinity of the site to verify that the wells are properly located to monitor the impoundments;

3) To compare downgradient metal concentrations with the upgradient, background levels;

4) To verify model predictions that chromium has not reached the groundwater; and

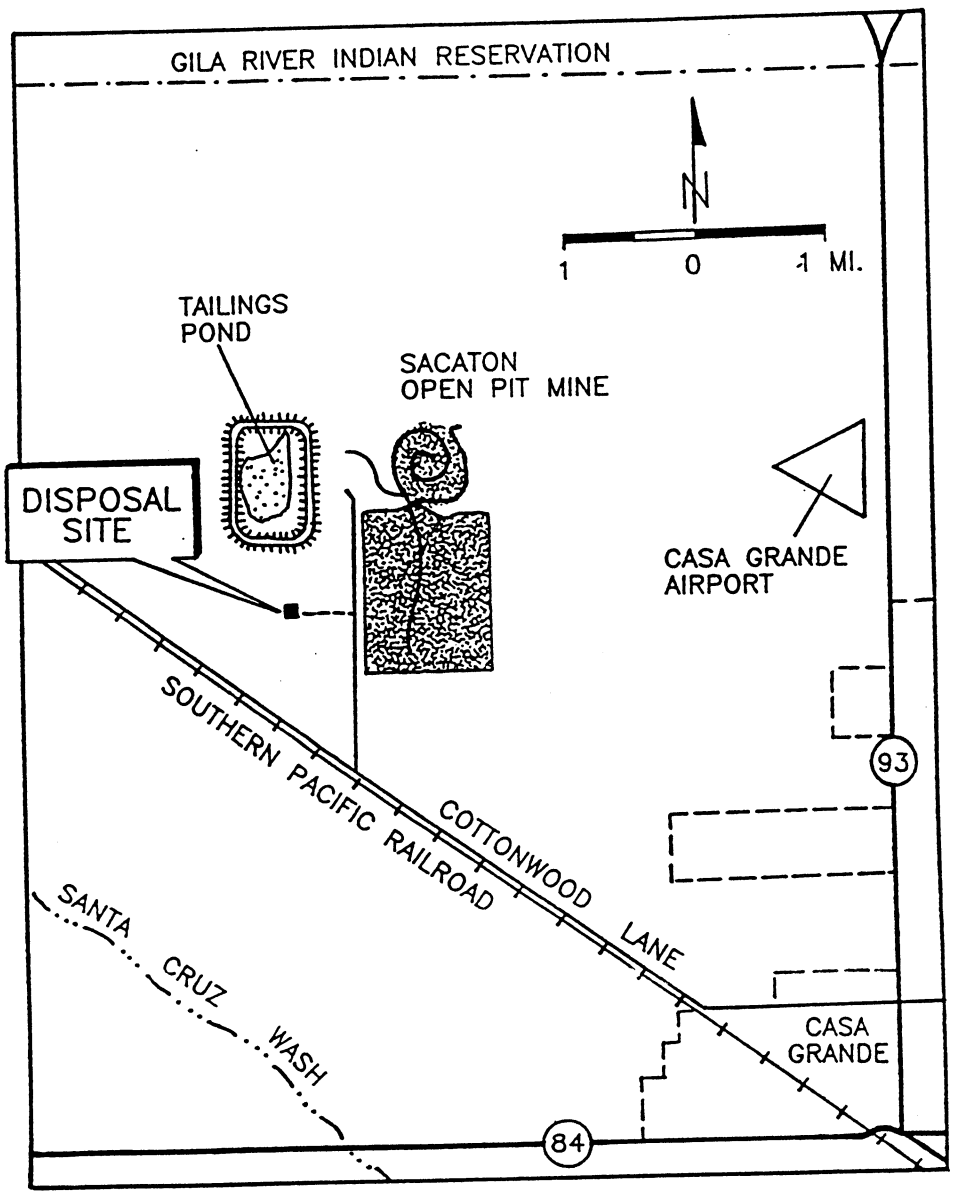
5) To continue to monitor groundwater quality in the vicinity of the impoundments to determine the effectiveness of the cap in preventing the downward migration of chromium.

II. LOCATION AND PHYSICAL SETTING

The site is located approximately 5 miles northwest of Casa Grande in Township 5 south, Range 5 east, Section 34, SW¼, SW¼, SW¼, SE¼ as shown in Figure 1. The surface impoundments occupy a 70-foot by 80-foot area approximately in the center of 2.5 acres of State land leased by the Hexcel Corporation (the current lease application is pending.)

The site lies on a gently sloping alluvial fan deposit which spreads south from the Sacaton mountains. The alluvial fan is truncated approximately 0.9 miles to the north and east by tailings piles from the ASARCO Sacaton mines. The tailings piles occupy more than 2½ sections of land surrounding the site to the north and east.

The gently sloping alluvial fan is dissected by small washes spread about ½-mile apart. The shallow channels, less than 2 feet deep, drain towards the north branch of the Santa Cruz Wash. The Vegetation in the area is sparse and consists of desert shrubs and grasses.



HYDRO GEO CHEM, INC.

SITE LOCATION MAP

Approved	Date	Revised	Date	Reference:	FIG.
[illegible]	[illegible]			37700F1	1

III. HYDROGEOLOGIC SETTING

The regional and local geology and hydrogeology of the Hexcel Chromium Disposal Site are described in the Hexcel Groundwater Monitoring Work Plan (HGC, 1989b). Montgomery and Associates (1986) also summarized the regional hydrogeologic conditions around the Asarco Sacaton open-cell mine directly north and northeast of the site. The site is located in the northeast corner of what the Arizona Department of Water Resources (ADWR) has termed the Maricopa-Stanfield sub-basin of the Pinal AMA.

The site is underlain by approximately 900 feet of basin-fill deposits that include an upper unconsolidated unit and lower conglomerate unit. A local unconsolidated gravel unit lies between the unconsolidated and conglomerate units. This unconsolidated gravel unit is described as part of the basin-fill deposits in the Maricopa-Stanfield sub-basin southwest of the site (Wickham and Corkhill, 1989). The upper unconsolidated unit consists predominantly of silty sand, sandy clay, and sandy gravels. The conglomerate unit consists of firmly-lithified sediment, most commonly a cemented clay and gravel, conglomerate, and cemented gravel.

Depth to groundwater at the site is approximately 120 feet. The direction of the regional groundwater movement is generally westward, away from the Casa Grande groundwater high located southeast of the site. In the vicinity of the abandoned chromium disposal site the groundwater is highly mineralized with total dissolved solids (TDS) exceeding 4,000 mg/L around the Sacaton tailings pile

(Montgomery and Associates, 1986). A water sample collected from the Sacaton mine pit, located approximately 1.5 miles northeast of the site, had a TDS of 8,400 mg/L in 1986. High concentrations of arsenic, chromium, selenium, and zinc have been reported in groundwater samples collected in the vicinity of the site (Montgomery and Associates, 1986). Montgomery and Associates identified five wells or mineral boreholes in the region in which arsenic levels in the groundwater were equal to or greater than ADEQ's MCL for drinking water (1986). The five wells are identified as (D-5-6) 28aac Well 1, (D-5-6) 28daa Well 2, (D-6-6) 7aaa2, (D-5-6) 33aaa well 3, and (D-5-5) 35aba Well 6. The well number identification numbers are in accordance with the Bureau of Land Management's system of land subdivision.

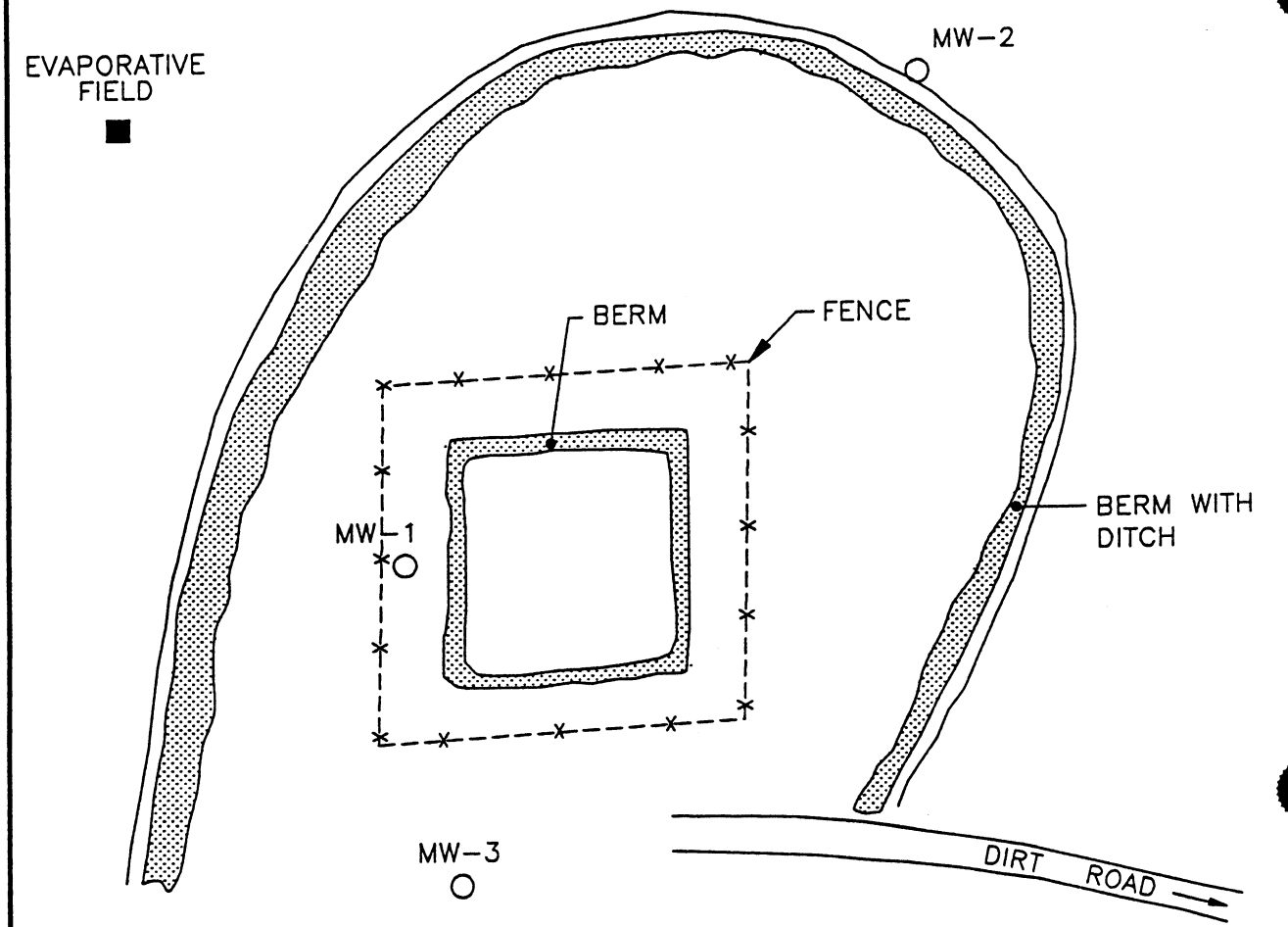
The wells or boreholes are located within four miles of the site to the northeast, east and southeast. The lateral extent of elevated levels of arsenic in the groundwater indicates that the arsenic does not have a local source. The high TDS, arsenic, and selenium levels render the groundwater unfit for domestic, livestock, or agricultural use (EPA, 1986).

IV. GROUNDWATER MONITORING WELL CONSTRUCTION

The revised groundwater work plan (1991c) called for the installation of two additional wells to augment the groundwater monitor well installed in January, 1990. The new monitoring wells were installed between May 22, 1992 and May 28, 1992, the three wells were then sampled on June 1 and 2, 1992.

The locations of the three monitoring wells are shown in Figure 2. The original monitoring well #1, MW-1, was completed in 1990 to a total depth of 219 feet below ground surface (BLS). The monitoring well completion diagram for MW-1 is shown in Figure 3. Details of the well drilling and completion are presented in the Hexcel Chromium Phase I Report (Hydro Geo Chem, 1990a).

The locations of the newly constructed monitoring wells (MW-2 and MW-3) are shown in Figure 2. The borings were advanced using a Gardner-Denver, air-rotary drill rig. The cuttings were removed from the hole using a combination of air, water and approximately 3 percent Baroid "drill foam", a mixture of anionic surfactants, isopropanol and ethanol. Grab samples of cuttings were collected every 5 feet for lithologic description. Because the wells were drilled in uncontaminated soils, the cuttings and the drilling fluid were not contained, and were discharged into a pit excavated near the drill hole. When the water table was intercepted, the pit was lined with plastic sheets and the fluid was transferred from the pit to the subsurface evaporation field (SEF). The SEF location is shown in Figure 2. The SEF was



HYDRO GEO CHEM, INC.

LOCATION OF THE ON-SITE MONITORING WELLS AND THE SUBSURFACE EVAPORATION FIELD

Approved	Date	Revised	Date	Reference:	FIG.
AEH	6/22/92			3770007B	2

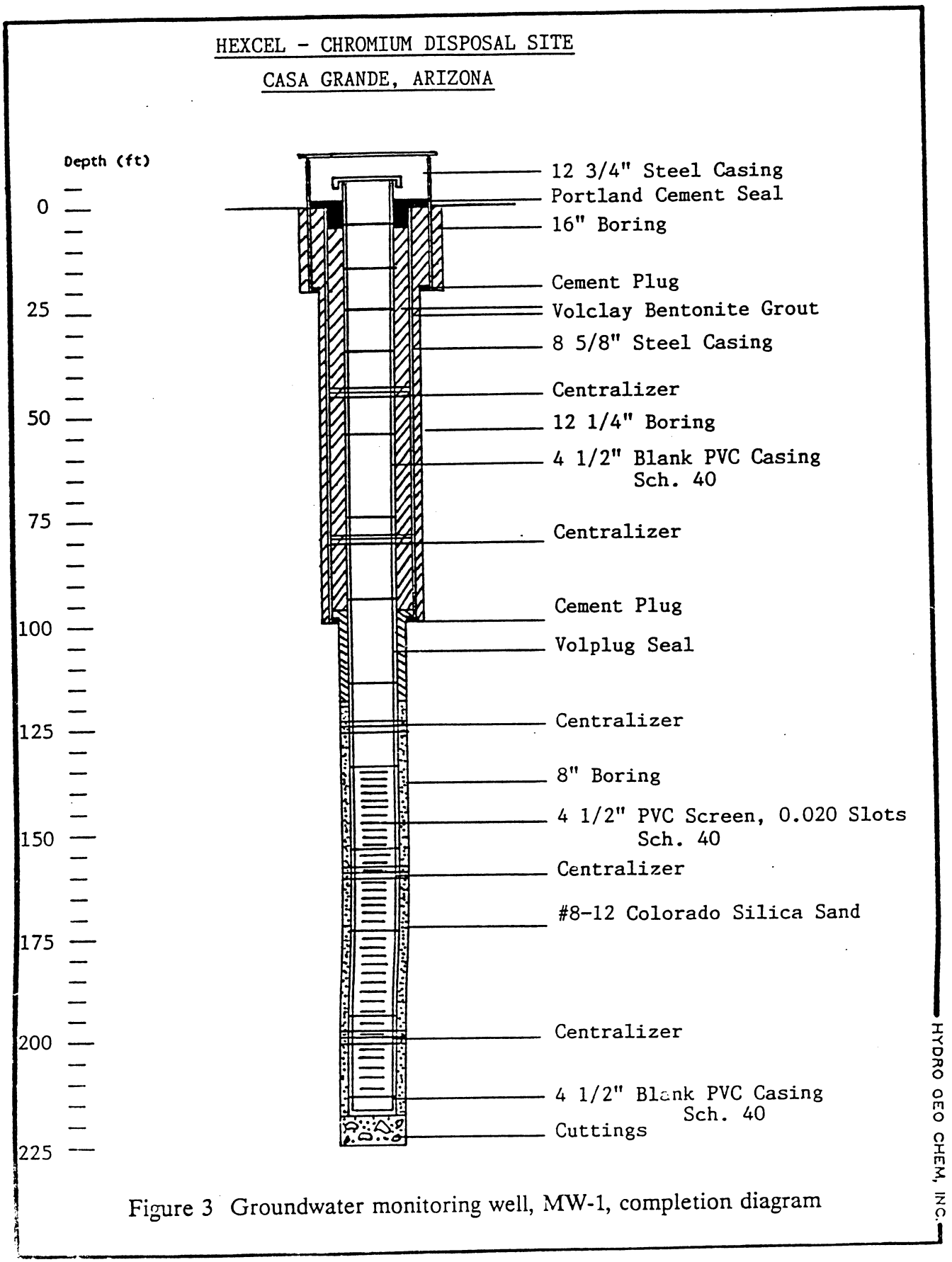
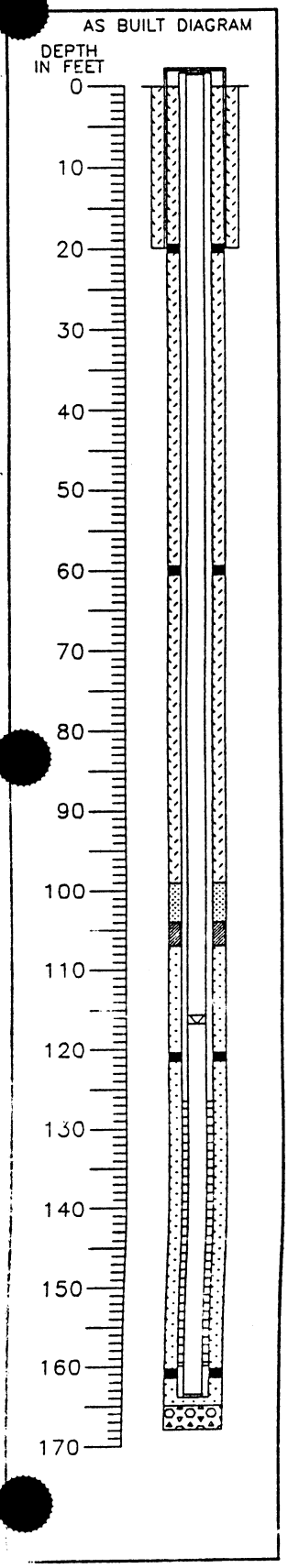


Figure 3 Groundwater monitoring well, MW-1, completion diagram

constructed to accept the poor quality well water produced during drilling and water sampling. Design and construction of the SEF was reviewed and approved by ADEQ and the State Land Department. The SEF was designed to handle more water than produced during water well sampling. The SEF consists of two 40-foot sections of 4-inch leach line placed on top of 5 feet of 2-inch river rock and backfilled with native soil to the surface. At ADEQ's request the SEF was deepened to 10 feet. Three layers of paper fiber were placed between the gravel bed and the native soil to prevent fine sediment from infiltrating into the leach field. The leach lines were placed at 90° angles and connected to a 10-foot length of pipe used as a sediment trap. An additional 10-foot section of leach line was placed in the 10-foot long sediment trap trench and used to discharge high-sediment load waters during well development. The leach line and high-sediment line were both connected to separate riser pipes and brought to a secured water box.

The drilling information and as-built diagram for MW-2 and MW-3 are summarized in Figure 4 and Figure 5, respectively. The upper 20 feet of both borings were cased and cemented with 8⅝" steel casing. After the cement was allowed to cure overnight, 8-inch borings were advanced to 168 feet for MW-2 and 165 feet for MW-3. The wells were constructed with 4.5-inch schedule 80 PVC casing and screened from 121.5 feet BLS to 160 feet BLS for MW-2 and 117.4 feet BLS to 156.1 feet BLS for MW-3. The screened sections were 0.02 slot 4.5-inch SDR-17 PVC. Centralizers were placed approximately every 50 feet to center the casing in the borehole. Pre-washed Colorado silica sand (size #8-12) was tremied into the annulus of the borings to 107 feet (BLS) (approximately 10 feet above the top of the screen). Two buckets of



WELL CONSTRUCTION SUMMARY

PROJECT: Hexcel-Chromium #37700 WELL: MW-2 (upgradient well)
LOCATION: T5S, R5E, Section 34, SW¼, SW¼, SE¼ Approx 100 feet northeast of pit fence

ELEVATION (GROUND): 1,374.6 feet (AMSC) GEOLOGIST: Warren Thompson/Alex Yiannakakis

DRILLING SUMMARY

Total Depth 168 feet

Hole Diam. 12¼", 0-20', 8", 20-168'

Driller Arizona Beeman Drilling Co.

Rig Gardner Denver 15W

Bit(s) 12½" Button Bit 0-20'
8½" Button Bit 20-168'

Fluid Water with "Baroid Drill Foam"

Casing 8⅝" OD, carbon steel 0-20'

WELL DATA

Casing:	C = Casing St = Steel	S = Screen P = PVC	
8⅝" --CSt		0 --20'	
4½" --CP		0 --121.5'	
4½" --SP		121.5'--160'	
4½" --CP		160' --	
--		--	

Casing: C1 8⅝" OD, carbon steel 0-20'

C2 4½" OD, FJ, PVC, Sch 80, 0-121.5'

Screen: S1 4½" OD, FJ, PVC, SDR-17 0.02" slot 121.5-160'
C3 4½" OD, FJ, PVC, Sch 80, sedtrap. 160-164'

Filter Pack: prewashed Colorado silica
Depth: 107-- 165 sand #8-12 (13 bags)

Bentonite: ¼" bentonite pelletes (10 gallons) 2-bags #60 fine silica sand
Depth: 99 -- 107

Cement: neat cement with 5% bentonite gel (powder).
Depth: 0-- 99

Other: Four stainless steel centralizers (161', 121', 60', 20')
Two crossover threads from Sched 80 FJ to SDR-17
neat cment with bentonite gel from 0-20' around the surface casing.

CONSTRUCTION TIME LOG

Task	Start Date/Time	End Date/Time
Drilling:		
0-20 feet	5/22/92 10:10	5/22/92 11:20
20-168 feet	5/26/92 8:27	5/26/92 11:00
Geophys. Log:	None	
Casing:		
8⅝" steel	5/22/92 11:20	5/22/92 12:15
4½" PVC	5/26/92 11:30	5/26/92 12:40
Filter Pack:	5/26/92 12:40	5/26/92 14:45
Cement: neat cement 5% bentonite	5/27/92 7:30	5/27/92 8:30
Development: air lift pump	5/26/92 11:00 5/28/92 14:30	5/26/92 11:30 5/28/92 15:37
Other:		

Well Development: circulate 190 gallons of H_2O on 5/26/92 with drill rig

Further develop the well 5/28/93 using a 5 gpm stainless steel submersible pump (¾ hp). Pumped 370 gallons.

Static Water Level: 116.86 feet below land surface

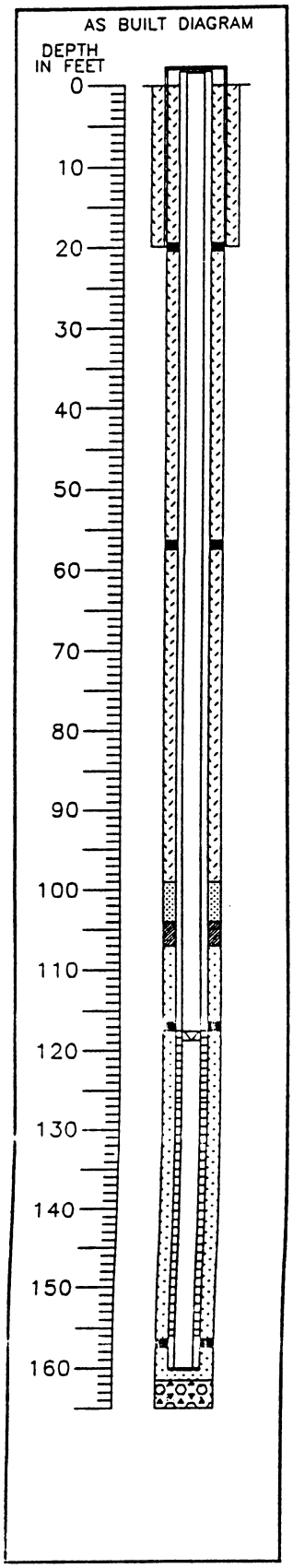
Remarks:

Final completion: prior to addition of slip cap PVC casing placed one foot above surface casing. Well completed on 6/1/92. Surface casing is 2.2" above land surface. PVC surface is 1.64' above ground surface.

Protective cap put on wells.

HYDRO GEO CHEM, INC.

Figure 4. Drilling information and "as-built" diagram for MW-2



WELL CONSTRUCTION SUMMARY

PROJECT: Hexcel-Chromium #37700 WELL: MW-3 (downgradient)
LOCATION: T55, R5E, Section 34, SW¼, SW¼, SE¼ Approx 50 feet south of pit fence

ELEVATION (GROUND): 1,372.09 feet (AMSC) GEOLOGIST: Warrent Thompson/Alex Yiannakakis

DRILLING SUMMARY

Total Depth 165 feet

Hole Diam. 12¼", 0-20', 8", 20-165'

Driller Arizona Beeman Drilling Co.

Rig Gardner Denver 15W

Bit(s) 12¼" Button Bit (tricone)
8" Button Bit (tricone)

Fluid Water with "Drilfoam" Baroid

Casing 8⅝" ,0-20', 4½", 0-160.5'

WELL DATA

Casing: C = Casing S = Screen
St = Steel P = PVC

8⅝" --CSt		0	--20'		
4½" --CP		0	--117.4'		
4½" --SP		117.4'	--156.1'		
4½" --CP		156.1'	--160.5'		
--			--		

Casing: C1 8⅝" OD, carbon steel 0-20'

C2 4½" OD, FJ, PVC, Sch 80, 0-117.4'

Screen: S1 4½" OD, FJ, PVC, SDR-17 0.02" slot 117.4-156.1'

C3 4½" OD, FJ, PVC, Sch 80, 156.1-160.5'

Filter Pack: prewashed Colorado silica
Depth: 107-- 160 sand #8--12
Bentonite: ¼" bentonite pelletes (10 gallons) 2-bags #60 fine silica sand
Depth: 99 -- 107

Cement: neat cement with 5% bentonite gel (powder).
Depth: 0-- 99

Other: Four stainless steel centralizers (157', 117', 57', 20' below land surface
Two crossover threads from Sched 80 FJ to SDR-17 screen
neat cment with bentonite gel from 0-20' around the surface casing.

CONSTRUCTION TIME LOG

Task	Start	End
Drilling:	Date/Time	Date/Time
0-20 feet	5/27/92 10:05	5/27/92 10:40
20-165 feet	5/28/92 7:15	5/28/92 9:45
Geophys. Log:	None	
Casing:		
0-20 feet	5/27/92 10:45	5/27/92 11:20
20-160.5 feet	5/28/92 12:00	5/28/92 12:30
Filter Pack:	5/28/92 12:30	5/28/92 13:50
Cement: neat cement 5% bentonite	5/28/92 14:50	5/28/92 16:05
Development: air lift	5/29/92 7:30	5/29/92 10:30
Other:		
Downtime	5/28/92 10:30	5/28/92 12:00

Well Development: Airlift at approximately 10 gpm for 3 hours = 1,800 gallons pH stable

Static Water Level: 118.84 feet below land surface

Remarks: Casing (PVC) had to be cut because it ended up 55" above the surface casing.

Used Jet Lube (Hydro Geo Chem free pipe dope) on threads.

Final completion: extended surface casing so that it is 2.09 feet above the land surface. PVC approximately 1.6 feet above land surface.

Protective lock cap put on wells.

HYDRO GEO CHEM, INC.

Figure 5. Drilling information and "as-built" diagram for MW-3

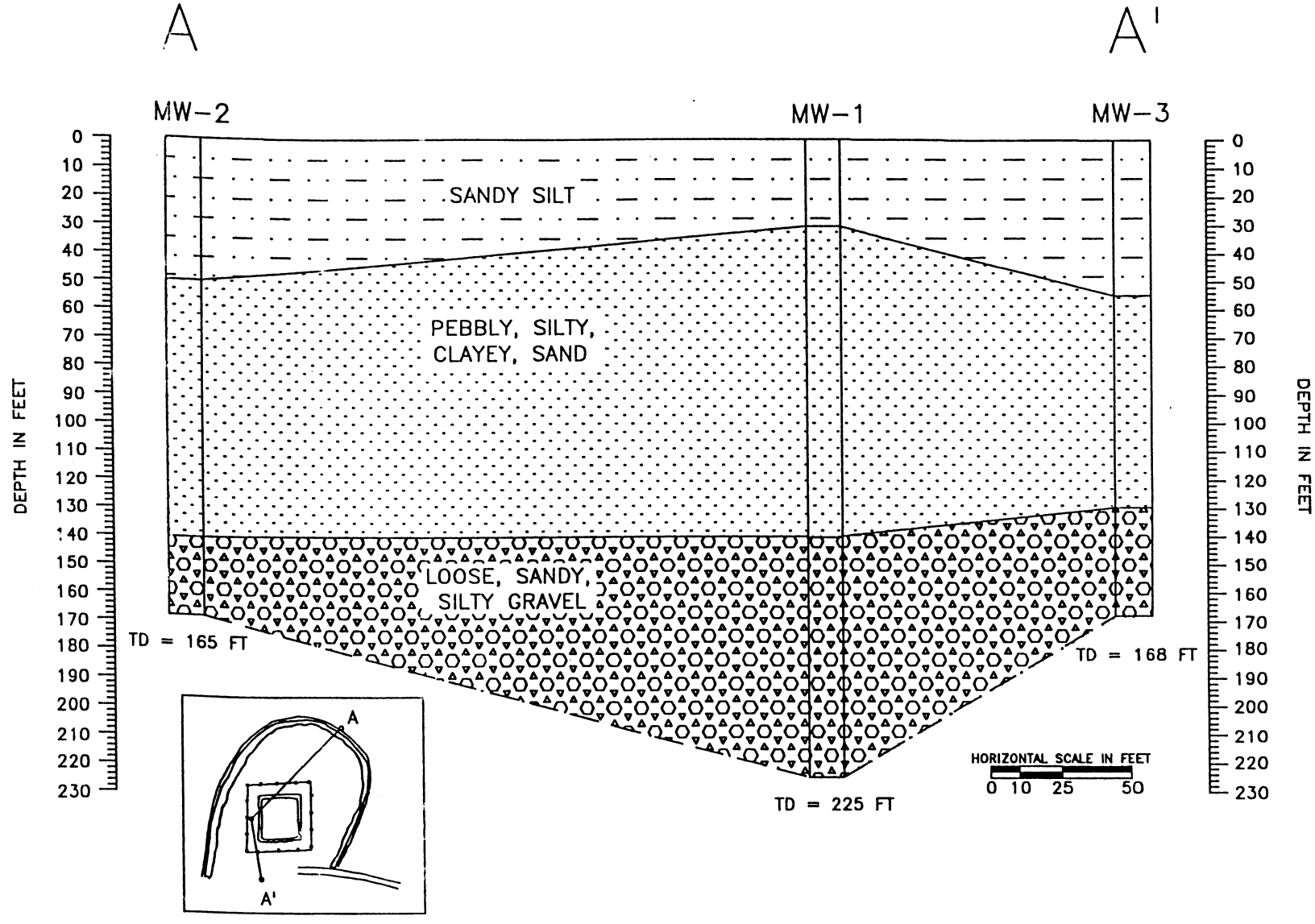
bentonite pellets were placed on top of the filter pack and hydrated. After at least two hours hydration time, two bags of #60 fine silica sand were tremied into the annulus to 99 feet BLS. Neat portland cement with 5% bentonite gel was used to fill the remaining annular space and to seal the annulus.

During drilling of the well, water production was first detected in both wells around 130 feet BLS. Monitoring well MW-2 was developed by circulating 190 gallons of water prior to installing the casing and further developed two days after the well was completed by pumping 370 gallons (approximately 5 bore volumes) of water using a 5 gpm stainless steel submersible pump. The water cleared up five minutes after pumping and the conductivity of the water stabilized after forty minutes. MW-3 was developed using an airlift method. Tremie pipe was placed inside the casing to the bottom of the screen and air jetted for 3 hours. The well produced at least 10 gpm for a total purge volume of 1,800 gallons. All development waters were discharged into the SEF.

V. SITE LITHOLOGY

A northeast to southwest lithologic cross-section, shown in Figure 6, was constructed from three monitoring well boring logs. The lithologic logs for the borings of the newly constructed wells are shown in Appendix A. The site lithology can be separated into three distinct units. The upper unit consists of finer sediments, a sandy silt with clay in parts. The color ranges from brown, light brown to slightly pinkish and the thickness ranges from 30-55 feet. The middle unit consists of a silty clayey sand with some gravels (up to 3mm in size). This unit ranges in thickness from 85 to 110 feet. The lower unit consists of an unconsolidated sandy, silty gravel with gravel up to 10 mm in size. The parent material of the gravels is mixed, comprised of quartz, granites, hornblend, biotite, and schists. Each of the three units coarsen with depth. The upper two units (0-140 feet) likely form part of the unconsolidated unit. The lower lithologic section is either of similar origin to the "local gravel unit" described in the Maricopa-Stanfield sub-basin lithologic cross-section (Wickham and Conklin, 1989) or is just a coarser grained portion of the unconsolidated unit.

gwmonito.rcs/hexcr



HYDRO GEO CHEM, INC.

LITHOLOGIC CROSS-SECTION FOR THE HEXCEL CHROMIUM SITE

Approved	Date	Revised	Date	Reference:	FIG.
	6/25/92			3770012B	6

VI. MONITORING WELL LEVELS AND GROUNDWATER FLOW DIRECTION

Water levels were measured in the three on-site monitoring wells on June 2, 1992 and June 10, 1992. The well locations and elevations were surveyed on June 10, 1992. These data were used to determine the direction of groundwater flow at the site and to verify that the wells are properly located to monitor the site. The topographic survey was conducted by Hansen, Bunger, and Hansen from Coolidge, Arizona. The locations of the well were determined relative to a USGC benchmark located approximately ¾ of a mile southwest of the site. The elevations of both the concrete platform surrounding the well and the top of the inner 4½-inch PVC casing were determined. Water levels were measured with an electronic level sounder using the inside casing, as the elevation reference point. Water levels were verified by measuring the water levels at each of the wells on 6/2/92 and 6/10/92. Individual readings at each well varied by less than one inch.

The surface elevations, reference elevations, water levels and the water levels above mean sea level (AMSL) for the three monitoring wells are listed in Table 1. The water level and well-coordinate data were entered into Hydro Geo Chem's in-house model GWGRAD to determine the gradient and flow direction in the vicinity of the Hexcel Chromium Site. A water level contour map is shown in Figure 7. The direction of groundwater computed in the vicinity of the site is to the southwest, 197° clockwise of north. The gradient is 1.49×10^{-2} ft/ft (or 79 ft/mile).

TABLE 1
WATER LEVEL ELEVATION PARAMETERS

Elev. Well #	Surface Elev. (ft AMSL)	Reference Elev. (ft AMSL)	Water Level 6/2/92 (ft)	Water Level 6/10/92 (ft)	Water Table (ft AMSL)
MW-1	1372.705	1373.05	118.226	118.26	1254.82
MW-2	1374.590	1376.15	118.36	118.47	1257.79
MW-3	1372.09	1373.52	120.16	120.26	1253.36

The southwest groundwater flow direction indicates that the downgradient groundwater wells are located properly to monitor potential releases from the surface impoundment. MW-3 is directly downgradient of the site, and MW-1, owing to it's close proximity to the west pit, would also be impacted by the site if chromium were being released to the groundwater. MW-2 is located upgradient of the site, as expected, and would not be impacted by the site.

VII. MONITORING WELL SAMPLING JUNE 1992

On June 1 and 2, 1992, Hydro Geo Chem personnel obtained groundwater samples from the three monitoring wells for the purpose of analysis for EPA priority pollutant metals. Additional samples were collected for ADEQ for volatile organic analyses and EPA priority pollutant metals analyses. A representative of ADEQ was present during the sampling process.

A ¾ HP stainless steel submersible pump was installed in the well to purge the well prior to collecting water samples. The pump was rinsed with deionized water before installation. Rinsate from the pump was collected, filtered, preserved in nitric acid, and included with the groundwater samples as an equipment blank.

Well Purging

Five bore volumes of water were purged from the wells to ensure that the samples were representative of the formation waters. The bore volume was calculated based on the static water level measured prior to sampling the well, the diameter of the well and the annular packing volume. MW-1, which was constructed to 218 feet, required a larger purge volume than MW-2 and MW-3, both of which were completed to around 165 feet. The temperature and conductivity measurements at the wells stabilized rapidly. Table 2 lists the purge time, purge volume, temperature, and conductivity data. In the future, a three bore volume purge of the well bore-volume will be utilized.

TABLE 2
SAMPLE STABILIZATION PARAMETERS

Well #	Purge Time (minutes)	Purge Volume (gallons)	Sample Time	Temp. C°	Cond. ms/cm
MW-1	165	825*	6/1/92 15:15	28.4	18.68
MW-2	85	380	6/2/92 15:50	28.2	18.74
MW-3	116	425	6/2/92 11:10	28.4	19.19

* five bore volumes for MW-1 is 800 gallons while MW-2 and MW-3 are 380 gallons due to the shallower completion depth.

The pump rate, calculated to be between 5 and 5.2 gpm for the three wells, was obtained at the SEF using a bucket and stopwatch. Temperature, pH and conductivity were checked periodically to determine if these parameters had stabilized. The pH meter readings were erratic; pH data were therefore not recorded for this sampling round. Previous pH readings at the site were 7.90.

Sample Collection

Quality assurance samples, a field blank and an equipment blank, were prepared prior to collection of water samples from the monitoring wells. The equipment blank preparation was previously described. The field blank was prepared by filtering deionized water and preserving the sample with nitric acid. In addition to these blanks, a trip blank was provided by the analytical laboratory.

Water sampling equipment consisted of a 3/4hp stainless steel submersible pump connected to 200 feet of flexible PVC tubing and a stainless steel tee. One end of the tee went to a ¼-inch stainless steel ball valve, the water sampling port, and the

other went to lay-flat hose which discharged the well waters into the subsurface evaporative field (SEF). The SEF accepted all the water injected into the system.

The first samples were collected at MW-1 on June 1, 1992 at 15:15. A filtered and unfiltered sample were collected and placed into 1000 ml bottles already containing the nitric acid preservative. A split of both unfiltered and filtered samples was collected for the ADEQ. In addition, a bubble-free water sample for organic analysis was collected for ADEQ in a 40 ml-VOA.

The sampling equipment was cleaned before collection of the next round of samples at MW-3, . The stainless steel pump was cleaned using Alconox soap and rinsed with Hinkley and Schmidt reverse-osmosis drinking water. Thirty gallons of this water was put in a plastic trash can, then pumped through the tubing followed by 10 gallons of deionized water. The cleaning procedure was repeated prior to sampling MW-2.

The second round of samples was collected at MW-3 on June 2, 1992 at 11:10 a.m. and the third round of samples was collected at MW-2 on June 2, 1992 at 15:50. The same cleaning procedures, type of samples, and preservation method were utilized for these samples.

The samples were kept in a cooler with blue ice until analyzed. The samples obtained by Hydro Geo Chem were delivered to Analytical Technologies, Inc. (ATI) laboratory in San Diego, California on June 3, 1992. Rush analyses were requested

because the analytical results were needed before the remedial investigation could proceed.

Results of Analyses

ATI performed the analyses for EPA priority pollutants on the Trip Blank Equipment Blank, the Field Blank, filtered samples for MW-1, MW-2, and MW-3, and an unfiltered sample for MW-3, the well directly downgradient of the site. Because the sample analyses were rushed, the unfiltered samples for MW-1 and MW-2 were not included. No particulates were detected on the filter paper and, as will be discussed later, there is no significant difference between the filtered and unfiltered sample of MW-3. Therefore, the analyses of the unfiltered samples of MW-1 and MW-2 will not be performed unless requested by ADEQ. Because a 6-month holding time is permitted for EPA priority pollutant metals, a delay will not jeopardize the analyses. The laboratory report and chain of custody information are included in Appendix B of this report.

The analytical results are summarized in Table 3. To support the June 2, 1992 analyses, the results from the previous sampling at MW-1 are summarized in Table 4. Results of the last round of sampling confirm the earlier data that chromium levels (0.03 mg/L) beneath the abandoned disposal site are below the ADEQ's MCL for drinking water of 0.05 mg/L (ADEQ, 1990). The similarity between metals concentrations of all the wells, both up- and down-gradient, indicates that the surface impoundment has not impacted the groundwater.

TABLE 3
ANALYTICAL RESULTS OF JUNE 1992
WATER SAMPLING AT THE HEXCEL CHROMIUM SITE
(all values in mg/L)

Metals	MCL	Trip Blank	Equipment Blank	Field Blank	MW-1-F	MW-2-F	MW-3-F	MW-3-UF
Arsenic	0.05	<0.002	<0.002	<0.002	0.34	0.34	0.41	0.38
Chromium (TOTAL)	0.1	<0.01	<0.01	<0.01	0.03	0.03	0.02	0.03
Copper	NA	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01
Selenium	0.01	<0.002	<0.002	<0.002	0.068	0.069	0.073	0.075
Zinc	NA	<0.05	<0.05	<0.05	<0.05	0.14	0.13	0.14

Notes: * 13 Priority pollutants metals were analyzed. Only detectable concentrations are listed in the table.
F indicates a filtered sample.
UF indicates an unfiltered sample.

TABLE 4
SUMMARY OF MW-1 WATER SAMPLING ANALYTICAL
RESULTS HEXCEL CHROMIUM SITE
(all values in mg/L)

Metals	June 1, 1992 Filtered	May 2, 1990 Filtered	May 2, 1990 Unfiltered	Jan. 26, 1990 Filtered
Arsenic	0.34	0.28	0.28	0.76
Chromium (TOTAL)	0.03	0.03	0.03	0.02
Copper	0.01	<0.02	<0.02	<0.02
Selenium	0.068	0.089	0.098	0.03
Zinc	<0.05	0.027	<0.01	0.55

Notes: * 13 Priority pollutants metals were analyzed. Only detectable concentrations are listed in the table.

The concentrations of arsenic and selenium in both up- and down-gradient wells are significantly above the 0.05 mg/L ADEQ action limits for groundwater. Neither arsenic nor selenium has been disposed of at the site by Hexcel. As noted in Section III of this report, five wells in the area were identified in a 1986 Montgomery and Associates hydrogeologic investigation as having arsenic levels at or above the MCL.

Identification of elevated levels of arsenic northeast, east and southeast of the site indicate the source is not associated with the abandoned chromium disposal site. High TDS values have also been observed in wells in the region, render the water unsuitable for drinking water, agriculture, and livestock (EPA, 1986).

VIII. CONCLUSIONS

Installation and sampling of three monitoring wells have established that the groundwater gradient at the site is to the southwest. MW-3 is, therefore, located directly downgradient of the site. This gradient direction verifies that MW-3 and MW-1 are properly located to monitor the impact of the Hexcel abandoned chromium surface impoundments on the groundwater quality in the vicinity of the site.

The chromium concentrations in all the monitoring wells were 0.03 mg/l, below ADEQ's MCL for drinking water of 0.1 mg/L. The same chromium concentration in the upgradient and downgradient wells indicates that the abandoned chromium surface impoundments are not adversely affecting groundwater quality. These data confirm the model results and experimental evaluations indicating that chromium has not reached the groundwater. Model predictions state further that, if the site is capped, groundwater under the site will not be impacted by the surface impoundments. As stated earlier, the water quality in the vicinity of the site is not suitable for drinking, domestic, livestock, or agricultural use. In conclusion, the Phase 1 groundwater monitoring results show that the remedial action plan approved by ADEQ (i.e., constructing an engineered cap, controlling surface drainage, and monitoring the groundwater and cap performance) can proceed following public approval of the plan.

IX. SUMMARY OF REMEDIAL ACTION PLAN TASKS

Tasks Completed to Date

This section describes the completed tasks for the site RAP. Detailed discussion of the work comprising these tasks is contained in Hydro Geo Chem Reports previously submitted to ADEQ (Hydro Geo Chem, 1983, 1985, 1988, 1989a, 1989b, 1990a, 1990b, 1991a, 1991b, 1992a, 1992b).

1) The vertical and lateral extent of contamination at the site has been assessed by collecting and analyzing soil in and around the chromium surface impoundments (HGC 1983 and 1988). The soil investigation results show that:

   a) Approximately 10,000 pounds of chromium has been disposed in the surface impoundments;

   b) Seven to nine thousand pounds of chromium reside in the top 20 feet of the soil beneath the impoundments;

   c) The remainder of the chromium lies in the following 20 to 30 feet interval;

   d) Soil collected 70 feet below ground surface of the surface impoundments did not contain chromium above the background levels, and

   e) At least 50 feet of uncontaminated soil separate the groundwater from the soils containing chromium wastes.

2) Subsurface movement of mobile soil constituents has been experimentally evaluated and numerically modeled (HGC, 1985). Experimental evaluation of the distribution of soil moisture and chloride concentration with depth indicates little water movement below 15 feet and therefore little likelihood of chromium movement to the groundwater. The study predicted further downward migration to be negligible, provided that the site is covered with a cap designed to prevent ponding and subsequent infiltration of rainwater and overland

flow. Overland flow is currently controlled by a berm and ditch constructed around the surface impoundments in 1983.

Simulations of the movement of moisture and chromium indicate the major movement to be upward due to evaporation and capillary forces (wicking). Forty percent of the total chromium was predicted to be transported to near surface soils after 100 years. The simulations showed that a surface cap should include a capillary barrier to prevent upward movement of chromium to the surface.

3) An in-situ chromium detoxification and immobilization program was conducted at the site from the summer, 1984 until January, 1985. Approximately 9 tons of sulfur dioxide gas were injected into site soils through a series of subsurface pipes to chemically reduce the hexavalent chromium to trivalent chromium. The results of the program showed that nearly 50% of the mobile and toxic hexavalent chromium was reduced to the non-mobile, less toxic trivalent form. This project assisted in stabilizing the chromium in the shallow soil horizon, reducing the spread of the contaminant and the threat to groundwater quality.

4) At the request of ADEQ, a RAP for the Hexcel chromium disposal site was prepared in 1989 (HGC, 1989a) and revised in 1992 (HGC, 1992a) to expand the scope of the groundwater monitoring system. The RAP for the chromium surface impoundments is based on the premise that capping the site will immobilize the residual wastes and prevent their movement to both the surface and the groundwater. The RAP includes three phases:

Phase 1 requires the installation of a groundwater monitoring system to determine if the abandoned chromium surface impoundments adversely affect the groundwater quality in the vicinity of the site. A portion of Phase 1 was completed in January, 1990 when one monitoring well was installed just west of the impoundments. The groundwater monitoring system reported herein completes Phase 1.

Phase 2 requires construction of a permanent multi-layer soils and geotextile cap over the surface impoundment. The surface cap will be designed and constructed to control and eliminate adverse environmental and human health impacts by long-term containment of the residual waste.

Phase 3 consists of operation and maintenance of the cap/closure plus a periodic sampling program to assure the cap is functioning properly.

Tasks Required to Complete the Remedial Action

All ADEQ requirements regarding the site investigation and remedial investigation have now been completed. The RAP requirements approved by ADEQ are listed as follows:

1) The remedial investigation detailing the source, nature, magnitude, and extent of the hazardous substance released from the facility;

2) Stabilizing/reducing the mobility and health hazards of the contaminant by 50% by reducing 50% of the hexavalent chromium to the less mobile, less toxic trivalent state;

3) Submitting a RAP (1983) and revising the plan (at ADEQ's request) in 1989 and 1992;

4) Submitting at ADEQ's request, an operation and maintenance plan in October, 1991 and revising the plan in 1992; and

5) Establishing public repositories in May, 1992 with pertinent Hexcel abandoned chromium disposal site documents at ADEQ Phoenix offices, at a local library (Casa Grande Main Library), and at Hydro Geo Chem's office. An updated version of the document package, including a summary of the documents and the well installation and groundwater monitoring results, will be submitted upon approval by ADEQ.

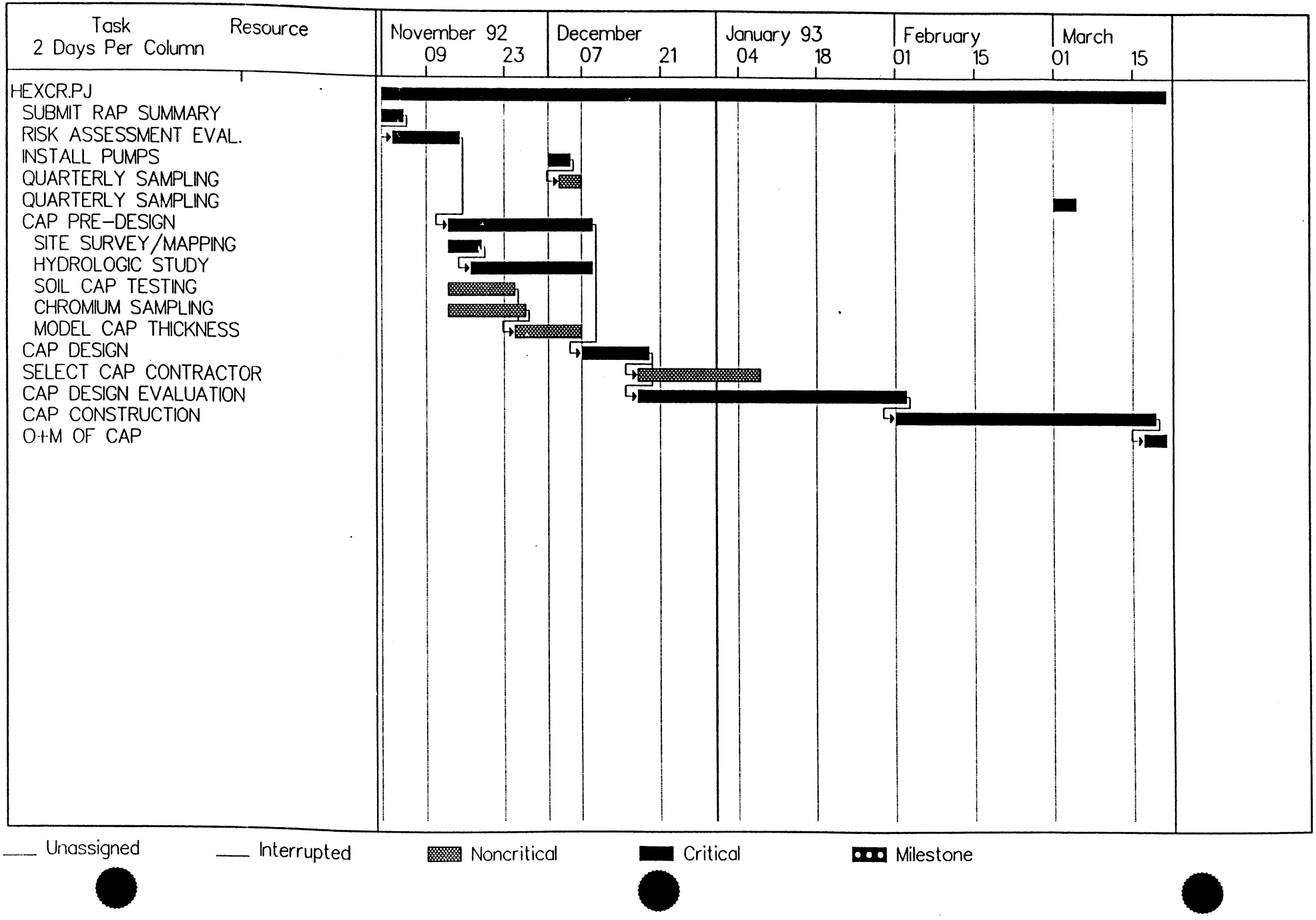
A schedule of the tasks remaining to be completed by Hexcel and/or Hydro Geo Chem are displayed in Figure 8 which also presents the critical path for the remaining tasks. Upon general approval of the RAP, work will continue on the predesign of the earthen cap.

All parties involved have agreed that expediting cap installation is critical to minimizing potential subsurface and surface migration of chromium. Hexcel would

GANTT-1
10--29--92 5:23p

Project: HEXCR.PJ
Revision: 1

Figure 8. Schedule of Tasks for Completion of RAP



like the cap to be installed by year's end, but meeting that goal does not seem feasible at this time.

As part of the Phase I of the RAP all groundwater monitoring wells will be sampled quarterly for a period of one year. If chromium is not detected above the Arizona MCL (0.1 mg/L), the sampling frequency will be reduced to once a year until five years after installation of the cap. Monitoring beyond five years will be done according to a long-term monitoring schedule to be negotiated with ADEQ.

IX. REFERENCES

ADEQ. January 1990. Arizona Aquifer Water Quality Standard Rules.

Hydro Geo Chem, Inc. 1983. Evaluation of Subsurface Chromium Contamination at Hexcel Waste Dump, Casa Grande, Arizona with Recommendations for Site Closure. Report to Hexcel Corporation.

Hydro Geo Chem, Inc. 1985. Potential for Vertical Movement of Chromium at Hexcel's Chromium Disposal Site, Casa Grande, Arizona. Report to Hexcel Corporation.

Hydro Geo Chem, Inc. 1988. Results of Soil Borings and Sampling at the Former Disposal Site near Casa Grande, Arizona. Report to Hexcel Corporation.

Hydro Geo Chem, Inc. 1989a. Remedial Action Plan for the Abandoned Chromium Disposal, Casa Grande, Arizona. Report to Hexcel Corporation.

Hydro Geo Chem, Inc. 1989b. Groundwater Monitoring Work Plan for the Hexcel Chromium Disposal Site, Casa Grande, Arizona. Report to Hexcel Corporation.

Hydro Geo Chem, Inc. 1990a. Report on Phase I Groundwater Monitoring for the Closure of the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Report submitted to Hexcel Corporation.

Hydro Geo Chem, Inc. 1990b. Results of May 1990 Groundwater Sampling at the Hexcel Abandoned Chromium Disposal Site, Casa Grande, Arizona. Report submitted to Hexcel Corporation.

Hydro Geo Chem, Inc. 1991a. Proposed Work Plan for the Completion of the Groundwater Monitoring System at the Abandoned Chromium Disposal Site. Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1991b. Proposed Operation and Maintenance Plan for CAP/Closure for the Abandoned Chromium Disposal Site. Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1991c. Revised Groundwater Monitoring Plan for the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992a. Revised Remedial Action Plan for the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

IX. REFERENCES (CONTINUED)

Hydro Geo Chem, Inc. 1992b. Revised Operation and Maintenance Plan for CAP/ Closure for the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Montgomery and Associates. 1986. Hydrogeologic Conditions Asarco Sacaton Open-pit Mine, Pinal County, Arizona. Preliminary report prepared by ASARCO.

US Environmental Protection Agency. 1986. Quality Criteria for Water. EPA 440/S-86-001.

Wickham, M.P. and Corkhill E.F. 1989. Hydrogeologic Framework, Water Budget, and Phase One Recommendations. Hydrology Division, Arizona Department of Water Resources.

APPENDIX A
LITHOLOGIC LOGS

HYDRO GEO CHEM, INC.

PROJECT: Hexcel Chromium	LOCATION: Upgradient Well Northeast of Pit	BORING ID: MW-2	PAGE 1 OF 3
DRILLING CO: Beeman Drilling Co.	START DATE/TIME: 5-22-92/08:30	COMPLETION DATE/TIME: 5-26-92 /16:00	
DRILLER: Todd Beeman	DRILL EQUIP/METHOD: 15W Gardner Denver Air Rotary	DRILLING FLUID: Water and drill foam	
SIZE/TYPE BIT: 8" tricone button	TOTAL NUMBER OF SAMPLES: 34	TOTAL DEPTH: 160' BLS + 3' sediment trap	
	FIRST WATER: approx. 130 feet	FINAL WATER: 116.86 BLS	
	LOGGED BY: Warren Thompson	CHECKED BY: Alex Yiannakakis	

DEPTH (FT BLS)	SAMPLES		DESCRIPTION	USCS SYMBOL	PERCENT GR/SA/FI	MOISTURE	COMMENTS
	INTER-VAL	BLOW COUNT					
5	0-5'	N/A	Sandy silt, well-graded, sand portion consists mostly of subangular to well-rounded quartz; some feldspars and mafic minerals (biotite and hornblend) as well as grains range in size from 4 mm down to clay sized particles. Color is a strong brown. Munsel color: Dry = 7.5 yr 5/6; Wet = 7.5 yr, 4/6.	ML	2/28/70	D	Root fragments are present to about 4½' BLS. Does not react with HCL.
	7'		Driller having difficulty getting down hole any further; feels that he is in a clayey zone. Is going to inject foam to remove cuttings at this point.	ML			Calcified horizon observed at this depth in pits dug at the site. Mild reaction with HCL.
20	7-20'		Sandy, clayey, silt, very well graded. Sand portion is angular to well rounded and containing predominantly grains of quartz and mafic minerals. Possibly some feldspars. Grain sizes range from 3 mm down to clay sized particles. Most cuttings are moderately plastic forming cohesive balls easily when squeezed between fingers. Color is strong brown. Munsell color: Dry = 7.5 yr, 5/6; Wet = 7.5 yr, 4/6.	ML	1/19/80		Cuttings are wet with the foam solution used to float them from the hole. When wetted with the foam they take on chalky appearance. Does not react with HCL.
25	20-25'		Sandy silt, sand grains are subangular to well-rounded and range in size from 2 mm down to silt size particles. Formation is well-graded. Sand grains are predominantly quartz and mafic minerals. Also present are a few chunks of a pliable, plastic clay; greenish color and about 1 cm in diameter. Color of sample is light brown, slightly pinkish. Munsell color: Dry = 7.5 yr, 6/4; Wet = 7.5 yr, 5/4.	ML	-/40/60	D	Reacts weak to moderately with HCL.
35	25-35'		Same as above.				
40	35-40'		Sandy silt; overall very similar to interval described above except that sand fraction is much finer material with individual grain sizes starting at about ½ mm in diameter grading downward to silt and clay size particles. Munsell color: Dry = 7.5 yr, 8/4; Wet = 7.5 yr, 5/4.	ML	-/40/60	D	Reacts moderately with HCL.
50	40-50'		Same as above except that consolidated chunks of soft clay are no longer present in cuttings.			D	
55	50-55		Sand silt mix; similar in appearance to above material except that sand portion is greater. Grains range in size from 1 mm downward. They are angular to subrounded and predominantly quartz, flecks of brotite are also present in minor amounts. Munsell color: Dry = 7.5 yr, 6/4; Wet 7.5 yr, 5/4.	SM/SC	5/55/40	D	Reacts slightly with HCL.

PROJECT: Hexcel Chromium	LOCATION: Upgradient Well Northeast of Pit	BORING ID: MW-2	PAGE 2 OF 3
DRILLING CO: Beeman Drilling Co.	START DATE/TIME: 5-22-92/08:30	COMPLETION DATE/TIME: 5-26-92 /16:00	
DRILLER: Todd Beeman	DRILL EQUIP/METHOD: 15W Gardner Denver Air Rotary	DRILLING FLUID: Water and drill foam	
SIZE/TYPE BIT: 8" tricone button	TOTAL NUMBER OF SAMPLES: 34	TOTAL DEPTH: 160' BLS + 3' sediment trap	
	FIRST WATER: approx. 130 feet	FINAL WATER: 116.86 BLS	
	LOGGED BY: Warren Thompson	CHECKED BY: Alex Viannakakis	

DEPTH (FT BLS)	SAMPLES		DESCRIPTION	USCS SYMBOL	PERCENT GR/SA/FI	MOISTURE	COMMENTS
	INTERVAL	BLOW COUNT					
60	55–60'		Sand, silt, clay mix; sand particles are angular to rounded and are moderately to well-graded. They range in size from about 3 mm down to clay size particles. Sand grains consist mainly of quartz. Sample is peppered with quite a few small fragments of biotite. Other dark colored minerals are also apparent. When wet, material is quite cohesive and sticky; easily molded into a ball when worked between fingers. Munsell color: Dry = 7.5 yr, 6/4; Wet = 7.5 yrs, 5/4.	SM/SC	10/50/40	D	Drillers are using foam to bring cuttings up from hole at this point. Weak reaction with HCL.
75	60–75'		Same as above.				
85	75–85'		Silty, clayey sand mix. Sand is angular to rounded, well-graded. Max grain size is 3 mm in dia. and grades downward to clay size particle. Sand grains are predominantly quartz with some mafic minerals. Mixture forms cohesive balls when wet and squeezed in the hand. Munsell color: Dry 7.5 yrs, 6/4; Wet 7.5 yr, 5/4.	SM/SC	10/50/40	D	Slight to moderate reaction with HCL.
100	85–100'		Same as above.				
120	105–120'		Clay, silt, sand mix. Very similar to above material. Sand grains are predominantly quartz and mafics (biotite and hornblend) and range in size down from about 3 mm in a well-graded manner to clay size particles. Grains are angular to rounded. Munsell color: Wet = 7.5 yr, 5/4.	SM/SL	10/50/40	D	Cuttings are very foamy because of drilling fluid. Slight reaction with HCL.
140	120–140'		Gravely, silty sand; sand grains range from about 10 mm down to clay size particles in a well-graded collection. Grains range from angular to rounded and are a mix of quartz and mafic minerals. Cuttings look as though they are peppered with biotite and hornblend fragments. May be a green schist. Munsell color: Wet = 7.5 yr, 5/4.	GM/SM	15/45/40	W	Drillers hit first water at 130–135' BLS. Slight reaction with HCL.
145	140–145'		Silty sandy gravel; pebbles are angular to rounded and grade down from about 10 mm. Much of the pebbly material appears to be quartz and a considerable amount of dark colored fine-grained quartz granites. Also present are fragments of chalk, biotite, hornblend, and chips of green schist material. Overall loose mix.	GM	40/30/30	W	No reaction with HCL.
160	145–160'		Much like above except that pebbly fraction is much less and grains are smaller ≤2 mm in dia. Munsell color: 7.5 yr, 5/4.	GM/SM	10/40/50	W	No reaction with HCL.

PROJECT: Hexcel Chromium	LOCATION: Upgradient well Northeast of Pit	BORING ID: MW-2	PAGE 3 OF 3
DRILLING CO: Beeman Drilling Co.	START DATE/TIME: 5-22-92/08:30	COMPLETION DATE/TIME: 5-26-92 /16:00	
DRILLER: Todd Beeman	DRILL EQUIP/METHOD: 15W Gardner Denver Air Rotary	DRILLING FLUID: Water and drill foam	
SIZE/TYPE BIT: 8" tricone button	TOTAL NUMBER OF SAMPLES: 34	TOTAL DEPTH: 160' BLS + 3' sediment trap	
	FIRST WATER: approx. 130 feet	FINAL WATER: 116.86 BLS	
	LOGGED BY: Warren Thompson	CHECKED BY: Alex Yiannakakis	

DEPTH (FT BLS)	SAMPLES		DESCRIPTION	USCS SYMBOL	PERCENT GR/SA/FI	MOISTURE	COMMENTS
	INTERVAL	BLOW COUNT					
168	160-168'		Silty sandy gravel; grain size ranges from 8 mm down to clay sized particles. Material is very loose and wet. Individual grains are angular to rounded and consist predominantly of quartz, fine grained quartz granites, fragments of biotite, and hornblend are also present as well as small grains of a reddish material that may be a chalk or feldspar. Munsell color: Wet = 7.5 yr, 5/6.	GM	30/45/25	W	No reaction with HCL.

HYDRO GEO CHEM, INC.

PROJECT: Hexcel Chromium	LOCATION: Downgradient Well Southwest of Pit	BORING ID: MW-3	PAGE 1 OF 2
DRILLING CO: Beeman Drilling Co.	START DATE/TIME: 5-27-92/10:05	COMPLETION DATE/TIME: 5-28-92 /16:05	
DRILLER: Todd Beeman	DRILL EQUIP/METHOD: 15W Gardner Denver Air Rotary	DRILLING FLUID: Drilling foam with water	
SIZE/TYPE BIT: 8" tricone button	TOTAL NUMBER OF SAMPLES: 33	TOTAL DEPTH: 165 feet BLS	
	FIRST WATER: approx. 130 feet BLS	FINAL WATER: 118.84 feet BLS	
	LOGGED BY: Warren Thompson	CHECKED BY: Alex Yiannakakis	

DEPTH (FT BLS)	SAMPLES		DESCRIPTION	USCS SYMBOL	PERCENT GR/SA/FI	MOISTURE	COMMENTS
	INTER-VAL	BLOW COUNT					
5	0-5'	N/A	Sandy silt, well-sorted, well-graded. Sand grains are angular to rounded and range is sized from ~5mm down to silt size particles. Sand portion is predominantly quartz with some mafic minerals present in minor amounts. Quite a few root fragments also present. Munsell color: Dry = 7.5 yr, 6/4; Wet = 7.5 yr, 5/4.	ML	5/35/60	D	Very slight reaction with HCL.
20	5-20'		Sandy, clayey silt. Similar to above description except that sand grain particles are much smaller having a maximum size of 2 mm, grading down to clay size particles. Grains are mostly quartz with quite a few pepper size flakes of biotite. Some quartz grains are rust stained. Formation is well sorted and well-graded. Grains are sub-angular to rounded. Munsell color: Dry = 7.5 yr, 6/4; Wet = 7.5 yr, 5/4.	ML	-/30/70		Very slight reaction with HCL. Caliche horizon observed in cuttings pit around 7 feet at the site.
30	20-30'		Sandy silt with some clay. Sand grains are predominantly angular to rounded quartz, some mafic minerals present in minor amounts. Sand grains range in size from 1 mm down to clay size particles in a well-graded fashion. Pea size clump of carbonate cemented silt also evident. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 5/8.	ML	-/35/65	D	Moderate reaction to HCL.
45	30-45'		Sand silt mix. Sand grains are predominantly angular to subrounded quartz with lesser amounts of mafic minerals (≤ 2 mm) (biotite, hornblend). Chunks of caliche also present (¼" max.) Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 5/8.	SM/ SC	-/45/55	D	Moderate reaction with HCL.
55	45-55'		Very much like above material except that sand grains are finer ≤ 1 mm.	SM/ SC	-/45/55	D	Moderate reaction with HCL.
75	55-75'		Silty sand with some pebble size gravels. Grains are subangular to rounded; well-graded from a size of 4 mm down to silt size particles. Sand grains are predominantly quartz with some mafic minerals and calcite cemented silts. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 5/8.	SM	5/60/35		Moderate reaction with HCL.
110	75-110'		Silty sand with some gravel. Sand grains are angular to subrounded and well-graded from about 4 mm down to silt size grains. Grains are predominantly quartz with some fragments of biotite, muscovite and hornblend. Mixture forms cohesive balls when wet and squeezed between fingertips. Calcite cementation is also present as small pea size chips of caliche. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 5/8.	SM	5/55/40		Moderate reaction with HCL.

HYDRO GEO CHEM, INC.

PROJECT: Hexcel Chromium	LOCATION: Downgradient Well Southwest of Pit	BORING ID: MW-3	PAGE 2 OF 2
DRILLING CO: Beeman Drilling Co.	START DATE/TIME: 5-27-92/10:05	COMPLETION DATE/TIME: 5-28-92 /16:05	
DRILLER: Todd Beeman	DRILL EQUIP/METHOD: 15W Gardner Denver Air Rotary	DRILLING FLUID: Drilling foam with water	
SIZE/TYPE BIT: 8" tricone button	TOTAL NUMBER OF SAMPLES: 33	TOTAL DEPTH: 165 feet BLS	
	FIRST WATER: approx. 130 feet BLS	FINAL WATER: 118.84 feet BLS	
	LOGGED BY: Warren Thompson	CHECKED BY: Alex Yiannakakis	

DEPTH (FT BLS)	SAMPLES		DESCRIPTION	USCS SYMBOL	PERCENT GR/SA/FI	MOISTURE	COMMENTS
	INTER-VAL	BLOW COUNT					
130	115-130'	N/A	Silty sand; sand grains are angular to subrounded and consist mainly of quartz and black mafic minerals. Quartz grains range in size from 1 mm down to silt size particles and are well-graded. Mafic fragments resemble pepper flakes. When wet and squeezed in fist, material easily forms cohesive balls. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 7/6.	SM	-/40/60	W	Very weak to no reaction with HCL.
145	130-145'		Silty sand and gravel mix; very similar to above sample except that gravel size pebbles begin to show up in cuttings. Pebbles have a maximum diameter of about 12 mm and grade moderately well down to silt size particles. The sand and pebble grains are mostly quartz with some mafic minerals, namely biotite and are subangular to subrounded. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 7/6.	SM/GM	30/35/35	W	No reaction with HCL. Mixture is loose and looks to be a good water producing unit.
160	145-160'		Silty sandy gravel; loose mixture. Gravel pebbles range from 15 mm down. Sand and gravel portion is made up of mostly quartz and what appears to be a basic green schist made up of hornblend and a peppering of small (≤ 1 mm) flakes of biotite. Grains in sample are subangular to subrounded. Mixture does not hold together well when wet because of high gravel content. Overall gravel portion tends to be moderately well sorted and mixture is moderately well-graded down to silt sized grains. Munsell color: Dry = 7.5 yr, 7/4; Wet = 7.5 yr, 7/8.	GM	60/20/20	W	No reaction with HCL.
165	160-165'		Silty sand and gravel mix; loose mixture similar to interval described above except that pebbles making up gravel portion are much smaller, bordering on a coarse grained sand. Grains are subangular to subrounded and grade down from a maximum size of about 4 mm. Gravel/sand portion is moderately well sorted and as a whole, the sample grades moderately well down to the silt fraction. Gravel and sand fragments are mostly quartz grains and may be a basic greenschist made up of hornblend and biotite.	SM/GM	20/60/60	W	No reaction with HCL.

APPENDIX B
WATER WELL ANALYSES RESULTS

Analytical Technologies, Inc. 9830 S. 51st Street Suite B-113 Phoenix, AZ 85044 (602) 496-4400

ATI I.D. 206563

June 18, 1992

Hydro Geo Chem
1430 North 6th Avenue
Tucson, AZ 85705

Project Name/Number: Hexcel-Cr/37700

Attention: Alex Yiannakakis

On 06/03/92, Analytical Technologies, Inc. received a request to analyze aqueous sample(s). The sample(s) were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Metals analyses were performed by ATI, San Diego.

If you have any questions or comments, please do not hesitate to contact us at (602) 496-4400.

M. Barry

Michael G. Barry
Project Manager

Lorraine Davis for

Robert V. Woods
Laboratory Manager

RVW:ehj
Enclosure

Analytical Technologies, Inc.

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CR

DATE RECEIVED : 06/[redacted]9
REPORT DATE : 06/11/9

ATI I.D. : 206563

ATI #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTE
01	TRIP BLANK	AQUEOUS	05/18/9
02	EB-1-6192	AQUEOUS	06/01/9
03	FB-1-60192	AQUEOUS	06/01/9
04	MW-1-F	AQUEOUS	06/01/9
05	MW-2-F	AQUEOUS	06/02/9
06	MW-3-F	AQUEOUS	06/02/9
07	MW-3-UF	AQUEOUS	06/02/9

----- TOTALS -----

MATRIX	# SAMPLES
AQUEOUS	7

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from t
date of this report. If an extended storage period is required, please c[redacted]a
our sample control department before the scheduled disposal date.

Analytical Technologies, Inc.

METALS RESULTS

ATI I.D. : 206563

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CR

DATE RECEIVED : 06/03/92
REPORT DATE : 06/11/92

PARAMETER	UNITS	01	02	03	04	05
SILVER	MG/L	<0.01	<0.01	<0.01	<0.01	<0.01
ARSENIC	MG/L	<0.002	<0.002	<0.002	0.34	0.34
BERYLLIUM	MG/L	<0.005	<0.005	<0.005	<0.005	<0.005
CADMIUM	MG/L	<0.0006	<0.0006	<0.0006	<0.003	<0.003
CHROMIUM	MG/L	<0.01	<0.01	<0.01	0.03	0.03
COPPER	MG/L	<0.01	0.02	<0.01	0.01	<0.01
MERCURY	MG/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
NICKEL	MG/L	<0.01	<0.01	<0.01	<0.01	<0.01
LEAD	MG/L	<0.002	<0.002	<0.002	<0.02	<0.02
ANTIMONY	MG/L	<0.03	<0.03	<0.03	<0.03	<0.03
SELENIUM	MG/L	<0.002	<0.002	<0.002	0.068	0.069
THALLIUM	MG/L	<0.002	<0.002	<0.002	<0.02	<0.02
ZINC	MG/L	<0.05	<0.05	<0.05	<0.05	0.14

Analytical Technologies, Inc.

METALS - QUALITY CONTROL

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CR

ATI I.D. : 206563

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RPD	SPIKED SAMPLE	SPIKE CONC	% REC
SILVER	MG/L	20656307	<0.01	<0.01	NA	1.78	2.00	89
ARSENIC	MG/L	20656306	0.41	0.41	0	2.39	2.00	99
BERYLLIUM	MG/L	20656307	<0.005	<0.005	NA	1.82	2.00	91
CADMIUM	MG/L	20656306	<0.003	<0.003	NA	2.27	2.00	114
CHROMIUM	MG/L	20656307	0.03	0.03	0	1.70	2.00	84
COPPER	MG/L	20656307	<0.01	<0.01	NA	1.74	2.00	87
MERCURY	MG/L	20699910	<0.0005	<0.0005	NA	0.0057	0.0050	114
NICKEL	MG/L	20656307	<0.01	<0.01	NA	1.75	2.00	88
LEAD	MG/L	20656306	<0.02	<0.02	NA	1.40	2.00	70
ANTIMONY	MG/L	20656307	<0.03	<0.03	NA	1.80	2.00	90
SELENIUM	MG/L	20656306	0.073	0.072	1	1.33	1.20	105
THALLIUM	MG/L	20656306	<0.02	<0.02	NA	1.39	2.00	70
ZINC	MG/L	20656307	0.14	0.13	7	2.04	2.00	95

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 1$$

PLEASE FILL THIS FORM IN COMPLETELY. SHADED AREAS ARE FOR LAB USE ONLY.

Analytical Technologies, Inc., Phoenix, Arizona
San Diego • Phoenix • Seattle • Pensacola • Ft. Collins • Portland

CHAIN OF CUSTODY

DATE: 6/3/92 PAGE 1 OF 1

ATI LAB I.D. 206563

PROJECT MANAGER: Alex Yiannakakis

COMPANY: Hydro Geo Chem
ADDRESS: 1430 N. 6th Av.
Tucson Az. 85705
PHONE: 602-623-6981
FAX: 602-623-6984

BILL TO: Same as above
COMPANY:
ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	The 13 Priority Pollutant Metals	RCRA Metals by Total Digestion	RCRA Metals by TCLP (1311)	NUMBER OF CONTAINERS
Trip Blank	5/18/92		H_2O	1	X			1
EB-1-6192	6/11/92	9:20	H_2O	2	X			1
FB-1-60192	6/11/92	12:10	H_2O	3	X			1
MW-1-F	6/11/92	15:30	H_2O	4	X			1
MW-2-F	6/12/92	15:58	H_2O	5	X			1
MW-3-F	6/12/92	11:00	H_2O	6	X			1
MW-3-UF	6/12/92	11:06	H_2O	7	X			1

Petroleum Hydrocarbons (418.1); (MOD 8015) Gas/Diesel; Diesel/Gasoline/BTXE/MTBE (MOD 8015/8020); BTXE/MTBE (8020); Chlorinated Hydrocarbons (601/8010); Aromatic Hydrocarbons (602/8020); SDWA Volatiles (502.1/503.1), 502.2 Reg. & Unreg.; Pesticides/PCB (608/8080); Herbicides (615/8150); Base/Neutral/Acid Compounds GC/MS (625/8270); Volatile Organics GC/MS (624/8240); Polynuclear Aromatics (610/8310); SDWA Primary Standards - Arizona; SDWA Secondary Standards - Arizona; SDWA Primary Standards - Federal; SDWA Secondary Standards - Federal

PROJECT INFORMATION

PROJ. NO.: 37700
PROJ. NAME: Hexcel-Cr
P.O. NO.:
SHIPPED VIA: Arizona Messenger Service

SAMPLE RECEIPT

NO. CONTAINERS: 1
CUSTODY SEALS: (N) / NA
RECEIVED INTACT: Y
RECEIVED COLD: Y

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☒ 24hr ☐ 48hr ☐ 72hr ☐ 1 WEEK (NORMAL) ☐ 2 WEEK

Comments:

SAMPLED & RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature: [signature] Time: 6/3/92	Signature: Time:	Signature: Time:
Printed Name: Alex Yiannakakis Date: 11:00	Printed Name: Date:	Printed Name: Date:
Company: Hydro Geo Chem Phone: 623-6981	Company:	Company:

RECEIVED BY: 1.	RECEIVED BY: 2.	RECEIVED BY:(LAB) 3.
Signature: Time:	Signature: Time:	Signature: [signature] Time: 4:57
Printed Name: Date:	Printed Name: Date:	Printed Name: Linda Eshleman Date: 6/3/92
Company:	Company:	Analytical Technologies, Inc.

GROUNDWATER MONITORING RESULTS
FOR SEPTEMBER 1992
AT THE
HEXCEL ABANDONED CHROMIUM DISPOSAL SITE
CASA GRANDE, ARIZONA

Prepared for:

Hexcel Corporation
11555 Dublin Blvd.
Dublin, California 94568

Prepared by:

Hydro Geo Chem, Inc.
1430 N. 6th Avenue
Tucson, Arizona 85705

December 7, 1992

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. LOCATION AND PHYSICAL SETTING 3

3. HYDROGEOLOGIC SETTING 5

4. GROUNDWATER MONITORING WELL CONSTRUCTION 7

5. SITE LITHOLOGY 12

6. GROUNDWATER LEVELS AND FLOW DIRECTION 14

7. MONITORING WELL SAMPLING SEPTEMBER 1992 16

   7.1 Decontamination 16
   7.2 Well Purging 17
   7.3 Sample Collection 17

8. RESULTS OF THE ANALYSES 20

9. REFERENCES 25

APPENDIX A: GROUNDWATER ANALYTICAL RESULTS

List of Figures

Figure		
1	Site Location Map	4
2	Location of the On-Site Monitoring Wells and the Subsurface Evaporation Field	8
3	Groundwater Monitoring Well, MW-1, Completion Diagram	9
4	Drilling Information and "As-Built" Diagram for MW-2	10
5	Drilling Information and "As-Built" Diagram for MW-3	11
6	Lithologic Cross-Section for the Hexcel Chromium Site	13

List of Tables

Table		
1	Water Level Elevation Parameters	15
2	Sample Sterilization Parameters	18
3	Analytical Results of 2nd Round of Quarterly Monitoring (September 1992) Water Sampling at the Hexcel Chromium Site (all values in mg/L)	21
4	Analytical Results of June 1992 Water Sampling at the Hexcel Chromium Site (all values in mg/L)	21
5	Summary of MW-1 Water Sampling Analytical Results Hexcel Chromium Site (all values in mg/L)	22

1. INTRODUCTION

The following groundwater monitoring report for the Hexcel Abandoned Chromium Disposal Site located near Casa Grande, Arizona is submitted as part of the remedial action plan defined in R18-7-108 of the Arizona Compilation of Rules and Regulations (ACRR). The purpose of the groundwater monitoring plan is to satisfy the requirements specified in Phase I of the Remedial Action Plan (RAP) detailed in the Revised Remedial Action Plan prepared by Hydro Geo Chem, Inc., (1992a) for the Hexcel Corporation. Groundwater monitoring at the site has been in progress since January, 1990 when one monitoring well was installed directly west of the disposal areas (Hydro Geo Chem, 1990a). The scope of groundwater monitoring plan was expanded in May 1992 when two additional monitoring wells were installed (Hydro Geo Chem, 1991, 1992b).

This report describes the results of the second quarterly round of groundwater sampling at the Hexcel Abandoned Chromium Disposal site. The groundwater sampling was performed on September 24 and 25, 1992. The purposes of the groundwater monitoring plan, as specified in Phase 1 of the RAP, are:

1) To determine if the abandoned chromium surface impoundment is adversely affecting groundwater quality;

2) To determine the direction of groundwater flow in the vicinity of the site to verify that the wells are properly located to monitor the sites;

3) To compare downgradient metal concentrations with the upgradient, background levels;

4) To verify model predictions that chromium has not reached groundwater; and

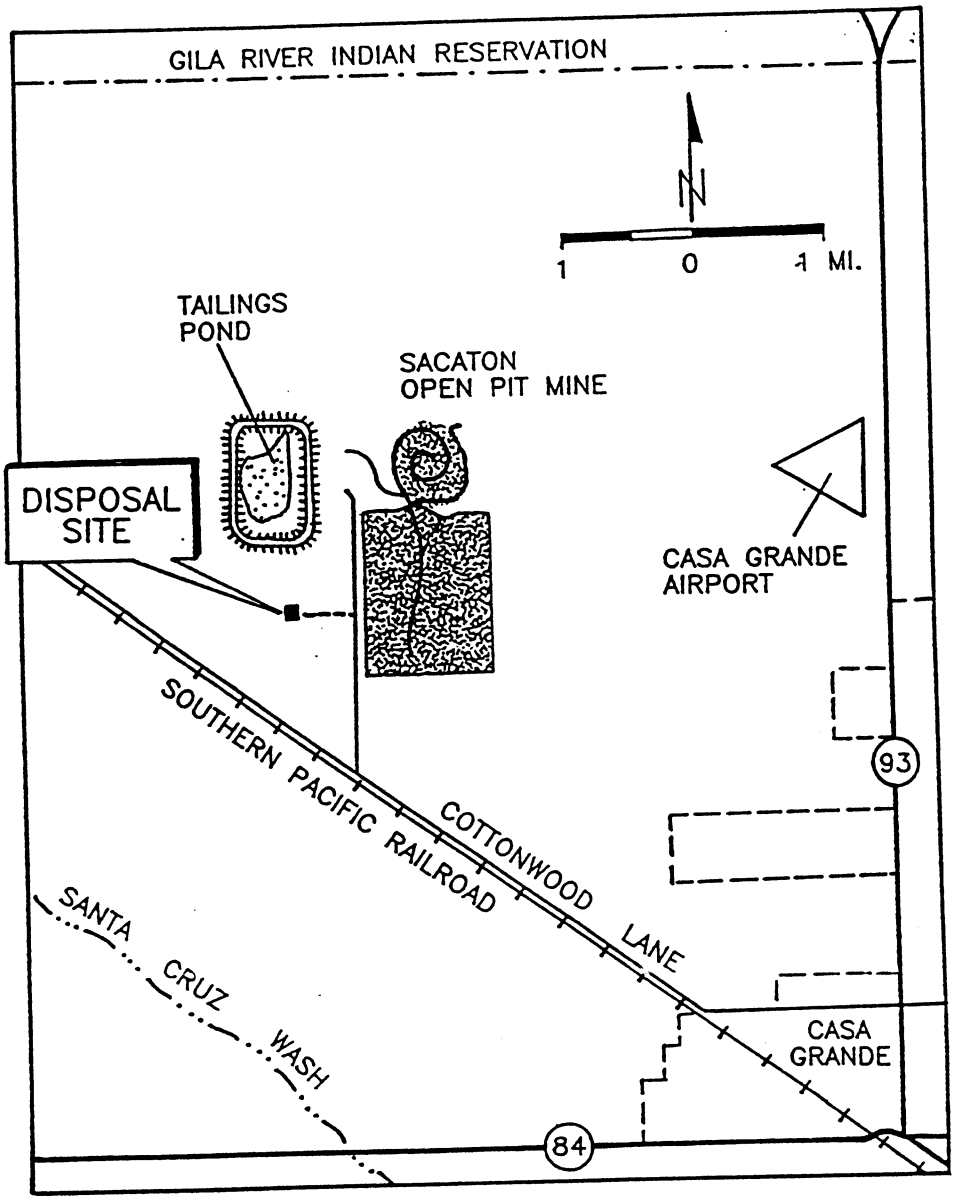
5) To continue to monitor groundwater quality in the vicinity of the impoundments to determine the effectiveness of the cap in preventing the downward migration of chromium.

2. LOCATION AND PHYSICAL SETTING

The site is located approximately 5 miles northwest of Casa Grande in Township 5 south, Range 5 east, Section 34, SW¼, SW¼, SW¼, SE¼ as shown in Figure 1. The former surface impoundments occupy a 70-foot by 80-foot area approximately in the center of 2.5 acres of State land leased by the Hexcel Corporation.

The site lies on a gently sloping alluvial fan deposit which spreads south from the Sacaton mountains. The alluvial fan is truncated approximately 0.9 miles to the north and east by tailings piles from the ASARCO Sacaton mines. The tailings piles occupy more than 2½ sections of land surrounding the site to the north and east.

The gently sloping alluvial fan is dissected by small washes spread about ½-mile apart. The shallow channels, less than 2 feet deep, drain towards the north branch of the Santa Cruz Wash. The vegetation in the area is sparse and consists of desert shrubs and grasses.



HYDRO GEO CHEM, INC.

SITE LOCATION MAP

Approved	Date	Revised	Date	Reference:	FIG.
JEH	6/26/96			37700F1	1

3. HYDROGEOLOGIC SETTING

The regional and local geology and hydrogeology of the Hexcel Chromium Disposal Site are described in the Hexcel Groundwater Monitoring Work Plan (Hydro Geo Chem, 1989b). Montgomery and Associates (1986) also summarized the regional hydrogeologic conditions around the Asarco Sacaton open-cell mine directly north and northeast of the site. The site is located in the northeast corner of what the Arizona Department of Water Resources (ADWR) has termed the Maricopa-Stanfield sub-basin of the Pinal AMA.

The site is underlain by approximately 900 feet of basin-fill deposits that include an upper unconsolidated unit and lower conglomerate unit. A local unconsolidated gravel unit lies between the unconsolidated and conglomerate units. This unconsolidated gravel unit is described as part of the basin-fill deposits in the Maricopa-Stanfield sub-basin southwest of the site (Wickham and Corkhill, 1989). The upper unconsolidated unit consists predominantly of silty sand, sandy clay, and sandy gravels. The conglomerate unit consists of firmly-lithified sediment, most commonly a cemented clay and gravel, conglomerate, and cemented gravel.

Depth to groundwater at the site is approximately 120 feet. The direction of the regional groundwater movement is generally westward, away from the Casa Grande groundwater high located southeast of the site. In the vicinity of the abandoned chromium disposal site the groundwater is highly mineralized with total dissolved solids (TDS) exceeding 4,000 mg/L around the Sacaton tailings pile

(Montgomery and Associates, 1986). A water sample collected from the Sacaton mine pit, located approximately 1.5 miles northeast of the site, had a TDS of 8,400 mg/L in 1986. Elevated concentrations of arsenic, chromium, selenium, and zinc have been reported in groundwater samples collected in the vicinity of the site (Montgomery and Associates, 1986). Montgomery and Associates identified five wells or mineral boreholes in the region in which arsenic levels in the groundwater were equal to or greater than ADEQ's MCL for drinking water. The five wells are identified as (D-5-6) 28aac Well 1, (D-5-6) 28daa Well 2, (D-6-6) 7aaa2, (D-5-6) 33aaa well 3, and (D-5-5) 35aba Well 6. The well number identification numbers are in accordance with the Bureau of Land Management's system of land subdivision.

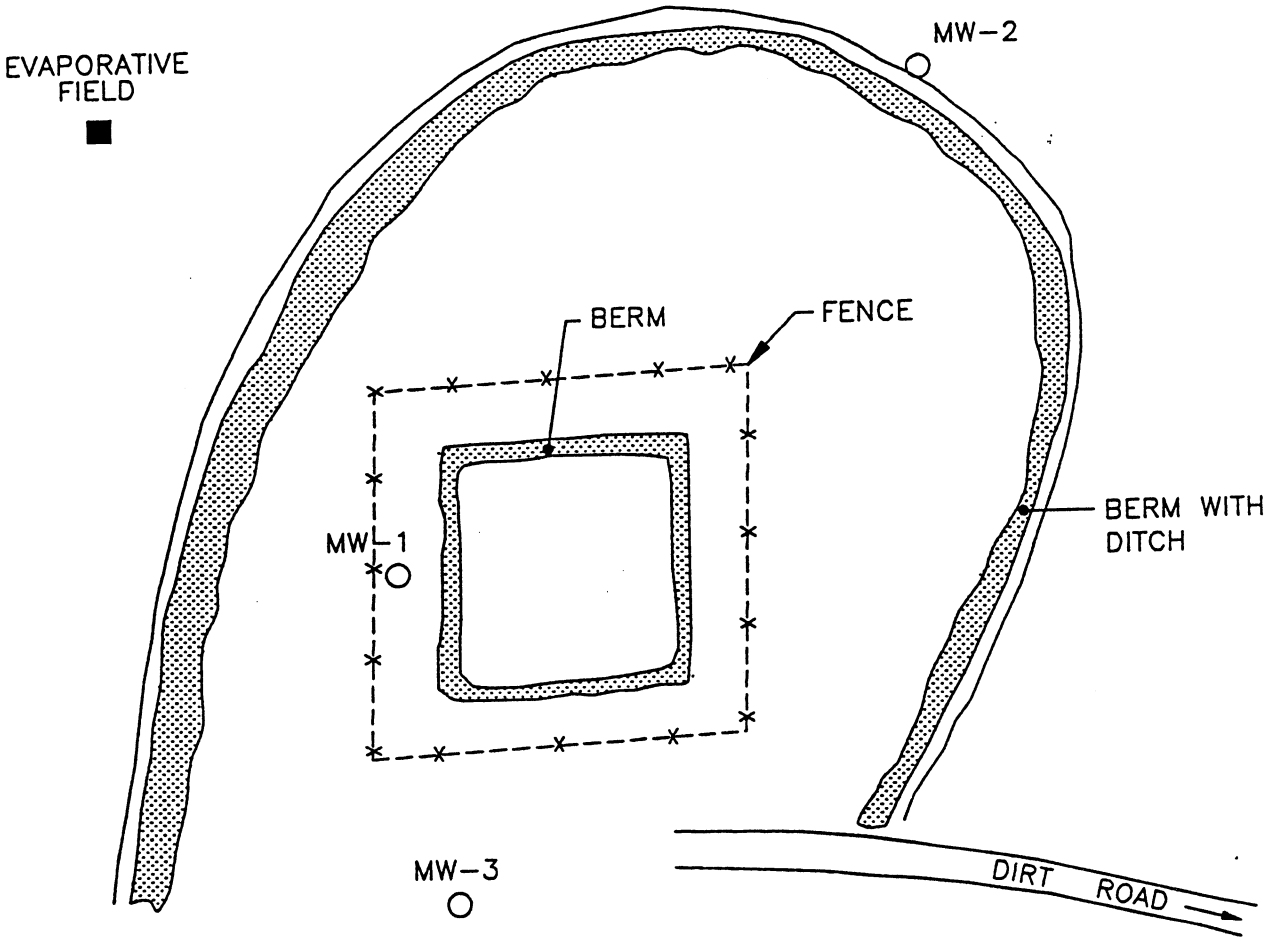
The wells or boreholes are located within four miles of the site to the northeast, east and southeast. The lateral extent of elevated levels of arsenic in the groundwater indicates that the arsenic does not have a local source. The high TDS, arsenic, and selenium levels render the groundwater unfit for domestic, livestock, or agricultural use (EPA, 1986).

4. GROUNDWATER MONITORING WELL CONSTRUCTION

Construction of the groundwater monitoring wells is described in Hydro Geo Chem (1990a, 1990b, and 1992b). Monitoring well MW-1 was constructed during the period January 22-24, 1990, and developed on January 26, 1990. Two additional monitoring wells, MW-2 and MW-3, were constructed during the period May 22-28, 1992 and developed between May 28, 1992 and June 1, 1992. The location of the monitoring wells and the former surface impoundments are shown in Figure 2.

MW-1 was completed to a depth of 219 feet below land surface (BLS) as shown in the well completion diagram, Figure 3. Details of the well drilling and completion are presented in Hydro Geo Chem (1990a). Monitoring wells MW-2 and MW-3 were completed to 168 feet BLS and 165 feet BLS, respectively as shown in Figures 4 and 5. Details of the drilling and completion are presented in Hydro Geo Chem (1992b).

Discharge waters produced during water sampling was transferred into the subsurface evaporation field (SEF). The SEF, whose location is shown in Figure 2, was constructed to accept the poor quality water produced during water sampling. Details regarding the design and construction of the SEF are described in Hydro Geo Chem (1992a and 1992b).



HYDRO GEO CHEM, INC.

LOCATION OF THE ON-SITE MONITORING WELLS AND THE SUBSURFACE EVAPORATION FIELD

Approved	Date	Revised	Date	Reference:	FIG.
	6/22/92			3770007B	2

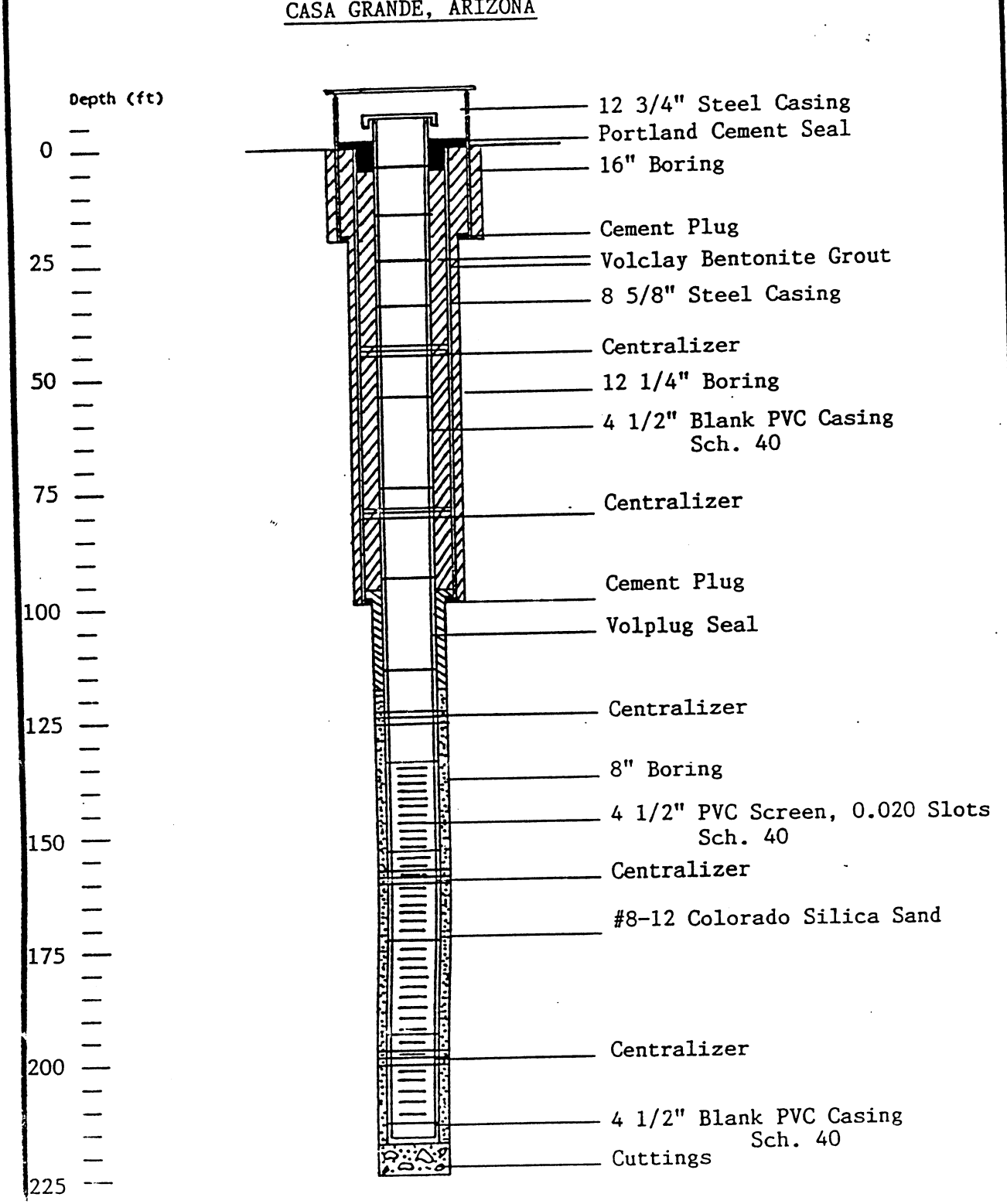
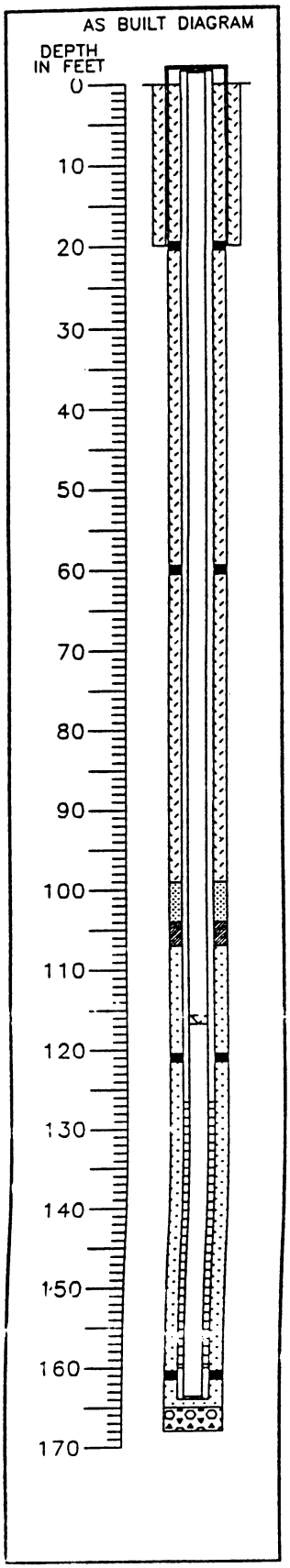


Figure 3 Groundwater monitoring well, MW-1, completion diagram



WELL CONSTRUCTION SUMMARY

PROJECT: Hexcel-Chromium #37700 WELL: MW-2 (upgradient well)
LOCATION: T55, R5E, Section 34, SW¼, SW¼, SE¼ Approx 100 feet northeast of pit fence

ELEVATION (GROUND): 1,374.6 feet (AMSC) GEOLOGIST: Warren Thompson/Alex Yiannakakis

DRILLING SUMMARY

Total Depth 168 feet

Hole Diam. 12¼", 0-20', 8", 20-168'

Driller Arizona Beeman Drilling Co.

Rig Gardner Denver 15W

Bit(s) 12¼" Button Bit 0-20'
8½" Button Bit 20-168'

Fluid Water with "Baroid Drill Foam"

Casing 8⅝" OD, carbon steel 0-20'

WELL DATA

Casing: C = Casing S = Screen
St = Steel P = PVC

8⅝"	CSt		0	20'	
4½"	CP		0	121.5'	
4½"	SP		121.5'	160'	
4½"	CP		160'		

Casing: C1 8⅝" OD, carbon steel 0-20'

C2 4½" OD, FJ, PVC, Sch 80, 0-121.5'

Screen: S1 4½" OD, FJ, PVC, SDR-17 0.02" slot 121.5-160'
C3 4½" OD, FJ, PVC, Sch 80, sedtrap, 160-164'

Filter Pack: prewashed Colorado silica
Depth: 107 -- 165 sand #8-12 (13 bags)

Bentonite: ¼" bentonite pelletes (10 gallons) 2-bags #60 fine silica sand
Depth: 99 -- 107

Cement: neat cement with 5% bentonite gel (powder).
Depth: 0 -- 99

Other: Four stainless steel centralizers (161', 121', 60', 20')
Two crossover threads from Sched 80 FJ to SDR-17
neat cment with bentonite gel from 0-20' around the surface casing.

CONSTRUCTION TIME LOG

Task	Start Date/Time	End Date/Time
Drilling:		
0-20 feet	5/22/92 10:10	5/22/92 11:20
20-168 feet	5/26/92 8:27	5/26/92 11:00
Geophys. Log:	None	
Casing:		
8⅝" steel	5/22/92 11:20	5/22/92 12:15
4½" PVC	5/26/92 11:30	5/26/92 12:40
Filter Pack:	5/26/92 12:40	5/26/92 14:45
Cement: neat cement	5/27/92 7:30	5/27/92 8:30
5% bentonite		
Development: air lift	5/26/92 11:00	5/26/92 11:30
pump	5/28/92 14:30	5/28/92 15:37
Other:		

Well Development: circulate 190 gallons of H_2O on 5/26/92 with drill rig

Further develop the well 5/28/93 using a 5 gpm stainless steel submersible pump (¾ hp). Pumped 370 gallons.

Static Water Level: 116.86 feet below land surface

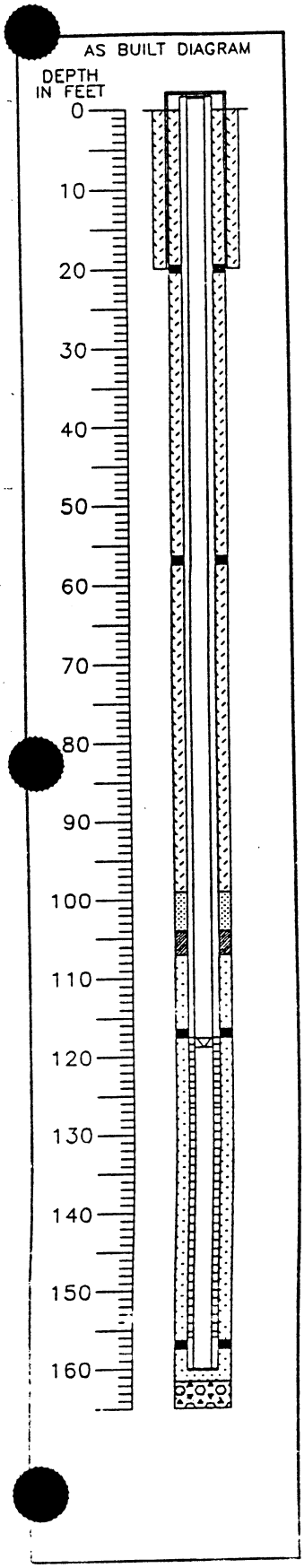
Remarks:

Final completion: prior to addition of slip cap PVC casing placed one foot above surface casing. Well completed on 6/1/92. Surface casing is 2.2" above land surface. PVC surface is 1.64' above ground surface.

Protective cap put on wells.

HYDRO GEO CHEM, INC.

Figure 4. Drilling information and "as-built" diagram for MW-2



WELL CONSTRUCTION SUMMARY

PROJECT: Hexcel-Chromium #37700 WELL: MW-3 (downgradient)
LOCATION: T55, R5E, Section 34, SW¼, SW¼, SE¼ Approx 50 feet south of pit fence

ELEVATION (GROUND): 1,372.09 feet (AMSC) GEOLOGIST: Warrent Thompson/Alex Yiannakakis

DRILLING SUMMARY

Total Depth 165 feet

Hole Diam. 12¼", 0-20', 8", 20-165'

Driller Arizona Beeman Drilling Co.

Rig Gardner Denver 15W

Bit(s) 12¼" Button Bit (tricone)
8" Button Bit (tricone)

Fluid Water with "Drilfoam" Baroid

Casing 8⅝" ,0-20', 4½", 0-160.5'

WELL DATA

Casing: C = Casing S = Screen
St = Steel P = PVC

8⅝" --CSt		0	--20'	
4½" --CP		0	--117.4'	
4½" --SP		117.4'	--156.1'	
4½" --CP		156.1'	--160.5'	
--			--	

Casing: C1 8⅝" OD, carbon steel 0-20'

C2 4½" OD, FJ, PVC, Sch 80, 0-117.4'

Screen: S1 4½" OD, FJ, PVC, SDR-17 0.02" slot 117.4-156.1'
C3 4½" OD, FJ, PVC, Sch 80, 156.1-160.5'

Filter Pack: prewashed Colorado silica
Depth: 107-- 160 sand #8--12
Bentonite: ¼" bentonite pelletes (10 gallons) 2-bags #60 fine silica sand
Depth: 99 -- 107

Cement: neat cement with 5% bentonite gel (powder).
Depth: 0-- 99

Other: Four stainless steel centralizers (157', 117', 57', 20' below land surface
Two crossover threads from Sched 80 FJ to SDR-17 screen
neat cment with bentonite gel from 0-20' around the surface casing.

CONSTRUCTION TIME LOG

Task	Start Date/Time	End Date/Time
Drilling:		
0-20 feet	5/27/92 10:05	5/27/92 10:40
20-165 feet	5/28/92 7:15	5/28/92 9:45
Geophys. Log:	None	
Casing:		
0-20 feet	5/27/92 10:45	5/27/92 11:20
20-160.5 feet	5/28/92 12:00	5/28/92 12:30
Filter Pack:	5/28/92 12:30	5/28/92 13:50
Cement: neat cement	5/28/92 14:50	5/28/92 16:05
5% bentonite Development: air lift	5/29/92 7:30	5/29/92 10:30
Other:		
Downtime	5/28/92 10:30	5/28/92 12:00

Well Development: Airlift at approximately 10 gpm for 3 hours = 1,800 gallons pH stable

Static Water Level: 118.84 feet below land surface

Remarks: Casing (PVC) had to be cut because it ended up 55" above the surface casing.

Used Jet Lube (Hydro Geo Chem free pipe dope) on threads.

Final completion: extended surface casing so that it is 2.09 feet above the land surface. PVC approximately 1.6 feet above land surface.

Protective lock cap put on wells.

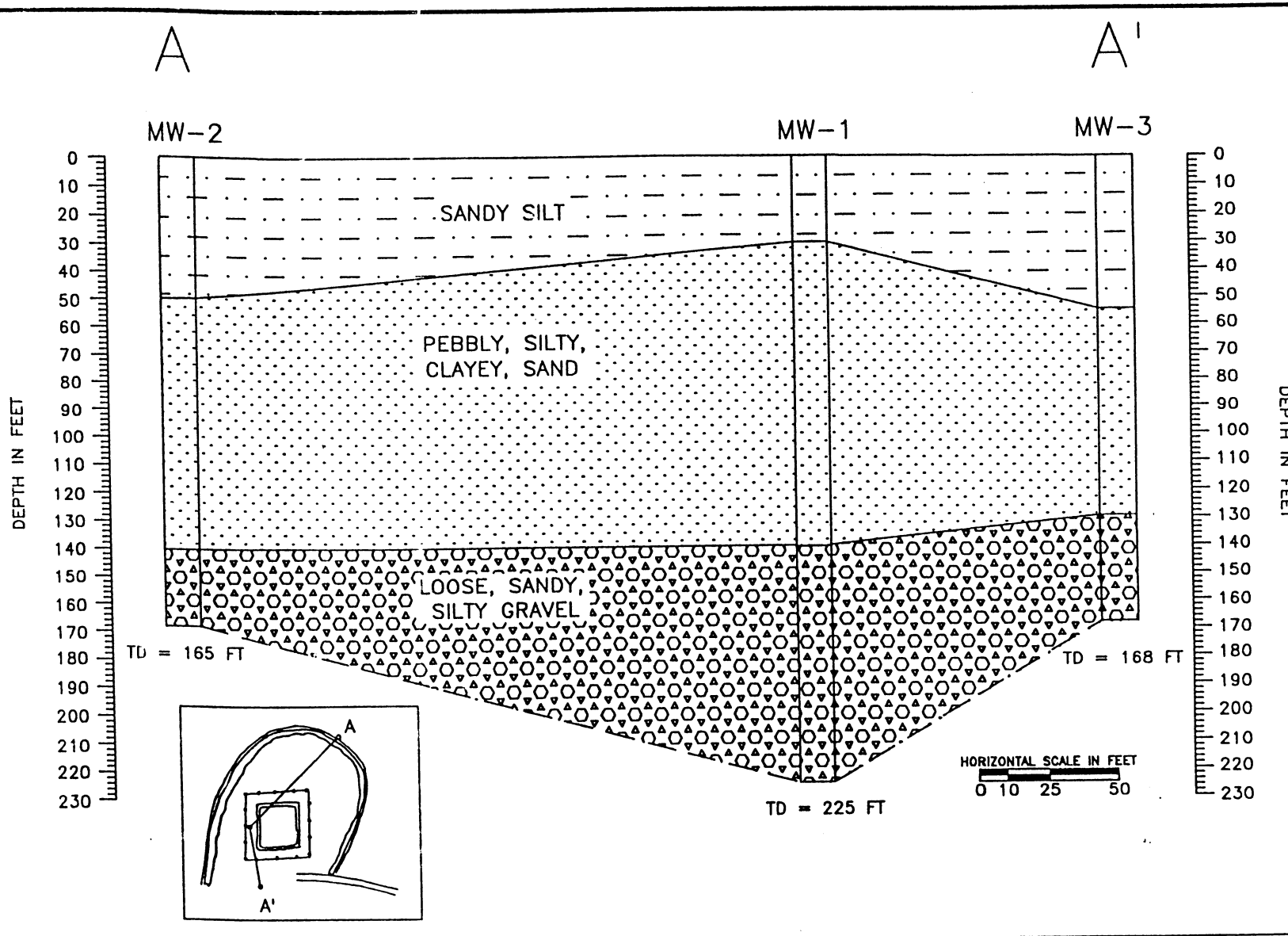
HYDRO GEO CHEM, INC.

Figure 5. Drilling information and "as-built" diagram for MW-3

5. SITE LITHOLOGY

A northeast to southwest lithologic cross-section, shown in Figure 6, was constructed from three monitoring well boring logs. The subsurface lithology can be separated into three distinct units. The upper unit consists of a sandy silt with clay. Its color ranges from brown, light brown to slightly pinkish and the thickness ranges from 30-55 feet. A distinct caliche bed exists approximately 7 to 8 feet below land surface. The middle unit consists of a silty, clayey sand with some gravel (up to 3mm in size). This unit ranges in thickness from 85 to 110 feet. The lower unit consists of an unconsolidated sandy, silty gravel with gravel up to 10 mm in diameter. The petrology of the gravels is mixed with quartz, granites, hornblend, and schists. Each of the three units coarsen with depth. The upper two units (0-140 feet) likely form part of the unconsolidated unit. The lower lithologic section is either of similar origin to the "local gravel unit" described in the Maricopa-Stanfield sub-basin lithologic cross-section (Wickham and Corkhill, 1989) or is a coarser grained portion of the unconsolidated unit.

gwmonito.rcs/hexcr



HYDRO GEO CHEM, INC.

LITHOLOGIC CROSS-SECTION FOR THE HEXCEL CHROMIUM SITE

Approved	Date	Revised	Date	Reference:	FIG.
CEH	6/25/92			3770012B	6

6. GROUNDWATER LEVELS AND FLOW DIRECTION

In the previous field investigation conducted in June, 1992 the monitoring well locations, elevations and water levels were measured for the three on-site monitoring wells to determine the direction of groundwater flow at the site and to verify that the wells were properly located to monitor the site. The average direction of groundwater and the gradient were computed in the vicinity of the site from the water elevations by solving the "three-point" problem for a plane. The direction of groundwater in the vicinity of the site was determined to the south 17° west and the gradient was 1.49 x 10^{-2} ft/ft/ or 79 ft/mile.

The southwest groundwater flow direction confirmed that the downgradient groundwater wells are properly located to monitor potential releases from the former surface impoundments with MW-3 being almost directly downgradient of the site. MW-2 is located up gradient of the site and is a sufficient distance, approximately 140 feet, from the surface impoundments to not be impacted by the site.

The water level measurements for the three monitoring wells during September, 1992 are listed in Table 1 along with the surface elevation, the reference elevation and the water levels above mean sea level (AMSL).

TABLE 1
WATER LEVEL ELEVATION PARAMETERS

Monitoring Well #	Surface Elevation (ft AMSL)	Reference Elevation (ft AMSL)	Water Level 9/24-25/92	Water Table (ft AMSL)
MW-1	1372.705	1373.05	118.37	1254.68
MW-2	1374.59	1376.15	118.706	1257.44
MW-3	1372.09	1373.52	120.36	1253.16

The water levels were measured with an electronic sounder using the inside casing as the elevation reference point. The water levels in the three monitoring wells were measured prior to pumping the wells on September 24 and 25, 1992. The direction of groundwater flow was south 11° west in September. The gradient was 1.48×10^{-2} ft/ft (78 ft/mile). A southwestern groundwater direction confirms MW-3 is down gradient of the site and that the gradient direction has not fluctuated.

7. MONITORING WELL SAMPLING

On September 24 and 25, 1992, Hydro Geo Chem personnel obtained groundwater samples from the three monitoring wells for the purpose of analyzing for EPA priority pollutant metals. Additional samples were collected for ADEQ for volatile organic, semi-volatile organic and EPA priority pollutant metals analyses.

A Rediflow-2 variable speed stainless steel submersible pump was temporarily installed in the wells to purge the wells prior to collecting water samples. A 1/2-inch diameter flexible PVC hose was used as the discharge line. With the variable speed pump, the pump rate could be controlled using a high pump rate (5gpm) for purging the wells and a low pump rate (100 ml/min) for sampling the water for VOC's.

7.1 Decontamination

The pump and discharge line were decontaminated prior to sampling. Initially the pump and discharge line were washed using a high pressure soap and water wash, followed by a high pressure tap water rinse and finally a deionized water rinse. Decon procedures between the sampling rounds consisted of scrubbing the outside of the pump and tubing with Alconox soap and a brush followed by pumping 5 gallons of Alconox and hot water through the pump and discharge line. The pump and discharge line were then rinsed with 50 liters of tap water followed by 2 gallons of distilled water.

7.2 Well Purging

Three bore volumes of water were purged from the wells to ensure that the samples were representative of the formation waters. The number of bore volumes required to purge the wells was reduced from 5 bore volumes because the temperature, pH, and conductivity of the purge water were observed to stabilize within three bore volumes and the desire to reduce the amount of water discharged into the SEF. The bore volume was calculated based on the static water level measured prior to sampling the well, the diameter of the well and the annular packing volume. MW-1, which was constructed to 218 feet BLS, required a larger purge volume (480 gallon) than MW-2 and MW-3 (230 gallons) completed to around 165 feet BLS. Table 2 lists the purge time, purge volume, the sample time, and the well stabilization parameters (temperature, conductivity and pH). The discharge rates, 5.66 gpm at MW-1, calculated at MW-2 to be 4.85 gpm, and 5 gpm at MW-3, were measured at the SEF using a bucket and stop watch. Temperature, pH and conductivity were checked periodically to determine if these parameters had stabilized and the wells were ready to sample.

7.3 Sample Collection

The monitoring wells were sampled using a Rediflo 2 stainless steel submersible pump connected to 150 feet of 1/2-inch diameter flexible PVC tubing and a stainless steel 1/4-inch stainless steel ball valve. Samples were collected from a 2-inch long 1/4-inch diameter stainless steel nipple connected to the ball valve.

TABLE 2
SAMPLE STABILIZATION PARAMETERS

Well	Purge Time (min)	Purge Volume (gal)	Sample Date	Temp. (°C)	Cond. mMohs	pH
MW-1	88	498	9/25/92 16:48	27.7	19.15	7.83
MW-2	55	264	9/21/92 19:20	27.0	19.48	7.88
MW-3	53	265	9/25/92 14:05	28.0	19.82	7.9

Filtered samples were collected by Hydro Geo Chem at the three monitoring wells for priority pollutant metals analyses, and placed into 1000 ml plastic bottles already containing nitric acid preservative. A split sample was collected for the ADEQ. Additionally a 2 1/2 liter sample was collected for semi-volatile organic analyses (SVOAs) and two-40 ml VOA samples for volatile organic analyses (VOAs) were collected at each well for ADEQ. The SVOAs samples were analyzed, by ADEQ, for chlorophenols. The pump rate was reduced to approximately 100 ml/min to collect the VOA and SVOA samples to prevent agitating the sample. The 40 ml VOA samples were collected with no headspace. Prior to shipping the 40 ml VOA bottles to the appropriate lab, small bubbles had formed in the water samples. The bubbles were thought to be the result of the formation of CO_2 gas created by the reaction of the acid preservative and the alkaline waters.

The samples were collected between September 24 and 25, 1992 as noted in Table 2. The samples were kept refrigerated and sent to the appropriate laboratories

on Monday, September 28, 1992 in a cooler with blue ice and packaging material. Hexcel's filtered samples were shipped to Analytical Technologies, Inc. (ATI) in Tempe, Arizona for priority pollutant metals analyses. The spilt metals samples and the SVOA samples were shipped to the State Laboratories in Phoenix, Arizona, while the VOA samples were shipped to McKenzie laboratories. McKenzie laboratories rejected the VOA samples due to air bubbles being present in the bottles invalidating the sample analyses.

Quality assurance samples consisted of a field blank and a trip blank. The field blank was prepared in the field by filtering deionized water and preserving the sample with nitric acid. The trip blank sample for the VOA samples was provided by the state analytical laboratory.

8. RESULTS OF THE ANALYSES

The groundwater samples collected on September 24 and 25, 1992 from MW-1, MW-2 and MW-3 satisfy the second round of quarterly sampling for the three monitoring wells at the Hexcel Abandoned Chromium Disposal Site near Casa Grande as part of Phase 1 of the Remedial Action Plan. In addition, MW-1 installed in January 1990 has been sampled separately, twice (January 1990 and May 1990) prior to the installation of MW-2 and MW-3 in May, 1992.

ATI performed the analyses for EPA priority pollutants on the field blank, and the filtered samples for MW-1, MW-2 and MW-3. The analytical results are summarized in Table 3. The laboratory report and claims of custody information are included in Appendix A of this report. The analytical results of the SVOA samples collected for ADEQ are not required for this report and will not be discussed further. To support the September 24-25, 1992 analyses, the June, 1992 results and the results from the previous sampling at MW-1 are summarized in Table 4 and 5 respectively. Results from the last round of sampling confirm the earlier results that chromium levels (0.03 mg/l) beneath the abandoned disposal site are not fluctuating

TABLE 3
ANALYTICAL RESULTS OF 2ND ROUND OF QUARTERLY MONITORING (SEPTEMBER 1992) WATER SAMPLING AT THE HEXCEL CHROMIUM SITE (ALL VALUES IN mg/L)

Metal	MCL	Field Blank	MW-1-F	MW-2-F	MW-3-F
Arsenic	0.05	<0.005	0.42	0.47	0.49
Chromium (total)	0.1	<0.01	0.028	0.030	0.031
Cadmium	0.01	<0.0005	0.0021	0.0021	0.0027
Selenium	0.01	<0.05*	<0.05*	<0.05*	<0.05*
Thallium	NA	<0.005	0.01	0.01	0.011
Zinc	NA	0.013	<0.01	0.026	0.012

Notes: * Due to matrix interference, selenium analyses of samples were run at a dilution. Detection limits have been raised accordingly. Thirteen (13) priority pollutant metals were analyzed. Only detectable concentrations were listed, except for selenium.

TABLE 4
ANALYTICAL RESULTS OF JUNE 1992 WATER SAMPLING AT THE HEXCEL CHROMIUM SITE (ALL VALUES IN mg/L)

Metals	MCL	Trip Blank	Equip. Blank	Field Blank	MW-1-F	MW-2-F	MW-3-F	MW-3-UF
Arsenic	0.05	<0.002	<0.002	<0.002	0.34	0.34	0.41	0.38
Chromium (total)	0.1	<0.01	<0.01	<0.01	0.03	0.03	0.02	0.03
Copper	NA	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01
Selenium	0.01	<0.002	<0.002	<0.002	0.068	0.069	0.73	0.75
Zinc	NA	<0.05	<0.05	<0.05	<0.05	0.14	0.13	0.14

Notes: * Thirteen (13) priority pollutant metals were analyzed. Only detectable concentrations are listed in the table
F indicates a filtered sample.
UF indicates an unfiltered sample.

TABLE 5
SUMMARY OF MW-1 WATER SAMPLING ANALYTICAL RESULTS HEXCEL CHROMIUM SITE
(ALL VALUES IN mg/L)

Metals	Sept. 25, 1992	June 1, 1992	May 2, 1990	Jan. 26, 1990
Arsenic	0.42	0.34	0.28	0.76
Chromium (total)	0.028	0.03	0.03	0.02
Copper	<0.01	0.01	<0.02	<0.02
Selenium	<0.05	0.068	0.089	0.03
Zinc	<0.01	<0.05	0.027	0.55

and are below the ADEQ's MCL for drinking water of 0.1 mg/l (ADEQ, 1992). The similarity between metals concentrations of all the wells, both up and down gradient, indicates that the former surface impoundment has not impacted the groundwater.

The concentration of arsenic in each the wells is significantly above the 0.05 mg/l ADEQ MCL for groundwater. Selenium, previously detected above the ADEQ's MCL of 0.01 mg/l, was not detected in the last round of samples above the detection limit. Due to matrix interference, samples for selenium analysis were diluted raising the detection limit from 0.002 to 0.05. Neither arsenic nor selenium has been disposed of at the site by Hexcel. Arsenic has been identified in a number of wells in the area (Montgomery and Associates, 1986). Elevated concentrations of arsenic northeast, east and southeast of the site indicate the source is not associated with the abandoned disposal site.

In summary, the last round of water samples and water level measurements indicates:

1. The groundwater gradient has not fluctuated and is still to the southwest verifying that MW-1 and MW-3 are properly located to monitor the impact of the Hexcel abandoned chromium disposal site.

2. The chromium concentrations in all the monitoring wells were approximately 0.03 mg/l, below the ADEQ's MCL for drinking water of 0.1 mg/l. The MCl of chromium was recently (June 1992) raised from 0.05 mg/l to 0.1 mg/l.

3. The water in the vicinity of the site is not suitable for drinking, domestic, livestock and agricultural use.

4. The groundwater investigation indicates the site is not adversely affecting groundwater in the vicinity of the site and Phase 2 of the remedial action plan should proceed as soon as possible to further minimize the risk to groundwater and the environment.

A groundwater monitoring schedule has been proposed in the RAP (1992a). The next round of groundwater sampling is scheduled for early December, 1992. Hexcel proposes to install dedicated pumps in the three on-site monitoring wells prior to the next round of groundwater sampling. ADEQ will be notified at least one week prior to sampling the on-site monitoring wells.

9. REFERENCE

ADEQ. June 1992. Human Health-Based Guidance Levels for the Investigation of Contaminants in Drinking Water and Soil.

Hydro Geo Chem, Inc. 1990a. Report on Phase I Groundwater Monitoring for the Closure of the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Report submitted to Hexcel Corporation.

Hydro Geo Chem, Inc. 1990b. Results of May 1990 Groundwater Sampling at the Hexcel Abandoned Chromium Disposal Site, Casa Grande, Arizona. Report submitted to Hexcel Corporation.

Hydro Geo Chem, Inc. 1991. Revised Groundwater Monitoring Plan for the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992a. Revised Remedial Action Plan for the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992b. Well Installation and Groundwater Monitoring Results at the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Montgomery and Associates. 1986. Quality Criteria for Water. EPA 440/S-86-001.

US Environmental Protection Agency. 1986. Quality Criteria for Water. EPA 440/S-86-001.

Wickham, M.P. and Corkhill, E.F. 1989. Hydrogeologic Framework, Water Budget, and Phase One Recommendations. Hydrology Division, Arizona Department of Water Resources.

APPENDIX A

Analytical Technologies, Inc. 9830 S. 51st Street Suite B-113 Phoenix, AZ 85044 (602) 496-4400

ATI I.D. 209889

October 19, 1992

Hydro Geo Chem
1430 North 6th Ave.
Tucson, AZ 85705

Project Name/Number: Hexcel-Chromium/37700

Attention: Alex Yiannakakis

On 09/30/92, Analytical Technologies, Inc. received a request to analyze aqueous sample(s). The sample(s) were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Due to matrix interference, Lead and Selenium analyses of samples MW-2-92492-F, MW-3-92592-F, and MW-1-92592-F were run at a dilution. Detection limits have been raised accordingly.

If you have any questions or comments, please do not hesitate to contact us at (602) 496-4400.

Steven E. Stanley
Project Manager

Robert V. Woods
Laboratory Manager

RVW:jat
Enclosure

Analytical Technologies, Inc.

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CHROM

DATE RECEIVED : 09/30
REPORT DATE : 10/19/92

ATI I.D. : 209889

ATI #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-2-92492-F	AQUEOUS	09/24/92
02	MW-3-92592-F	AQUEOUS	09/25/92
03	FB-1-92592-F	AQUEOUS	09/25/92
04	MW-1-92592-F	AQUEOUS	09/25/92

----- TOTALS -----

MATRIX	# SAMPLES
AQUEOUS	4

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from th
date of this report. If an extended storage period is required, please co
our sample control department before the scheduled disposal date.

Analytical Technologies, Inc.

METALS RESULTS

ATI I.D. : 209889

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CHROM

DATE RECEIVED : 09/30/92

REPORT DATE : 10/19/92

PARAMETER	UNITS	01 (MW-2)	02 (MW-3)	03 (FB)	04 (MW-1)
SILVER	MG/L	<0.010	<0.010	<0.010	<0.010
ARSENIC	MG/L	0.47	0.49	<0.005	0.42
BERYLLIUM	MG/L	<0.005	<0.005	<0.005	<0.005
CADMIUM	MG/L	0.0021	0.0027	<0.0005	0.0021
CHROMIUM	MG/L	0.030	0.031	<0.010	0.028
COPPER	MG/L	<0.010	<0.010	<0.010	<0.010
MERCURY	MG/L	<0.0002	<0.0002	<0.0002	<0.0002
NICKEL	MG/L	<0.020	<0.020	<0.020	<0.020
LEAD	MG/L	<0.010	<0.010	<0.002	<0.010
ANTIMONY	MG/L	<0.05	<0.05	<0.05	<0.05
SELENIUM	MG/L	<0.05	<0.005	<0.05	<0.05
THALLIUM	MG/L	0.010	0.011	<0.005	0.010
ZINC	MG/L	0.026	0.012	0.013	<0.010

Analytical Technologies, Inc.

METALS - QUALITY CONTROL

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEXCEL-CHROM ATI I.D. : 209889

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RPD	SPIKED SAMPLE	SPIKE CONC	% REC
SILVER	MG/L	20988903	<0.010	<0.010	NA	0.089	0.100	89
ARSENIC	MG/L	20988301	0.009	0.010	11	0.059	0.050	100
ARSENIC	MG/L	21051114	<0.005	<0.005	NA	0.023	0.025	92
BERYLLIUM	MG/L	20988903	<0.005	<0.005	NA	0.095	0.100	95
CADMIUM	MG/L	20986901	<0.0005	<0.0005	NA	0.0045	0.0050	90
CHROMIUM	MG/L	20988903	<0.010	<0.010	NA	0.097	0.100	97
COPPER	MG/L	20988903	<0.010	<0.010	NA	0.092	0.100	92
MERCURY	MG/L	20988904	<0.0002	<0.0002	NA	0.0046	0.0050	92
NICKEL	MG/L	20988903	<0.020	<0.020	NA	0.099	0.100	99
LEAD	MG/L	20986530	0.018	0.019	5	0.070	0.050	104
ANTIMONY	MG/L	20988903	<0.05	<0.05	NA	1.06	1.00	106
SELENIUM	MG/L	20988901	<0.05	0.05	NA	0.36	0.50	72
THALLIUM	MG/L	21057101	<0.005	<0.005	NA	0.043	0.050	86
ZINC	MG/L	20988903	0.013	0.012	8	0.121	0.100	108

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 10$$

HYDRO GEO CHEM, INC.
Groundwater Consultants

Chain of Custody

DATE 9/25/92 PAGE 1 OF 1

PROJ. MGR. Alex Yiannakakis
COMPANY Hydro Geo Chem
ADDRESS 1430 N. 6th AU
Tucson Az 85705

SAMPLERS (SIGNATURE) (PHONE NO.) 602-623-6981

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418			PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SDWA - INORGANICS PRIMARY/SECONDARY						NUMBER OF CONTAINERS
MW-2-92492-F	9/24/92	19:30	water	1													X									1
MW-3-92592-F	9/25/92	14:15	"	2													X									1
FB-1-92592-F	9/25/92	13:45	"	3													X									1
MW-1-92592-F	9/25/92	17:00	"	4													X									1

ANALYSIS REQUEST

PROJECT INFORMATION	
PROJECT	Hexcel-Chromium
PO NO	37700
SHIPPING ID. NO.	
VIA	FedEx

SAMPLE RECEIPT	
TOTAL NO. OF CONTAINERS	4
CHAIN OF CUSTODY SEALS	Y
REC'D GOOD CONDITION/COLD	Y
CONFORMS TO RECORD	Y
LAB NO.	209889

SPECIAL INSTRUCTIONS/COMMENTS: Please contact Alex Yiannakakis or Harold Bentley if you have any questions

INVOICE TO: As above

RELINQUISHED BY 2.	RELINQUISHED BY 3.
(Signature) (Time) 14:20	(Signature) (Time)
(Printed Name) Alex Yiannakakis (Date)	(Printed Name) (Date)
(Company) Hydro Geo Chem	(Company)
RECEIVED BY 2.	RECEIVED BY (LABORATORY) 3.
(Signature) (Time)	(Signature) (Time) 7:10
(Printed Name) (Date)	(Printed Name) Linda Eshelman 9/30/92
(Company)	

DISTRIBUTION: WHITE, CANARY - ANALYTICAL LABORTORY • PINK - ORIGINATOR

GROUNDWATER MONITORING RESULTS FOR DECEMBER 1992 AT THE HEXCEL ABANDONED CHROMIUM SITE CASA GRANDE, ARIZONA

Prepared for:

Hexcel Corporation
5794 W. Las Positas Blvd.
Pleasanton, California 94588

Prepared by:

Hydro Geo Chem, Inc.
1430 N. Sixth Ave.
Tucson, Arizona 85705

December 31, 1992

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. BACKGROUND 2

3. DEDICATED PUMP INSTALLATION 2

4. GROUNDWATER LEVELS AND FLOW DIRECTIONS 3

5. MONITORING WELL SAMPLING - DECEMBER 1992 4

   5.1 Well Purging 6

   5.2 Sample Collection 7

   5.3 Results of the Analysis 8

6. REFERENCES 11

List of Tables

Table

1. Water Level Elevation 3

2. Sample Stabilization Parameter 7

3. Analytical Results of All Water Samples Collected at the Hexcel Chromium Site 9

List of Figures

Figure **Page**

1 Location of the On-site Monitoring Wells and the Subsurface Evaporation Field 5

1. INTRODUCTION

The following groundwater monitoring report for the Hexcel Abandoned Chromium Disposal Site located near Casa Grande, Arizona, is submitted as part of the remedial action plan defined in R18-7-108 of the Arizona Compilation of Rules and Regulations (ACRR). The purpose of the groundwater monitoring plan is to satisfy the requirements specified in Phase I of the Remedial Action Plan (RAP) detailed in the Revised Remedial Action Plan prepared by Hydro Geo Chem, Inc. (1992a) for the Hexcel Corporation. Groundwater monitoring at the site has been in progress since January 1990 when one monitoring well was installed directly west of the disposal areas (Hydro Geo Chem, 1990a). The scope of groundwater monitoring plan was expanded in May 1992 when two additional monitoring wells were installed (Hydro Geo Chem, 1991, 1992b).

This report describes the results of the third quarterly round of groundwater sampling at the Hexcel Abandoned Chromium Disposal site. Dedicated pumps were installed in the monitoring wells on December 8, 1992. The groundwater sampling was performed on December 9, 1992.

2. BACKGROUND

For details regarding the location of the site, the physical setting, the hydrogeologic setting, the groundwater well construction, and the site lithology, refer to the "Well Installation and Groundwater Monitoring Results Report" (Hydro Geo Chem (HGC), 1992b) and the "Groundwater Monitoring Results for September 1992" (HGC, 1992c).

3. DEDICATED PUMP INSTALLATION

Dedicated pumps were installed by Hydro Geo Chem in the three groundwater monitoring wells on December 8, 1992. All equipment was steam cleaned prior to installation. The equipment was wrapped in plastic until placed in the well. The pumps were connected to ⅛" stainless steel cable and then lowered into the well using a hoist.

The dedicated pumps, Grundfos ½ hp stainless steel 5 gpm pumps, were set 140 feet below the top of the inner casing. One-inch ID threaded, Schedule 80 PVC pipe was used for the pump discharge line. An open-ended ½-inch ID, threaded, Schedule 80 PVC pipe was lowered to 130 feet below the top of the inner casing to collect water level measurements. The discharge line and water level protective pipe are supported on a steel well-seal cover. The pipes were sealed with threaded plugs until the wells were sampled. The pumps will be left in place for the duration of the project.

4. GROUNDWATER LEVELS AND FLOW DIRECTIONS

Water levels were measured for the three on-site monitoring wells on December 8, 1992, prior to installing the dedicated pumps. The water level measurements will determine the direction of groundwater flow at the site and verify that the wells were properly located to monitor the site.

The water level measurements for the three monitoring wells for December 8, 1992, are listed in Table 1, along with the surveyed surface elevation, the reference elevation and the water levels above mean sea level (AMSL).

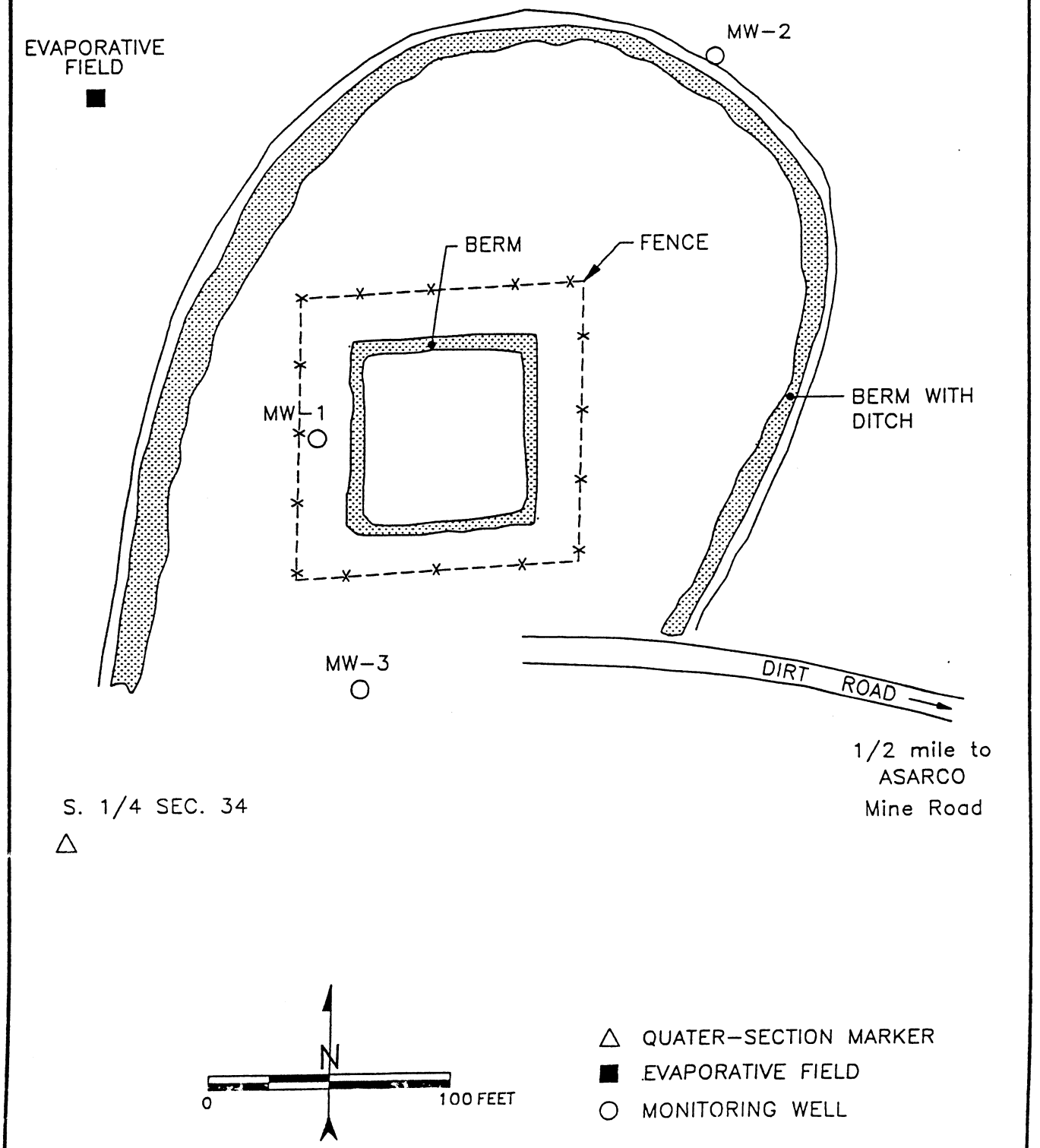
TABLE 1
WATER LEVEL ELEVATION

Monitoring Well #	Surface Elevation (ft AMSL)	Reference Elevation (ft AMSL)	Water Level 9/24-25/92	Water Table (ft AMSL)
MW-1	1372.705	1373.05	118.63	1254.42
MW-2	1374.59	1376.15	118.845	1257.305
MW-3	1372.09	1373.52	120.555	1252.965

The average direction of groundwater and the gradient were computed in the vicinity of the site from the water elevations by solving the "three-point" problem for a plane. The direction of groundwater in the vicinity of the site was determined to be south 15.5° west and the gradient was 1.46×10^{-2} ft/ft (77.1 ft/mile). The southwestern groundwater direction did not fluctuate during the first three quarterly sampling rounds and still confirms MW-1 and MW-3 are downgradient of the site.

5. MONITORING WELL SAMPLING DECEMBER 1992

On December 9, 1992, Hydro Geo Chem personnel obtained groundwater samples from the three monitoring wells shown in Figure 1 for the purpose of analyzing for EPA priority pollutant metals. Split samples were collected for ADEQ for EPA priority pollutant metals analyses. In addition, a water sample was collected for hexavalent chromium analysis. Moses Olade, an ADEQ representative, was present during the groundwater sample collection.



HYDRO GEO CHEM, INC.

LOCATION OF THE ON-SITE MONITORING WELLS AND THE SUBSURFACE EVAPORATION FIELD

Approved	Date	Revised	Date	Reference:	FIG.
	6/22/92			3770007B	1

5.1 Well Purging

Three bore volumes of groundwater were purged from the wells using the dedicated pumps, 5 gpm stainless steel Grundfos submersible pumps. The three-bore volumes of water purged from the wells ensure that the samples were representative of the formation waters. The bore volumes were calculated based on the static water level measured prior to sampling the well, the diameter of the well and the annular packing volume. MW-1, which was constructed to 218 ft BLS, required a larger purge volume (480 gallons) than MW-2 and MW-3 (230 gallons) completed to around 165 ft BLS.

Table 2 lists the purge time, purge volume, the sample time, and the well stabilization parameters (temperature, conductivity, and pH). The pump rates, calculated at MW-1 to be 6.6 gpm, 6.4 gpm at MW-2 and 6.4 gpm at MW-3, were obtained at the SEF using a bucket and stopwatch. Temperature, pH, and conductivity were checked periodically to determine if these parameters had stabilized and the wells were ready to sample. The water parameters stabilized rapidly, and therefore the three-bore volume limit was used to assure that the samples were representative of the formation waters.

TABLE 2
SAMPLE STABILIZATION PARAMETER

Well	Purge Time (min)	Purge Volume (gal)	Sample Date	Temp (oC)	Cond. (MS)	pH
MW-1	72	480	11/9/92 11.00 a.m.	25.5	18.12	7.81
MW-2	35	220	11/9/92 1.32 p.m.	25.9	18.20	7.86
MW-3	33	211	11/9/92 12.15 p.m.	25.7	18.70	7.85

5.2 Sample Collection

The monitoring wells were sampled using dedicated stainless steel submersible pumps connected to 140 feet of 1-inch diameter Schedule 80 PVC pipe and a stainless steel ¼-inch ball valve. Samples were collected from a 2-inch long ¼-inch diameter stainless steel nipple connected to the ball valve. The purge waters were discharged in the subsurface evaporation field, the location of which is shown in Figure 1.

Filtered samples were collected by Hydro Geo Chem at the three monitoring wells for priority pollutant metals analyses, and placed into 1,000 ml plastic bottles already containing nitric acid preservatives. A split unfiltered sample was collected for ADEQ. Additionally, ADEQ collected a sample for hexavalent chromium in a 1,000 ml plastic bottle with no preservatives.

The samples were collected on December 9, 1992, as noted in Table 2. The samples were immediately refrigerated in a cooler with blue ice. ADEQ hand

delivered their samples to the appropriate laboratory(ies). Hexcel's filtered samples were shipped to Analytical Technologies, Inc. (ATI) in Tempe, Arizona, by United Parcel Service on December 9, 1992, for priority pollutant metals analyses.

Quality assurance samples consisted of a field blank. The field blank was prepared in the field by filtering distilled water and preserving the sample with nitric acid.

5.3 Results of the Analysis

The groundwater samples collected on December 9, 1992, from MW-1, MW-2, and MW-3 satisfy the third round of quarterly sampling for the three monitoring wells at the Hexcel Abandoned Chromium Disposal Site near Casa Grande, Arizona. The groundwater monitoring plan is part of Phase 1 of the Remedial Action Plan.

ATI performed the analyses for EPA priority pollutant metals on the field blank and the filtered samples for MW-1, MW-2, and MW-3. MW-2 was the only filtered sample which had fine sediments collected on the filter paper. The other filters were clear of particulates. No priority pollutant metals, except low concentrations of zinc, were detected in the field blank. The analytical results are summarized in Table 3. The results from previous sampling rounds are also included in Table 3. Note two additional samples were collected from MW-1 which was installed in January 1990 prior to the installation of MW-2 and MW-3 in May 1992.

The laboratory report and chains of custody information for the third round of samples are included in Appendix A to this report.

TABLE 3
ANALYTICAL RESULTS OF ALL WATER SAMPLES COLLECTED AT THE HEXCEL CHROMIUM SITE
(Values in mg/l)

Well #	Date	Arsenic	Chromium (total)	Copper	Selenium	Zinc
MW-1	12/9/92	0.35	0.027	<0.01	0.046	<0.010
MW-1	9/25/92	0.42	0.028	<0.01	<0.05	<0.010
MW-1	6/1/92	0.34	0.030	0.01	0.068	<0.050
MW-1	5/2/90	0.28	0.030	<0.02	0.089	0.027
MW-1	1/26/90	0.76	0.020	<0.02	0.030	0.550
MW-2	12/9/92	0.42	0.030	<0.01	0.046	0.017
MW-2	9/21/92	0.47	0.030	<0.01	<0.05	0.026
MW-2	6/2/92	0.34	0.030	<0.01	0.069	0.140
MW-3	12/9/92	0.42	0.030	<0.01	0.043	0.018
MW-3	9/25/92	0.49	0.031	<0.01	<0.050	0.012
MW-3	6/2/92	0.41	0.020	<0.01	0.073	0.130

Thirteen priority pollutant metals were analyzed. Only detectable concentrations were listed, except for thallium and cadium which were only detected in September 1992 at concentrations less than or equal to 0.01 mg/l.

The results from the third quarterly round of sampling (December 1992) did not differ from the previous rounds in that (1) chromium levels (0.03 mg/l) beneath the abandoned disposal site have not fluctuated and are below the ADEQ's MCL for

drinking water of 0.1 mg/l (ADEQ, 1992); (2) the metals concentration at all the wells, both upgradient and downgradient, are similar, indicating that the surface impoundments have not impacted the groundwater; and (3) arsenic is the only groundwater constituent significantly above the ADEQ's MCL for groundwater of 0.05 mg/l. Previously reported information indicates the source of arsenic is not associated with the site. Selenium, which was not detected in the previous sampling round due to its high detection limit of <0.05 mg/l, was detected in all the wells at levels (0.043 to 0.046 mg/l) just below ADEQ's recently modified MCL of 0.05 mg/l.

The final round of quarterly groundwater sampling required to fulfill the initial stage of Phase 1 of the RAP is scheduled for early March 1993. ADEQ will be notified at least a week in advance of sampling the on-site monitoring wells. Because the groundwater results continue to indicate the site is not adversely affecting groundwater in the vicinity, Phase 2 of the RAP should commence upon approval by the ADEQ.

6. REFERENCES

ADEQ. June 1992. Human Health-Based Guidance Levels for the Investigation of Contaminants in Drinking Water and Soil.

Hydro Geo Chem, Inc. 1990a. Report on Phase I Groundwater Monitoring for the Closure of the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Report submitted to Hexcel Corporation.

Hydro Geo Chem, Inc. 1991. Revised Groundwater Monitoring Plan for the Abandoned Chromium Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992a. Revised Remedial Action Plan for the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992b. Well Installation and Groundwater Monitoring Results at the Abandoned Disposal Site, Casa Grande, Arizona. Prepared for Hexcel Corporation.

Hydro Geo Chem, Inc. 1992c. Groundwater Monitoring Results for September 1992 at the Hexcel Abandoned Disposal Site Casa Grande, Arizona. Prepared for Hexcel Corporation.

APPENDIX A

Analytical Technologies, Inc. 9830 S. 51st Street Suite B-113 Phoenix, AZ 85044 (602) 496-4400

ATI I.D. 212717

December 31, 1992

Hydro Geo Chem
1430 North 6th Ave.
Tucson, AZ 85705

Project Name/Number: Hex-Cr/37700

Attention: Alex Yiannakakis

On 12/10/92, Analytical Technologies, Inc. received a request to analyze **aqueous** sample(s). The sample(s) were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Due to matrix interferences, cadmium, selenium, and thallium spikes were performed using the Method of Standard Additions (MSA); the spike result given is the correlation coefficient (CC), which is ≥ 0.995.

Due to matrix interference, thallium analysis of sample MW-3-12992 was run at a dilution. Detection limit has been raised accordingly.
If you have any questions or comments, please do not hesitate to contact us at (602) 496-4400.

Steven E. Stanley
Project Manager

Robert V. Woods
Laboratory Manager

RVW:ktd
Enclosure

Analytical Technologies, Inc.

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEX-CR

DATE RECEIVED : 12/10/92
REPORT DATE : 12/24/92

ATI I.D. : 212717

ATI #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	FB-1-12992	AQUEOUS	12/09/92
02	MW-1-12992	AQUEOUS	12/09/92
03	MW-3-12992	AQUEOUS	12/09/92
04	MW-2-12992	AQUEOUS	12/09/92

----- TOTALS -----

MATRIX	# SAMPLES
AQUEOUS	4

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

Analytical Technologies, Inc.

METALS RESULTS

ATI I.D. : 212717

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEX-CR

DATE RECEIVED : 12/10/92
REPORT DATE : 12/24/92

PARAMETER	UNITS	01	02	03	04
SILVER (EPA 200.7/6010)	MG/L	<0.010	<0.010	<0.010	<0.010
ARSENIC (EPA 206.2/7060)	MG/L	<0.005	0.35	0.42	0.42
BERYLLIUM (EPA 200.7/6010)	MG/L	<0.005	<0.005	<0.005	<0.005
CADMIUM (EPA 213.2/7131)	MG/L	<0.0005	<0.0005	<0.0005	<0.0005
CHROMIUM (EPA 200.7/6010)	MG/L	<0.010	0.027	0.030	0.030
COPPER (EPA 200.7/6010)	MG/L	<0.010	<0.010	<0.010	<0.010
MERCURY (EPA 245.1/7470)	MG/L	<0.0002	<0.0002	<0.0002	<0.0002
NICKEL (EPA 200.7/6010)	MG/L	<0.020	<0.020	<0.020	<0.020
LEAD (EPA 239.2/7421)	MG/L	<0.002	<0.010	<0.010	<0.010
ANTIMONY (EPA 200.7/6010)	MG/L	<0.05	<0.05	<0.05	<0.05
SELENIUM (EPA 270.2/7740)	MG/L	<0.005	0.046	0.043	0.046
THALLIUM (EPA 279.2/7841)	MG/L	<0.005	<0.005	<0.025	<0.005
ZINC (EPA 200.7/6010)	MG/L	0.017	<0.010	0.018	0.017

Analytical Technologies, Inc.

METALS - QUALITY CONTROL

CLIENT : HYDRO GEO CHEM
PROJECT # : 37700
PROJECT NAME : HEX-CR

ATI I.D. : 212717

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RPD	SPIKED SAMPLE	SPIKE CONC	% REC
SILVER	MG/L	21271101	<0.010	<0.010	NA	0.481	0.500	96
ARSENIC	MG/L	21271101	0.006	0.006	NA	0.047	0.050	82
ARSENIC	MG/L	21274001	<0.005	<0.005	NA	0.046	0.050	92
BERYLLIUM	MG/L	21271704	<0.005	<0.005	NA	0.867	1.00	87
CADMIUM	MG/L	21271702	<0.0005	<0.0005	NA	MSA	CC=	.999
CHROMIUM	MG/L	21271101	<0.010	<0.010	NA	0.993	1.00	99
COPPER	MG/L	21271101	0.016	0.011	37	0.496	0.500	96
MERCURY	MG/L	21270202	<0.0002	<0.0002	NA	0.0051	0.0050	102
NICKEL	MG/L	21271101	0.144	0.151	5	1.15	1.00	101
LEAD	MG/L	21271101	<0.002	<0.002	NA	0.036	0.050	72
ANTIMONY	MG/L	21271704	<0.05	<0.05	NA	1.02	1.00	102
SELENIUM	MG/L	21271101	<0.005	<0.005	NA	0.038	0.050	76
SELENIUM	MG/L	21283401	<0.005	<0.005	NA	MSA	CC=	.998
THALLIUM	MG/L	21270201	<0.005	<0.005	NA	MSA	CC=	.999
ZINC	MG/L	21271101	0.036	0.029	22	0.545	0.500	102

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

Analytical Technologies, Inc., Albuquerque, NM
San Diego • Phoenix • Seattle • Pensacola • Ft. Collins • Portland

CHAIN OF CUSTODY

DATE: 12/9/92 PAGE 1 OF 1

ATI LAB I.D. 21271

PLEASE FILL THIS FORM IN COMPLETELY. SHADED AREAS ARE FOR LAB USE ONLY.

PROJECT MANAGER:

COMPANY: HydroGeoChem
ADDRESS: 1430 W. 6th Av
Tucson AZ 85705
PHONE: 602-623-6981
FAX: 602-623-6984

BILL TO: Same as above
COMPANY:
ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	NUMBER OF CONTAINERS
FB-1-12992	12/9/92	10:45	Water	1	1
MW-1-12992	" "	11:00	" "	2	1
MW-3-12992	" "	12:15	" "	3	1
MW-2-12992	" "	13:30	Water	4	1

Analyses requested (Petroleum Hydrocarbons (418.1); (MOD 8015) Gas/Diesel; Diesel/Gasoline/BTXE/MTBE (MOD 8015/8020); BTXE/MTBE (8020); Chlorinated Hydrocarbons (601/8010); Aromatic Hydrocarbons (602/8020); SDWA Volatiles (502.1/503.1), 502.2 Reg. & Unreg.; Pesticides/PCB (608/8080); Herbicides (615/8150); Base/Neutral/Acid Compounds GC/MS (625/8270); Volatile Organics GC/MS (624/8240); Polynuclear Aromatics (610/8310); SDWA Primary Standards - Arizona; SDWA Secondary Standards - Arizona; SDWA Primary Standards - Federal; SDWA Secondary Standards - Federal; The 13 Priority Pollutant Metals; RCRA Metals by Total Digestion; RCRA Metals by TCLP (1311)):
- FB-1-12992: The 13 Priority Pollutant Metals
- MW-1-12992: The 13 Priority Pollutant Metals
- MW-3-12992: The 13 Priority Pollutant Metals
- MW-2-12992: The 13 Priority Pollutant Metals

PROJECT INFORMATION

PROJ. NO.: 37700
PROJ. NAME: Hex-Cr
P.O. NO.: 37700
SHIPPED VIA:

SAMPLE RECEIPT

NO. CONTAINERS: 4
CUSTODY SEALS: (Y) N / NA
RECEIVED INTACT: Y
RECEIVED COLD: Y

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

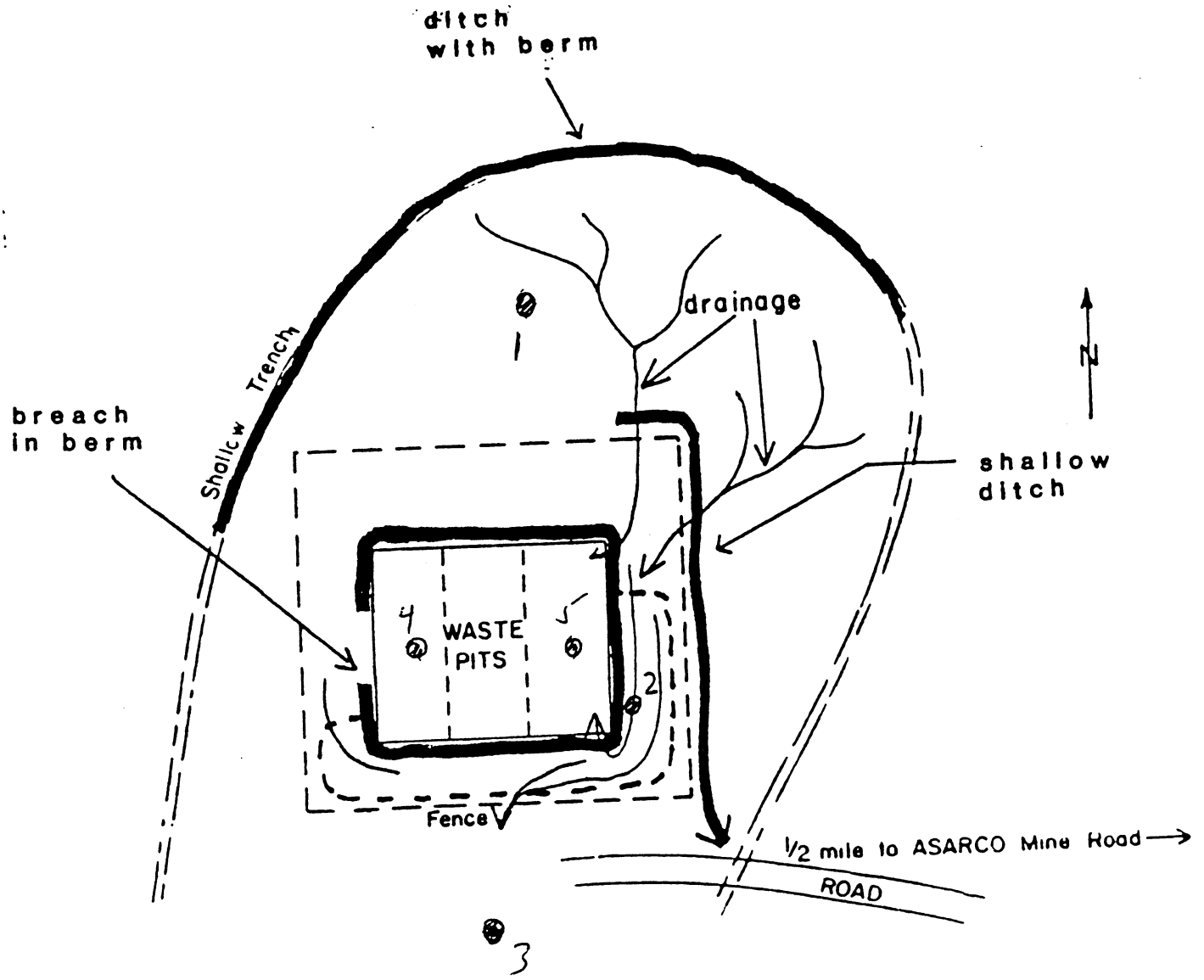
(RUSH) ☐ 24hr ☐ 48hr ☐ 72hr ☐ 1 WEEK (NORMAL) ☒ 2 WEEK

Comments:

SAMPLED & RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature: Time: 1800	Signature: Time:	Signature: Time:
Printed Name: Alex Yannakakis Date: 12/9/92	Printed Name: Date:	Printed Name: Date:
Company: HydroGeoChem Phone: 623-6981	Company:	Company:

RECEIVED BY: 1.	RECEIVED BY: 2.	RECEIVED BY: (LAB) 3.
Signature: Time:	Signature: Time:	Signature: Time: 1120
Printed Name: Date:	Printed Name: Date:	Printed Name: Date: Received
Company:	Company:	Analytical Technologies, Inc. 12/10/92

ATI Labs: San Diego (619) 458-9141 • Phoenix (602) 496-4400 • Seattle (206) 228-8335 • Pensacola (904) 474-1001 • Portland (503) 684-0447 • Albuquerque (505) 344-3777 DISTRIBUTION: White, Canary - ATI • Pink - ORIGINATOR



SCALE: 1 inch = approx. 50 feet

FIGURE 1: SKETCH OF WASTE SITE AREA

AGRICULTURE
CHEMICAL ANALYSIS
PETROLEUM

BC LABORATORIES INC.

J. J. EGLIN, REG. CHEM. ENGR.
3016 UNION AVE. BAKERSFIELD, CALIFORNIA 93305 PHONE 324-1815
MAIN OFFICE: 4100 PIERCE ROAD, BAKERSFIELD, CA. 93308 PHONE 327-4911

Hydro Geo Chem Inc.
744 North Country Club
Tucson, Arizona 85716

Attention: Seth Gifford

Date Reported: 9-17-82
Date Received: 8-31-82
Laboratory No.: 9834-9837,9839-98(
9845-9848,9850,9852,9854,9856,985(
9860

Sample Descriptions		Total Chromium Parts/million (as received)
#1 -	Sample #1 IN-1	5.17
#2 -	Sample #2 IN-5	4.51
#3 -	Sample #3 IN-10	4.20
#4 -	Sample #4 IN-15	3.91
#5 -	Sample #6 2S-1	9.20
#6 -	Sample #7 2S-4	4.56
#7 -	Sample #8 2S-8	5.17
#8 -	Sample #9 2S-12	4.97
#9 -	Sample #10 2S-15.5	5.52
#10-	Sample #12 3E-S	5.98
#11-	Sample #13 3E-5	4.17
#12-	Sample #14 3E-10	4.58
#13-	Sample #15 3E-15	4.80
#14-	Sample #17 4PW-S	1,166.
#15-	Sample #19 4PW-8	2,760.
#16-	Sample #21 4PW-15.5	77.9
#17-	Sample #23 5PE-S	172.
#18-	Sample #25 5PE-8	3,070.
#19-	Sample #27 5PE-15.5	216.

Note: All Total Chromium values reported in parts per million on an as received basis.
Sample was digested in nitric acid and filtered. Filtrate analyzed for Chromium by atomic absorption.

B C LABORATORIES, INC.

BY J. J. Eglin
J. J. Eglin

rs

Table 3: Chromium content in samples

AGRICULTURE
MICAL ANALYSIS
PETROLEUM

BC LABORATORIES INC

J. J. EGLIN, BIO CHEM ENGR
3016 UNION AVE BAKERSFIELD, CALIFORNIA 93305 PHONE 324-1815
MAIN OFFICE 4100 PIERCE ROAD, BAKERSFIELD CA 93308 PHONE 327-4911

Hydro Geo Chem, Inc.
744 North Country Club Road
Tucson, Arizona 85716

Date Reported: 2/23/83
Date Received: 2/15/83
Laboratory No.: 1634 - 1639

Sample Description:	Total Chromium	Moisture
#1 - 4PW 4' 8/4/82	14,900 ppm	9.94 %
#2 - 4PW 12' 8/4/82 12:34	527 ppm	7.13 %
#3 - 4PW 20' 8/4/82 13:00	6.36 ppm	5.01 %
#4 - 5PE 4' 8/4/82	5,100 ppm	14.80 %
#5 - 5PE 12' 8/4/82	682 ppm	10.84 %
#6 - 5PE 20' 8/4/82 14:15	305 ppm	7.56 %

Comment: All samples digested in Nitric Acid to solubilize Chromium Compounds. Values reported in ppm or as received basis. Moisture determined on separate aliquot of sample.

B C LABORATORIES, INC.

BY J. J. Eglin

kc

Table 3: Chromium content in samples (Cont.)

Rec'd 3/3/88

ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

March 2, 1988

Mr. Norm Weiss
Assistant Director
Arizona Department of Environmental Quality
2005 North Central Avenue
Phoenix, AZ 85004

Dear Mr. Weiss:

RE: Hexcel Chromium Disposal Site

This letter constitutes ASARCO's response to the Department as requested by Phil King at the February 25, 1988 meeting called by the Department about the above site.

ASARCO has thoroughly reviewed both the Department's files and ASARCO's own records to determine whether ASARCO has ever used the Hexcel site. The relevant facts as understood by ASARCO are set forth in my February 22 letter to you, and I will not repeat them here at length. Our conclusion, based on our review of the facts, is that ASARCO's only tie to the site is the fact that the site was included within an area leased by ASARCO from the State Land Department between the years 1972 and 1987. ASARCO never associated itself with the disposal or release of any hazardous substances on or from the site.

Under these circumstances, ASARCO is not liable for any release or threatened release related to the site. Under A.R.S. § 49-283(A)(1), only the "owner" or "operator" of a facility at which a release has occurred or is threatened is liable for remedial action costs. ASARCO is neither an owner nor an operator of the site. It has never owned the site. ASARCO has never been the operator of the site because it has never disposed of hazardous substances at the site, managed the site as a disposal facility or done anything else with

the site. Further, ASARCO did not own or operate the site at any of the critical times described in A.R.S §49-283(A)(1). ASARCO first acquired its leasehold interest in the site after the disposal and release of hazardous substances on or from the site.

To the extent that ASARCO is deemed a former "owner" of the site under the definition of "owner" contained in the Department's rules, A.C.R.R. R18-7-102(7), ASARCO is also entitled to the defenses contained in §49-283(B). Under that subsection, ASARCO is not liable because ASARCO:

1. never engaged in the business of generating, transporting, storing, treating or disposing of a hazardous substance or other waste at the site nor knowingly permitted others to engage in such a business at the site;

2. has never permitted any person to use the site for disposal of a hazardous substance;

3. did not know that a hazardous substance was located on the site when ASARCO first acquired its interest in the site and has not engaged in any conduct by which ASARCO has associated itself with any release; and,

4. has never taken any action which significantly contributed to any release after ASARCO knew or should have known that a hazardous substance was located in or on the site.

These defenses also immunize ASARCO from any remedial action order issued by the Department, because an order may only be issued to a responsible party as defined by statute.

ASARCO understands that Hexcel Corporation, which admits disposing of the chromic acid waste at the site, will be proposing a plan under which Hexcel will voluntarily investigate and remediate the site. ASARCO applauds Hexcel's willingness to shoulder its responsibilities and urges the Department to accept any reasonable remedial investigation alternatives proposed by Hexcel that will adequately protect the environment at a lower cost than the Department's proposal.

ASARCO does not intend to participate in this investigation because ASARCO believes that Hexcel and the State Land Department are solely responsible for the site. ASARCO,

however, remains perfectly willing to cooperate with the Department, Hexcel and the State Land Department in any reasonable manner so that the investigation and remediation of the Hexcel site may be accomplished quickly and easily.

Very truly yours,

T. E. Scartaccini

T. E. Scartaccini
General Manager
Southwestern Mining Department
ASARCO Incorporated

cc: Burton M. Apker, Esq.
James G. Derouin, Esq.
Mr. Simon Navarro
James L. Woods, Esq.
Jeffrey C. Zimmerman, Esq.