REPORT 60620

FARO TAILINGS ABANDONMENT PLAN DEVELOPMENT PROGRAM 1989 PROGRESS REPORT ON THE TAILINGS COVERS TEST FACILITY

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REPORT 60620
FARO TAILINGS ABANDONMENT PLAN DEVELOPMENT PROGRAM
1989 PROGRESS REPORT ON THE TAILINGS COVERS TEST FACILITY

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1.0 INTRODUCTION

Curragh Resources Inc. initiated the Tailings Abandonment Plan Development Program (APDP) for the Faro, Yukon, lead-zinc mine in 1987. A part of this four year program included testing the affects of various cover types on Faro tailings. The APDP is described in detail in Steffen Robertson and Kirsten Report 60602, 1986.

The tailings covers test facility was constructed during the summer of 1987. It is installed in the oldest of Faro's three tailings impoundment areas at the location shown on Figure 1-1, (see page 3). It was designed to test the abilities of various cover materials in inhibiting acid generation in the tailing waste and in reducing the transport rate of leached contaminants through the tailings, and to investigate the factors controlling acid generation and contaminant transport.

Acid generation is a time-dependent process and controlled primarily by:

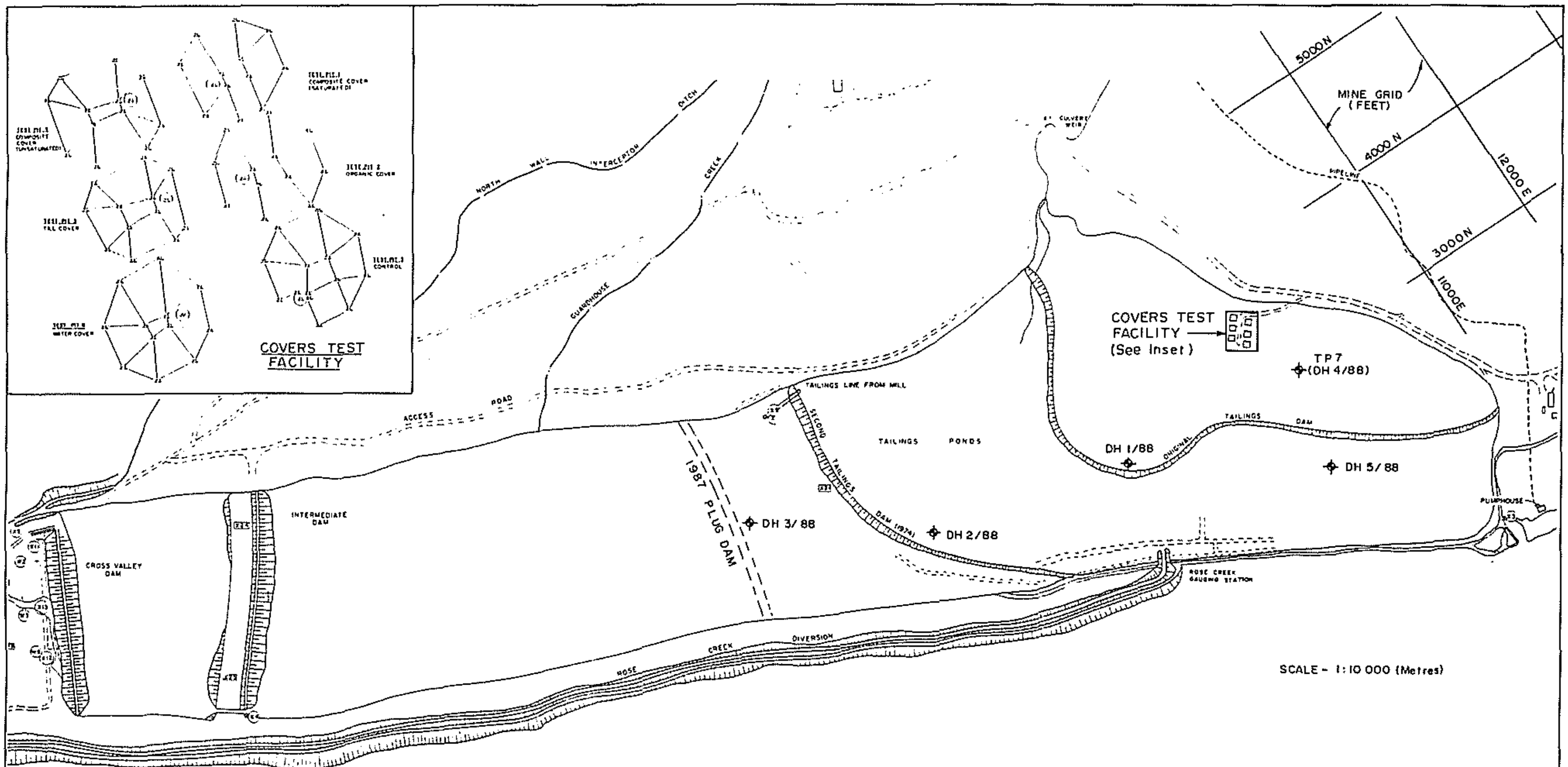
- the presence and nature of reactive sulphides
- the exposure of the reactive sulphides
- bacterial action
- temperature
- the availability of water
- the availability of oxygen (by convection and diffusion)
- pH or the presence of alkaline reactants

The cover test facility consists of six test pits. Tailings were deposited in the test pits in 1987. A site designated TP7 within the old tailings adjacent to the test plots is also instrumented and monitored (Drill hole DH4/88). Tailings were deposited in this impoundment area between 1969 and 1982. Five cover types are being investigated. These include: a shallow water cover; a till cover; a composite cover; a saturated composite cover; and an organic cover. One test pit acts as a control. Vertical profiles of the tailings and the covers in the test pits are shown schematically in Figure 1-2, (see page 4). The site within the old tailings provides comparative information on more mature tailings.

Prior to 1989, samples have been collected from the test pits during October, 1987 and September, 1988. Details of construction of the test facility and the baseline chemical composition of the tailings in the test pits are presented in the 1987 Progress Report (CRI, Apr. 1988). A summary of the 1988 maintenance work, and interim sampling and monitoring results are presented in the 1988 Progress Report (CRI, Oct. 1988).

In 1989, the pore water and tailings in the test pits were sampled during July and October. Cation and anion concentrations in the samples were determined in the B.C. Research laboratory. Temperature, oxygen, carbon dioxide, pH, Eh, conductivity, pore pressure, alkalinity, and acidity were measured in the field during each sampling period. Temperature profiles for each test pit were determined monthly. Oxygen/ carbon dioxide concentrations were measured in October, 1989. The 1989 chemical analyses results are discussed with reference to the results from 1987 and 1988. The discussion focuses on concentration changes in chemical parameters with depth within the test pits and with time.

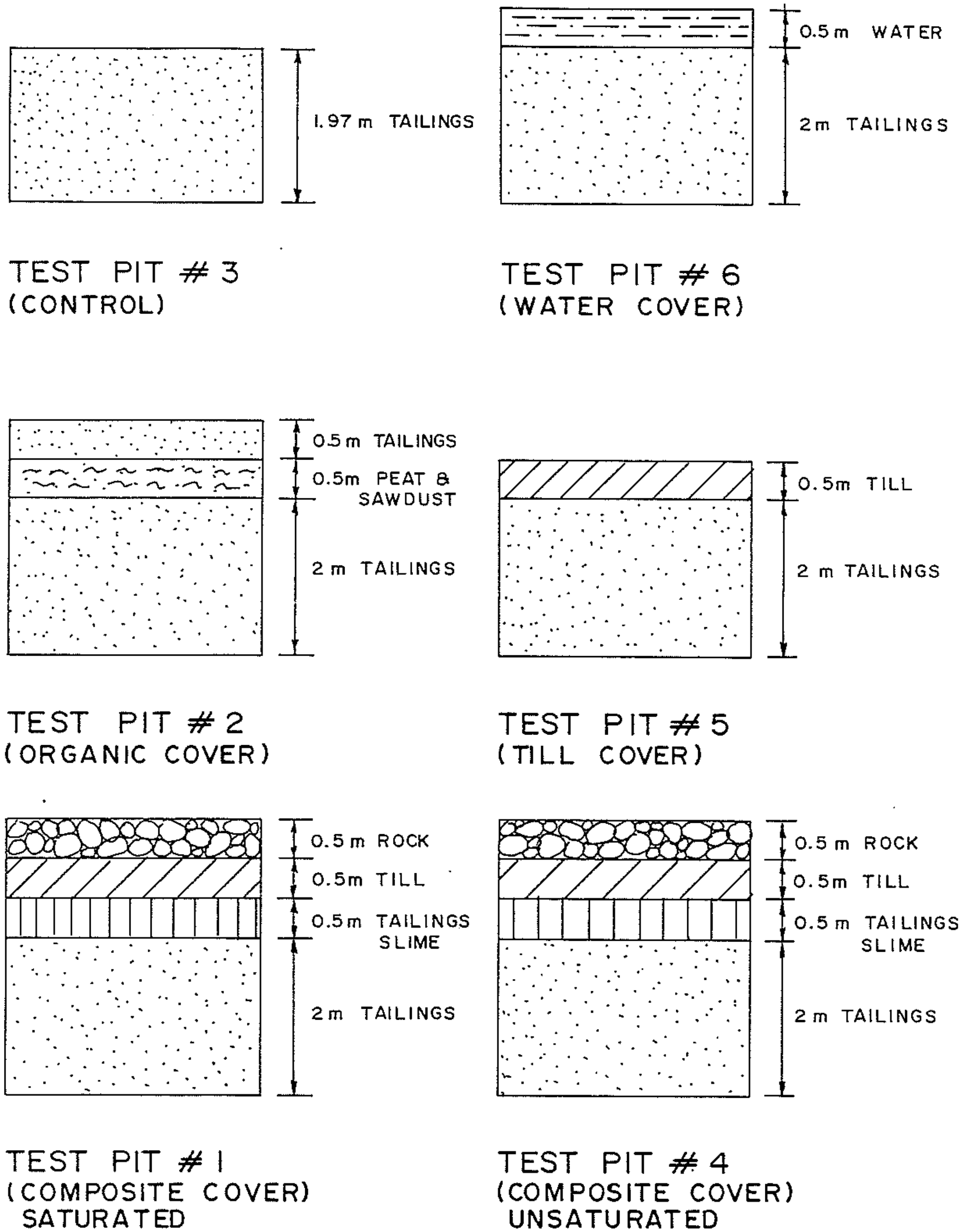
The sampling and monitoring of the test facility provided for in the Tailings Abandonment Plan Development Program will be concluded in 1990. Further annual monitoring is recommended to evaluate the long term performance of the covers. The present status of the covers test program is reviewed, and recommendations for the 1990 sampling and monitoring program are presented in this report.



LEGEND

DH 2/88 1988 DRILL HOLE (Approx. location)

CURRAGH RESOURCES — FARO MINE	DATE APRIL 1990
	PROJ. NO. 60620
TAILINGS TEST FACILITY FARO TAILINGS IMPOUNDMENT AREA	APPROVED
	NO. 1-1



CURRAGH RESOURCES – FARO MINE	DATE APRIL 1990
TAILINGS TEST FACILITY SCHEMATIC OF VERTICAL PROFILES OF TAILINGS AND COVERS IN TEST PITS	PROJ. NO. 60620 APPROVED NO. 1-2

2.0 METHODS AND PROCEDURES

2.1 Instrumentation Monitoring

Two types of instruments are installed in the test pits: thermistors and piezometers. In 1989, forty thermistors were monitored monthly, beginning in July. Temperature is read directly from each thermistor lead. Twenty pneumatic piezometers were monitored in July, September, October, and November, 1989 to determine pore water pressures.

2.2 Water Sampling

Water samples were collected from 27 air/ water samplers, 6 lysimeters, and 5 pit bottom drains in July, 1989. Water samples were collected from 13 air/ water samplers, 9 lysimeters, and 4 pit bottom drains in October, 1989.

Pore water was extracted from the air/ water samplers and the lysimeters using a variable speed peristaltic pump.

Temperature, pH, Eh, conductivity, and dissolved oxygen were measured on unfiltered sample water. Measurements were made at one minute intervals over a ten minute period or until the readings stabilized. A liquid filled combination pH electrode and a combination platinum electrode were used to determine pH and Eh, respectively. The pH electrode was calibrated using 4.0, 7.0 and 10.0 buffers maintained at tail water temperatures. The Eh electrode was checked regularly using Zobell's solution.

Alkalinity and acidity were measured immediately in the field by titration. Alkalinity and acidity were determined by titration with standardized H_2SO_4 and NaOH respectively. The titrations were completed immediately to limit the effects of iron oxidation and hydrogen ion generation.

After field measurements were completed, water samples were extracted and filtered through 0.45 micron millepore filters. Two samples from each air/ water sampler and lysimeter were collected in clean, acid washed plastic 250 milli-litre containers. Samples for cation analysis were acidified immediately to a pH of less than one using concentrated HCl. Both the acidified cation samples and the non-acidified anion samples were refrigerated to four degrees Celsius, and shipped to B.C. Research laboratory for chemical analysis.

Water samples were analyzed by B.C. Research for:

Acidified Samples

Silver	(Ag)	Potassium	(K)
Arsenic	(As)	Magnesium	(Mg)
Calcium	(Ca)	Manganese	(Mn)
Cadmium	(Cd)	Sodium	(Na)
Cobalt	(Co)	Nickel	(Ni)
Chromium	(Cr)	Lead	(Pb)
Copper	(Cu)	Selenium	(Se)
Iron	(Fe)	Zinc	(Zn)

Non-Acidified Samples

Chorine	(Cl)
Fluorine	(F)
Nitrates	(NO_{-3})
Sulphates	(SO_4^{-2})
Total Inorganic Carbon	
Laboratory pH	

2.3 Solids (Tailings) Sampling

In October, 1989, tailings samples were extracted from the uppermost of the sampling tubes installed in each test pit and submitted for laboratory analysis. A sample was collected from near the surface in each of four test pits. (Test Pit 2, 3, 5, and 6). A duplicate sample was collected from Test Pit 2. Sample extraction from Test Pit 1 and Test Pit 4 was not successful. Samples were extracted using a two inch diameter auger, and sample access was obtained through the horizontal PVC sampling pipes. Prior to auger insertion, the PVC pipes were flushed with nitrogen. After the sample was collected, the pipes were again flushed with nitrogen, and then sealed.

The five tailings samples were shipped to B.C. Research Laboratory. Samples were analyzed for metals, total sulphur, sulphate sulphur, and sulphide sulphur. Acid/ base accounting was also performed.

2.4 Oxygen/Carbon Dioxide Measurements

Oxygen and carbon dioxide concentrations in the unsaturated zone of the test tailings were measured in October, 1989 and February, 1990.

In October, 1989, 11 measurements were made from dry air/ water samplers in the test pits. Fourteen measurements were made from air sampler tubes installed at various depths in the old tailings area (TP7). Air sample collection and concentration measurement were made using a portable O_2/CO_2 gas analyzer.

3.0 RESULTS

In 1989 the samplers continued to function well. Over 90 percent of the air/ water samplers were operational during September, 1988 and July, 1989. In October, 1989, low water levels in the test pits affected the efficiency of the air/ water samplers; however, the units are still considered to be operational. Ten back-up lysimeters continue to operate as pore water samplers. Tailings samples were also successively extracted from the solid samplers in four test pits. Solid samples could not be extracted from the samplers in test pit 1 and test pit 4 PVC pipes appears to be plugged.

Of the instrumentation in the test facility, the thermistors have been the most dependable. Forty of the forty-three thermistors in the test pits were still operational in October, 1989. The pore pressures in the tailings are at, or near the resolution of the pressure read-out monitor and indicate that excess pore pressure have dissipated. The oxygen/ carbon dioxide analyzer also failed during 1989; however, this unit was repaired and working in October, 1989.

Chemical analysis of the pore water and tailings solids indicates that five of the six test pits are operating as planned. Test pit six, with the water cover, is not functioning properly. The seal between the instrument access tank and the test pit continues to leak despite repair efforts. The liner in the test pit may also leak. As a result, maintenance of the water cover has not been possible. Periodic loss of the water cover is considered to accelerate metals leaching from the tailings. Elevated zinc levels ranging from 10 to 51 milligrams per litre (mg/L) in the near surface pore water confirm this.

Selected results of the 1989 sampling programs are presented below. The 1987 and 1988 results are presented for comparison. Pore water and air sample results are presented in Sections 3.1 to 3.4. Solids (Tailings) sample results are presented in Section 3.5.

3.1 Temperature, pH, Alkalinity, Acidity, Inorganic Carbon, and Oxygen/ Carbon Dioxide

Temperature, pH, alkalinity, acidity, and oxygen/ carbon dioxide parameters were measured in the field. Pore water samples were sent to B.C. Research Laboratory and analyzed for concentrations of total inorganic carbon (TIC). Results are presented in Tables 3.1-1, 3.1-2 and 3.1-3, (see pages 9, 13 to 15, 19 and 20).

Temperature profiles within the test pits for each monitoring period since 1987 are shown graphically on Figure 3.1-1, (see pages 10 to 12). The pH profiles for each test pit are shown on Figure 3.1-2, (see pages 16 to 18). Oxygen and carbon dioxide concentration profiles are shown on Figure 3.1-3 and Figure 3.1.4, (see pages 21 to 25).

3.2 Calcium, Potassium, Sodium, Magnesium, and Manganese

Pore water samples were sent to B.C. Research Laboratory and analyzed for concentrations of calcium (Ca), potassium (K), sodium (Na), magnesium (Mg), and manganese (Mn). Results are presented in Table 3.2-1, (see page 26). Calcium concentration profiles are shown on Figure 3.2-1, (see pages 29 to 31).

3.3 Chlorine, Fluorine, Nitrates, and Sulphates

Pore water samples were sent to B.C. Research Laboratory and analyzed for concentrations of chlorine (Cl), fluorine (F), nitrates (HNO_3) and sulphates (SO^{2-}_4). Results are presented in Table 3.3-1, (see pages 32 to 34). Sulphate concentration profiles of each test pit are shown on Figure 3.3-1, (see pages 35 to 37).

3.4 Chromium, Copper, Iron, Nickel, Lead, and Zinc

Pore water samples were sent to B.C. Research Laboratory and analyzed for concentrations of chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), lead (Pb), and zinc (Zn). Results are presented in Table 3.4-1, (see pages 38 to 40). Zinc concentration profiles for each test pit are shown on Figure 3.4-1, (see page 41).

3.5 Solids (Tailings) Samples

The five tailings samples were sent to B.C. Research Laboratory and analyzed for metal and sulphur concentrations. Results are presented in Table 3.5-1, (see page 42). In 1987, during placement of the tailings into the test pits, samples were collected and sent to the laboratory for chemical analysis. Results of the 1987 baseline chemical composition of the tailings in the test pits are presented in Table 3.5-2, (see page 43) for comparison.

Acid/ base accounting was performed on the 1989 samples. Results from these tests, together with acid/ base accounting test results from tailings samples collected in 1987 are presented in Table 3.5-3, (see page 44).

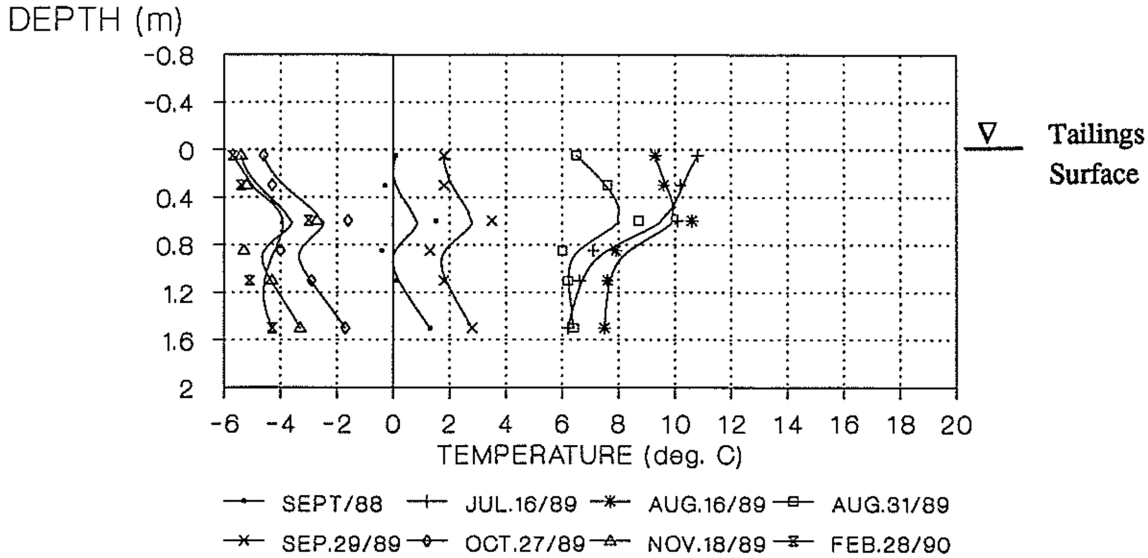
TABLE 3.1-1
TEMPERATURE PROFILES OF THE TAILINGS COVERS TEST PITS

NOTES	SENSOR	DEPTH (m)	SEPT. 1988	JUL.16 1989	AUG.16 1989	AUG.31 1989	SEP.29 1989	OCT.27 1989	NOV.18 1989	FEB.28 1990
TEST PIT ONE (TP1)	1.1	-0.60	0.8	6.2	5.6	6.2	0.1	-3.3	-4.5	-5.4
	1.2	-0.40	0.8	5.6	5.3	5.9	0.0	-3.6	-4.4	-5.6
ROCK (3.0 to 3.5 m)	1.3	-0.15								
TILL (2.5 to 3.0 m)	1.4	0.10	2.4	3.7	4.1	5.4	1.1	-1.9	-3.4	-5.0
SLIME (2.0 to 2.5 m)	1.5	0.30	2.5	2.4	3.0	4.5	0.9	-1.9	-3.4	-5.1
TAIL (0 to 2.0 m)	1.6	0.70	3.1	1.1	2.2	4.0	1.2	-1.4	-2.9	-5.0
	1.7	0.85	3.2	0.9	1.5	3.3	0.9	-1.3	-2.9	-5.1
	1.8	1.05	4.4	0.9	2.3	4.0	1.9	-0.1	-1.7	-3.9
	1.9	1.80	4.4	-1.3	0.4	2.7	1.4	0.0	-1.7	-4.0
TEST PIT TWO (TP2)	2.6	-0.40	0.7	5.4	7.1	6.2	1.7	-2.4	-3.6	-5.4
	2.5	-0.10	2.9	5.0	6.7	6.5	3.5	0.0	-1.4	-3.5
TILL (2.4 to 2.9 m)	2.4	0.25	3.3	2.7	5.2	4.8	2.6	-0.5	-1.9	-4.3
ORGANICS (1.9- 2.4 m)	2.3	0.80	3.9	3.4	5.6	5.8	4.2	1.5	0.0	-2.4
TAIL (0 to 1.9 m)	2.2	1.15	2.1	2.2	3.1	3.4	2.3	-0.1	-1.6	-4.1
	2.1	1.90	1.3	-0.2	2.0	2.1	0.9	-0.3	-1.6	-2.6
TEST PIT THREE (TP3)	3.6	0.05	0.1	10.8	9.3	6.5	1.8	-4.6	-5.4	-5.7
	3.5	0.30	-0.3	10.2	9.6	7.6	1.8	-4.3	-5.2	-5.4
TAIL (0 to 1.9 m)	3.4	0.60	1.5	10.1	10.6	8.7	3.5	-1.6	-2.7	-3.0
	3.3	0.85	-0.4	7.1	7.9	6.0	1.3	-4.0	-5.3	
	3.2	1.10	0.1	6.6	7.6	6.2	1.8	-2.9	-4.3	-5.1
	3.1	1.50	1.3	6.2	7.5	6.4	2.8	-1.7	-3.3	-4.3
TEST PIT FOUR (TP4)	4.9	-0.70	0.4		8.6	6.2		-4.5	-1.8	
	4.8	-0.50	1.4	7.3	8.7	7.4		-2.8	-4.1	
ROCK (3.0 to 3.5 m)	4.7	-0.35		5.2	6.7	6.0		-2.8	-3.9	
TILL (2.5 to 3.0 m)	4.6	-0.15	1.7							
SLIME (2.0 to 2.5 m)	4.5	0.15	1.7	1.8	3.8	3.8		-2.2	-3.7	
TAIL (0 to 2.0 m)	4.4	0.45	4.0	1.5	3.9	4.4		0.1	-1.3	
	4.3	0.70	3.5	3.0	5.3	5.5		-0.5	-1.8	
	4.2	1.20	3.4		1.1	2.0		-0.4	-2.0	
	4.1	1.65	2.1	-3.1	-0.5	0.3		-0.9	-2.9	
TEST PIT FIVE (TP5)	5.6	0.00	2.5	11.8	12.8	10.8		-1.1	-1.8	-2.5
	5.5	0.35	-0.8	7.1	8.7	7.3		-4.3	-5.4	-6.5
TILL (2.0 to 2.5 m)	5.4	0.70	1.9	8.1	9.9	8.9		-1.4	-2.5	-3.9
TAIL (0 to 2.0 m)	5.3	0.90	0.8	6.0	8.1	7.3		-2.4	-3.7	-5.3
	5.2	1.55	2.0	5.4	7.7	7.4		-1.1	-2.5	-4.3
	5.1	2.00	0.5	2.0	6.4	6.1		-2.3	-3.6	-5.1
TEST PIT SIX (TP6)	6.6	-0.25	1.5	11.9	10.5	7.5		-4.4	-5.0	-4.7
	6.5	0.30	2.8	5.4	9.4	10.3		-3.5	-3.5	-4.6
WATER (1.8 to 2.3 m)	6.4	0.70	2.2	8.6	11.0	7.6		-3.1	-4.2	-6.4
TAIL (0 to 1.8 m)	6.3	1.00	1.2	6.5	7.7	6.1		-4.0	-5.2	-5.1
	6.2	1.40	3.2	7.4	8.7	7.4		-1.8	-3.1	-4.6
	6.1	1.80	2.1		9.8	7.3		-1.6	-3.0	-5.0
"OLD TAILS" SITE (#7)	7.1	0.30		14.8	16.1	12.0				
	7.2	0.60		10.8	13.1	10.5		0.2	-1.7	
	7.3	1.00		6.8	9.7	9.2		0.0	-1.7	
	7.4	1.50		10.4	13.8	11.8		-1.0	-2.7	
	7.5	2.00		8.1	5.9	6.0		-0.8	-2.5	
	7.6	2.50		4.4	6.5	5.7		0.9	-1.6	
	7.7	3.00		0.8	3.5	3.8		0.8	-0.7	
	7.8	3.50		-1.1	1.3	1.6		-0.1	-1.5	
	7.9	4.00		-2.6	-0.3	-0.1		-1.0	-2.2	

TAILINGS TEST FACILITY

TEST PIT THREE (TP3)

(CONTROL)



TAILINGS TEST FACILITY

TEST AREA SEVEN (TP7)

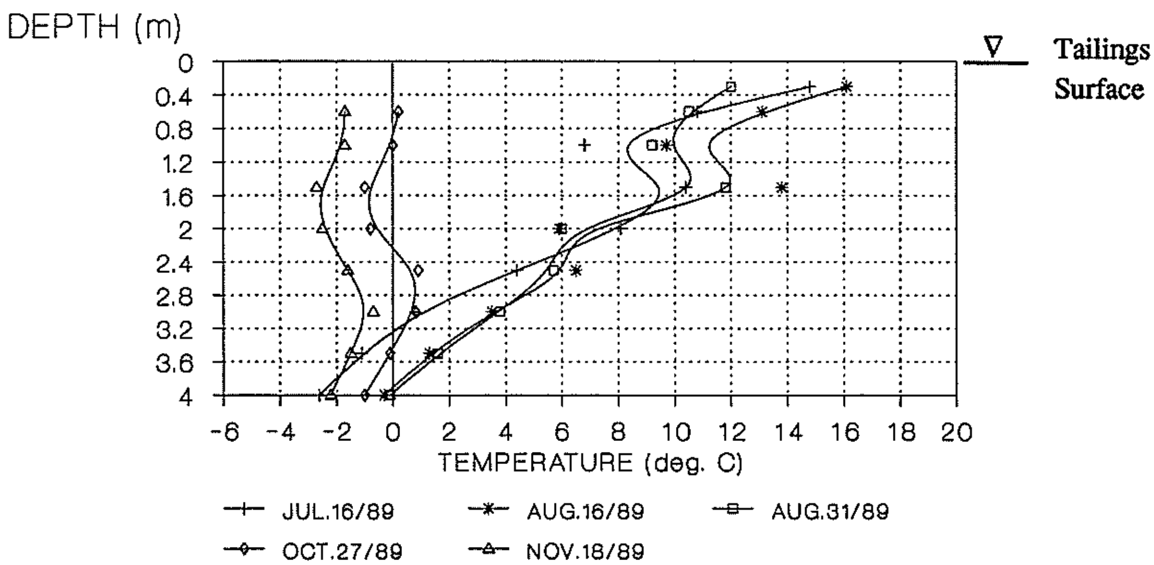
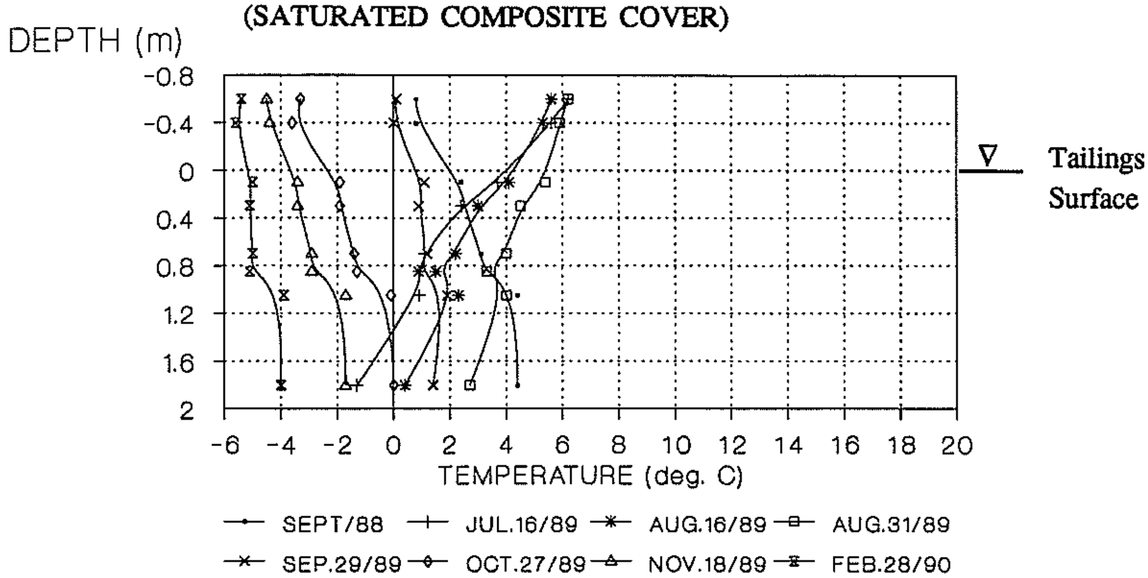


FIGURE 3.1-1 (Part A)

TAILINGS TEST FACILITY

TEST PIT ONE (TP1)

(SATURATED COMPOSITE COVER)



TAILINGS TEST FACILITY

TEST PIT FOUR (TP4)

(UNSATURATED COMPOSITE COVER)

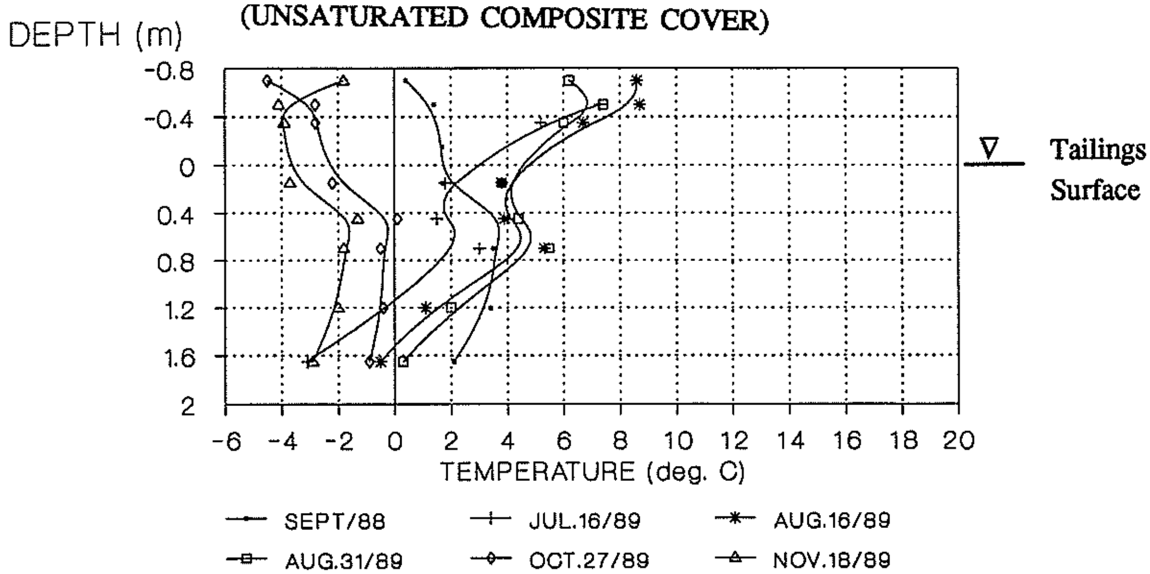
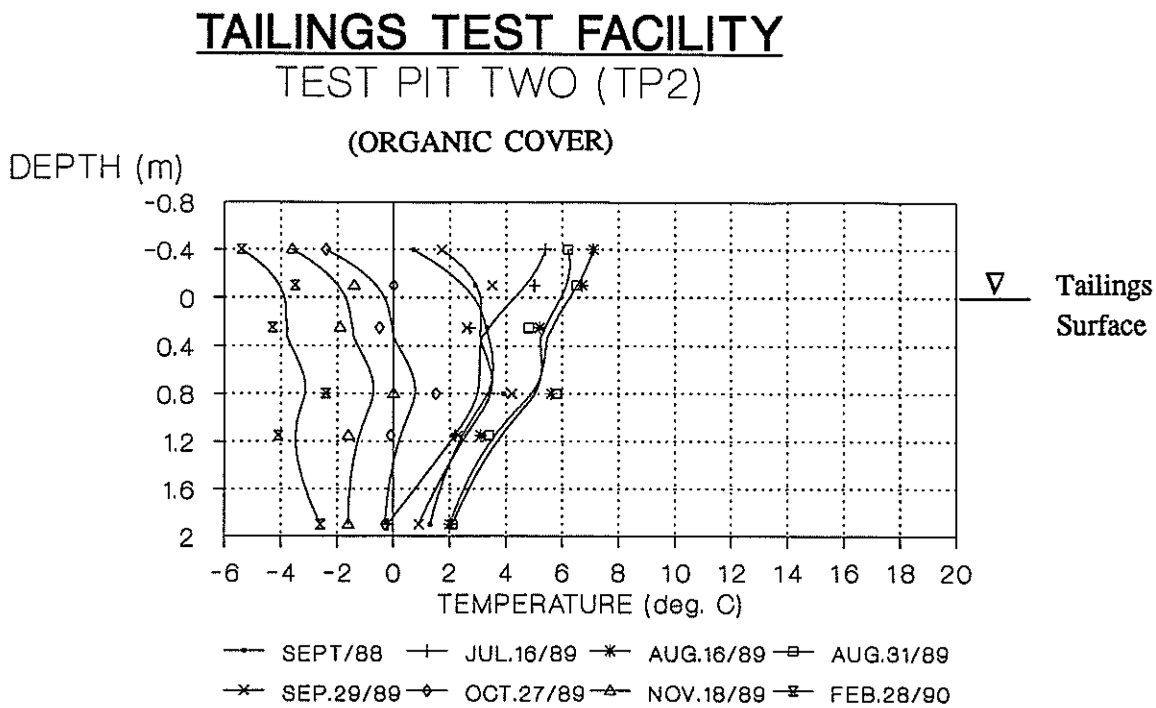


FIGURE 3.1-1 (Part B)



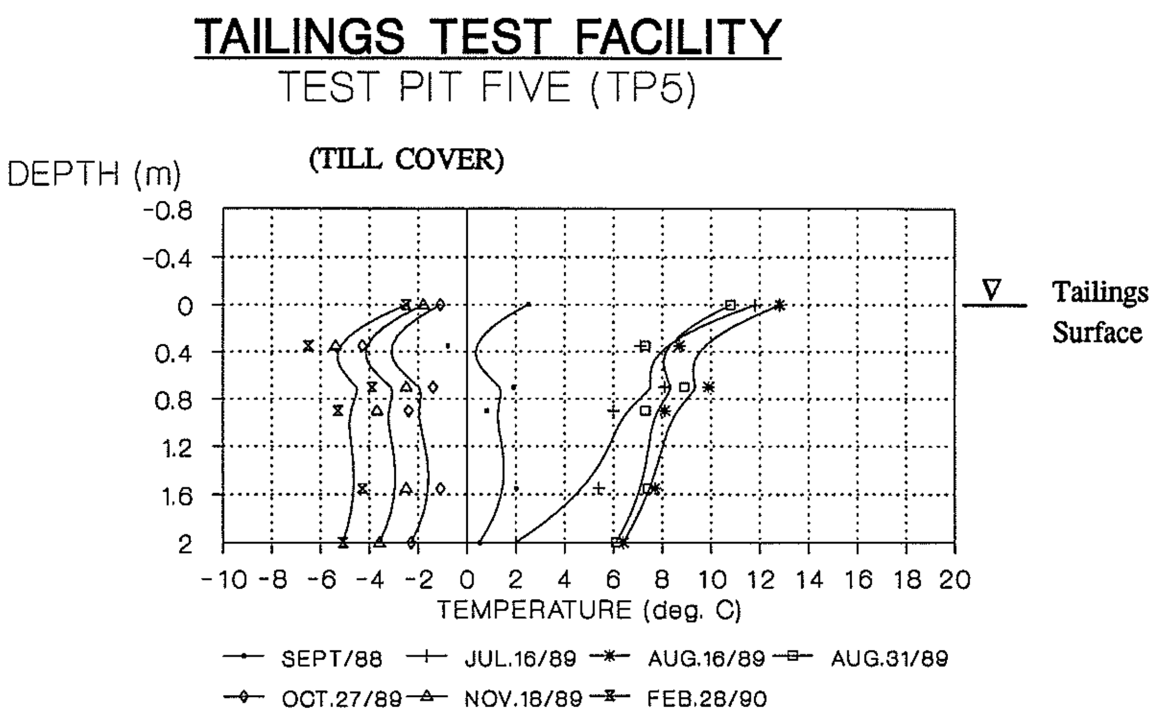


FIGURE 3.1-1 (Part C)

TABLE 3.1-2
pH, ALKALINITY, AND ACIDITY OF THE PORE WATER
TAILINGS TEST FACILITY

Sampler	Date	Depth (m)	pH	Alkalinity (mg/L)	Acidity (mg/L)
TEST PIT #1					
AW1-5	Oct-89	-0.10		DRY	DRY
L1-5	Oct-89	0.15			
AW1-6	Oct-89	0.20	6.95	56	8
AW1-4	Oct-89	0.50	6.94	56	8
L1-4	Oct-89	0.50			
L1-3	Oct-89	0.55			
L1-2	Oct-89	0.60			
AW1-3	Oct-89	0.65	6.75	22	8
AW1-2 DUP	Oct-89	0.75			
AW1-2	Oct-89	0.75	6.73	92	118
AW1-1	Oct-89	0.85	6.23	182	346
L1-1	Oct-89	0.95			
T1#PTRAP	Oct-89	2.00	5.80		
AW1-5	Jul-89	-0.10			
AW1-6	Jul-89	0.20	7.05	178	18
AW1-4	Jul-89	0.50	7.34	75	6
AW1-3	Jul-89	0.65			
AW1-2	Jul-89	0.75	6.74	45	43
AW1-1 DUP	Jul-89	0.85	6.65	321	244
AW1-1	Jul-89	0.85	6.83	339	203
L1-1	Jul-89	0.95			
AW1-4 DUP	Sep-88	0.50			
AW1-4	Sep-88	0.50	8.32		3
L1-3	Sep-88	0.55	7.38		
L1-2	Sep-88	0.60	6.87		
AW1-3	Sep-88	0.65	7.99	59	
AW1-2	Sep-88	0.75	8.83	83	5
AW1-1	Sep-88	0.85	7.47	114	127
L1-1	Sep-88	0.95	8.66		
T1#PTRAP	Sep-88	2.00	6.93	138	276
TEST PIT #2					
AW2-3	Oct-89	0.45	5.93	314	372
AW2-2	Oct-89	0.85	7.4	28	0
AW2-1	Oct-89	0.90	6.72	22	0
T2#PTRAP	Oct-89	2.00	6.70		
AW2-3	Jul-89	0.45	6.19	319	316
L2-3	Jul-89	0.50			
AW2-2	Jul-89	0.85	7.42	32	4
AW2-1	Jul-89	0.90	7.66	24	2
L2-1	Jul-89	0.90			
T2#PTRAP	Jul-89	2.00	6.60		
AW2-3	Sep-88	0.45	7.14	152	66
AW2-2	Sep-88	0.85	8.53	71	
AW2-1	Sep-88	0.90	9.05	45	2
T2#PTRAP	Sep-88	2.00	7.85	83	4

TABLE 3.1-2 Cont'd

pH, ALKALINITY, AND ACIDITY OF THE PORE WATER
TAILINGS TEST FACILITY

Sampler	Date	Depth (m)	pH	Alkalinity (mg/L)	Acidity (mg/L)
TEST PIT #3					
AW3-5	Jul-89	0.30	6.32	75	552
AW3-4	Jul-89	0.45	6.81	27	22
L3-3	Jul-89	0.55			
AW3-3	Jul-89	0.60	6.92	17	10
AW3-3 DUP	Jul-89	0.60	6.89	14	57
L3-1	Jul-89	0.90			
AW3-2	Jul-89	1.00			
AW3-1	Jul-89	1.25	6.81	100	45
T3#PTRAP	Jul-89	2.00	5.20		
AW3-5 DUP	Sep-88	0.30			
AW3-5	Sep-88	0.30	7.87	102	84
AW3-4	Sep-88	0.45	7.67	19	8
AW3-3	Sep-88	0.60	8.48	29	5
AW3-1	Sep-88	1.25	7.13	126	32
T3#PTRAP	Sep-88	2.00	8.1	45	1
TEST PIT #4					
AW4-6	Oct-89	-0.10	6.89	130	108
L4-6	Oct-89	0.00			
L4-5	Oct-89	0.05			
AW4-5	Oct-89	0.10	7.07	188	168
AW4-4	Oct-89	0.50	7.83	18	0
L4-4	Oct-89	0.55			
L4-3	Oct-89	0.65			
AW4-3	Oct-89	0.65	7.53	10	0
L4-2	Oct-89	0.70			
AW4-2	Oct-89	0.70	8.11	14	0
L4-1	Oct-89	0.95			
AW4-1	Oct-89	1.00	5.91	26	44
AW4-1 DUP	Oct-89	1.00			
T4#PTRAP	Oct-89	2.00	5.30		
AW4-6	Jul-89	-0.10	7.13	98	86
AW4-5	Jul-89	0.10	7.13	116	37
AW4-4	Jul-89	0.50	7.79	21	3
AW4-3	Jul-89	0.65	7.41	23	4
L4-3	Jul-89	0.65			
L4-2	Jul-89	0.70			
AW4-2 DUP	Jul-89	0.70	7.79	21	12
AW4-2	Jul-89	0.70	8.60	16	3
AW4-1	Jul-89	1.00	7.42	20	4
T4#PTRAP	Jul-89	2.00	6.00		
AW4-6	Sep-88	-0.10	8.24	148	109
AW4-5	Sep-88	0.10	8.13	221	85
AW4-4	Sep-88	0.50	7.28	43	5
AW4-3 DUP	Sep-88	0.65			
AW4-3	Sep-88	0.65	6.12	11	5
AW4-2	Sep-88	0.70	8.86	25	1
AW4-1	Sep-88	1.00	8.88		

TABLE 3.1-2 Cont'd

pH, ALKALINITY, AND ACIDITY OF THE PORE WATER
TAILINGS TEST FACILITY

Sampler	Date	Depth (m)	pH	Alkalinity (mg/L)	Acidity (mg/L)
AW4-1 DUP	Sep-88	1.00			
T4#PTRAP	Sep-88	2.00			
T4#PTRAP	Sep-88	2.00	6.8	124	250
TEST PIT #5					
AW5-6	Oct-89	0.50	7.92		
AW5-5	Oct-89	0.75 AW5-4		Oct-89	0.90
L5-1	Oct-89	1.00			
AW5-2	Oct-89	1.25	9.31	48	
AW5-1	Oct-89	1.30	9.82	54	
AW5-3 DUP	Oct-89	1.30			
AW5-3	Oct-89	1.30	9.67	44	
L5-5	Jul-89	0.35			
L5-4	Jul-89	0.50			
AW5-6	Jul-89	0.50	7.54	19	2
L5-3	Jul-89	0.70			
AW5-5	Jul-89	0.75	8.08	33	1
AW5-4	Jul-89	0.90	7.74	26	1
L5-1	Jul-89	1.00			
AW5-2 DUP	Jul-89	1.25	7.76	43	16
AW5-1	Jul-89	1.30	7.31	36	3
AW5-3 DUP	Jul-89	1.30	8.68	50	3
AW5-3	Jul-89	1.30	8.17	48	1
T5#PTRAP	Jul-89	2.00	7.30		
AW5-6	Sep-88	0.50	8.46	34	8
AW5-2 DUP	Sep-88	1.25			
AW5-2	Sep-88	1.25	9.41	60	
AW5-3	Sep-88	1.30	9.3	57	
AW5-1	Sep-88	1.30	9.41	54	
AW5-5		0.75	9.05		
AW5-4		0.90	9.05		
TEST PITS #6					
AW6-4	Oct-89	0.35			
AW6-3	Oct-89	0.50			
AW6-2	Oct-89	0.65	7.96	22	0
AW6-1	Oct-89	0.80			
T6#PTRAP	Oct-89	2.00	5.20		
AW6-4 DUP	Jul-89	0.35	6.30	106	626
AW6-4	Jul-89	0.35	6.32	98	720
AW6-3	Jul-89	0.50	6.66	73	85
AW6-3 DUP	Jul-89	0.50			
AW6-2	Jul-89	0.65	7.71	37	5
AW6-1	Jul-89	0.80	7.23	38	5
T6#PTRAP	Jul-89	2.00	5.70		
AW6-4	Sep-88	0.35	6.33	83	96
AW6-4 DUP	Sep-88	0.35			
AW6-3	Sep-88	0.50	7.49	104	87
AW6-2	Sep-88	0.65	8.83	30	3
AW6-1	Sep-88	0.80	8.8	63	1

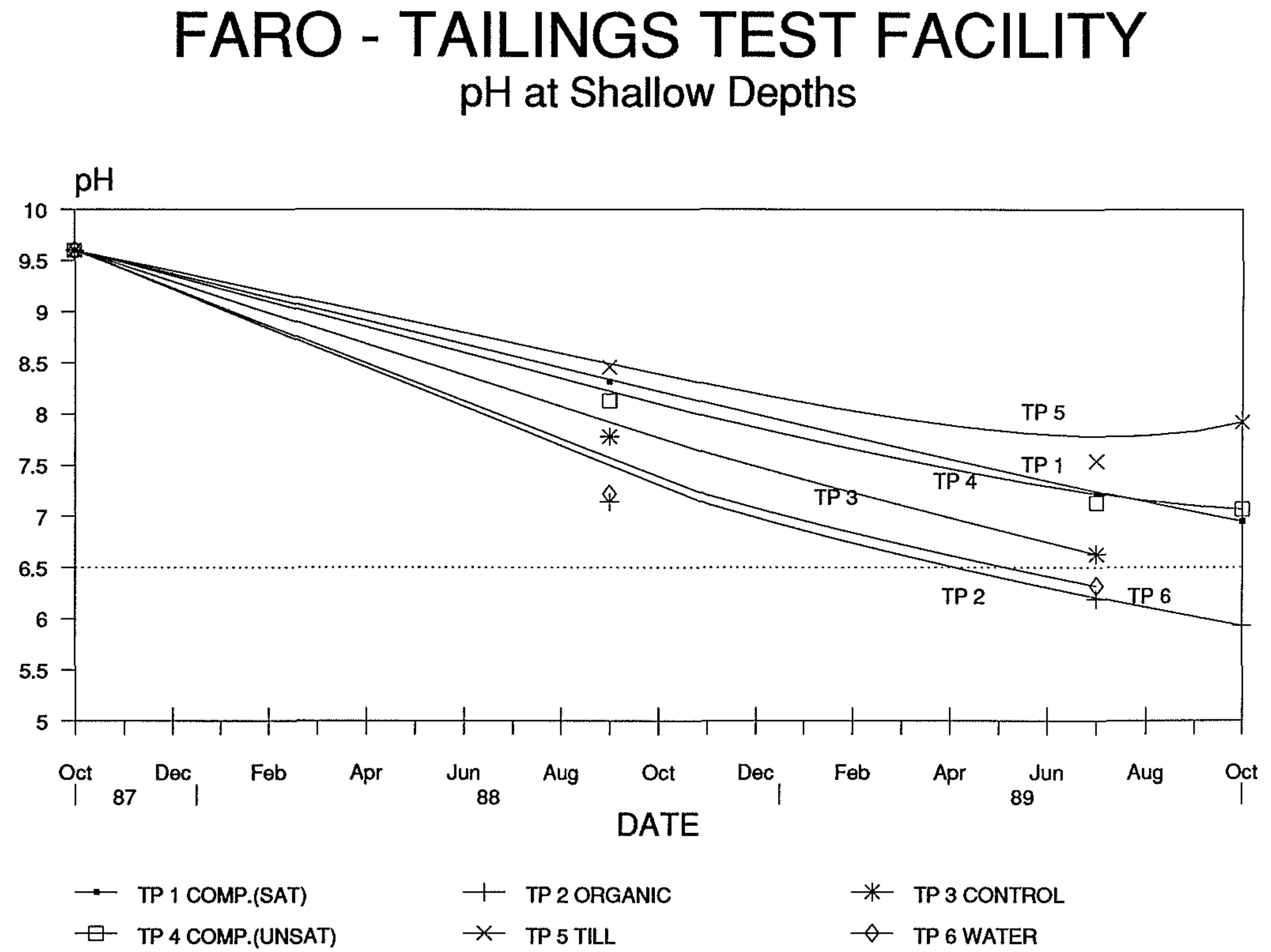


FIGURE 3.1-2: pH PROFILES (PART A)

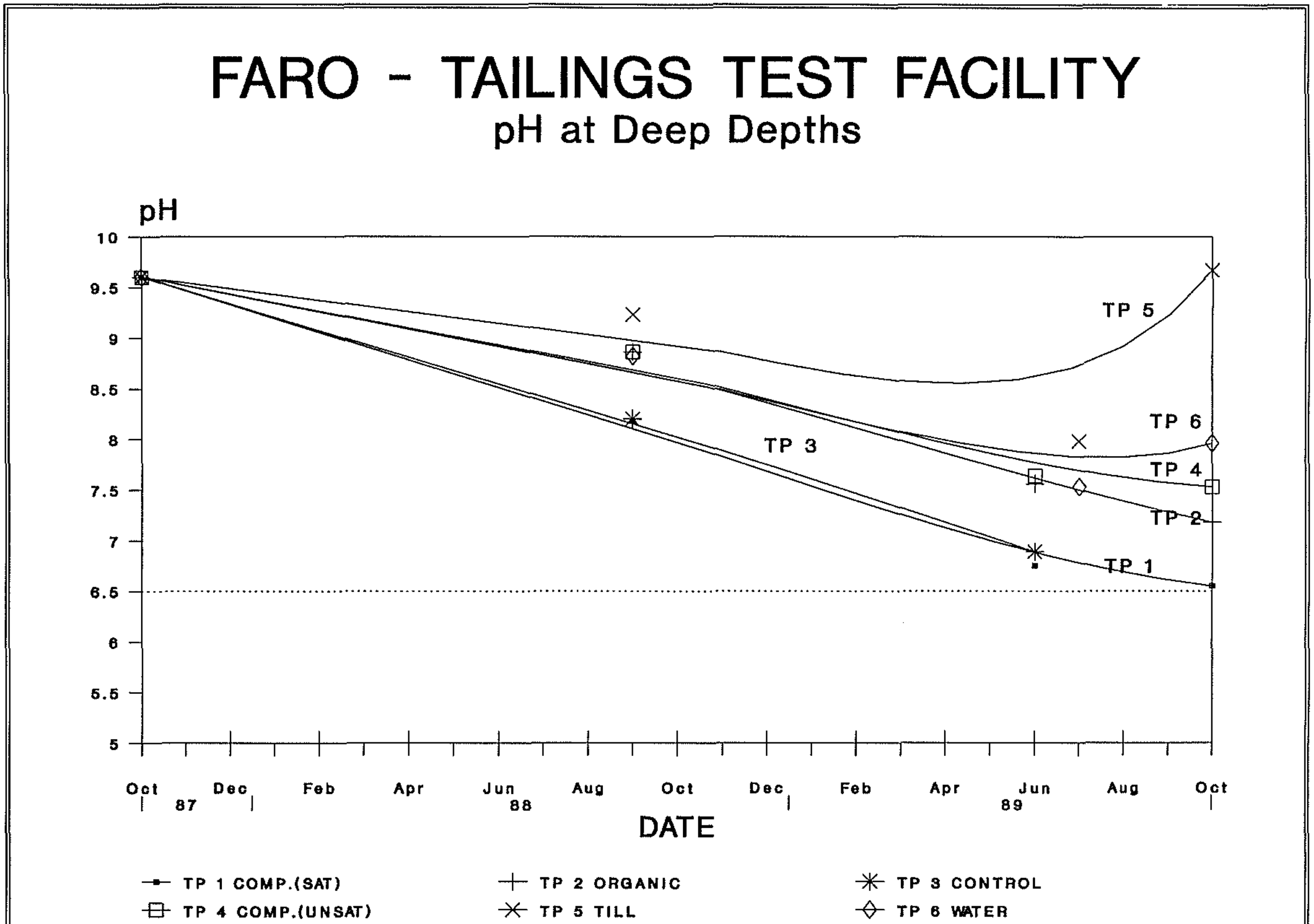


FIGURE 3.1-2: pH PROFILES (PART B)

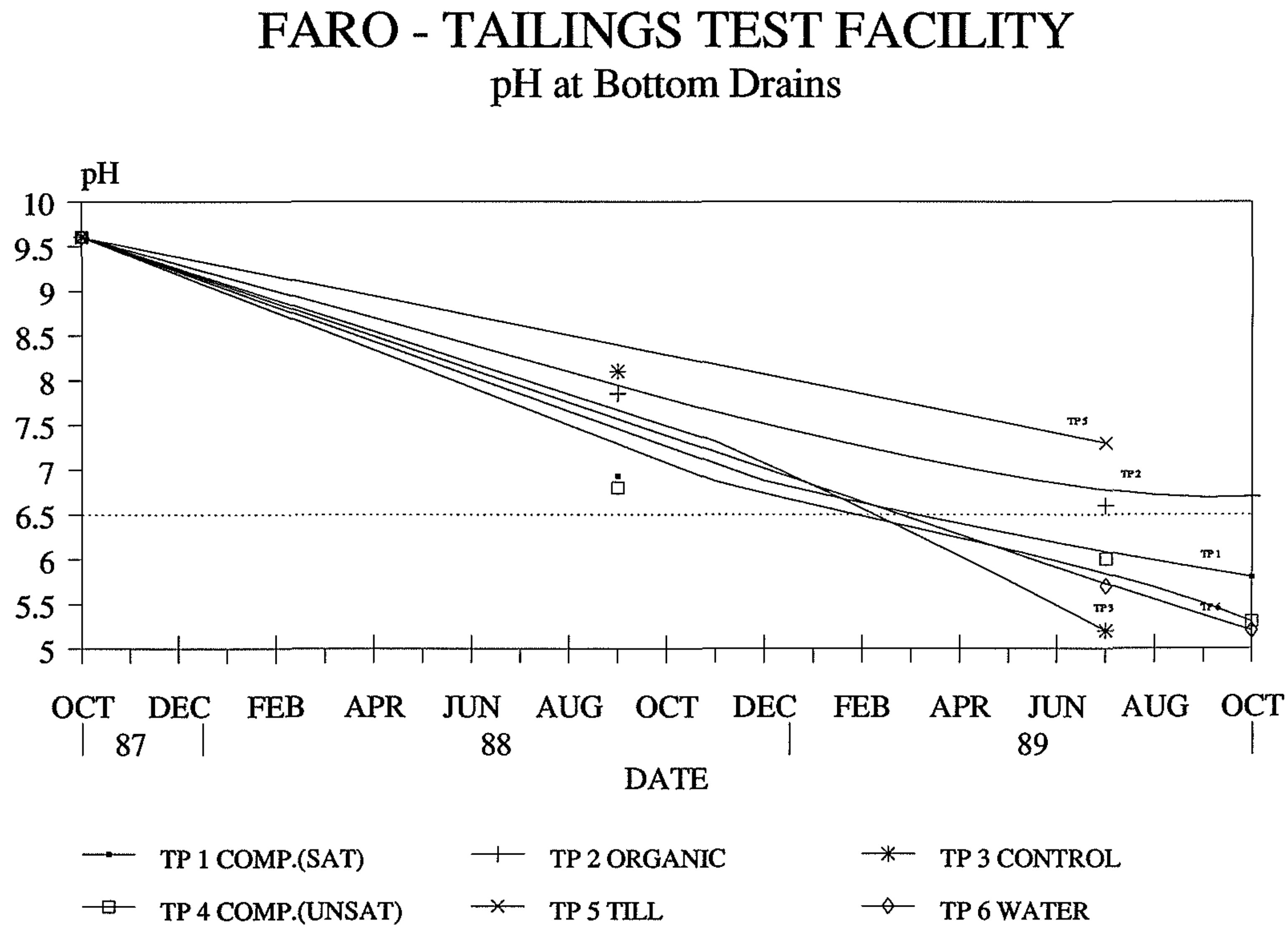


FIGURE 3.1-2: pH PROFILES (PART C)

TABLE 3.1-3
OXYGEN/CARBON DIOXIDE
CONCENTRATIONS IN THE TEST PIT

Sensor	Depth	CO_2 Oct 23/89	O_2 Oct 23/89	C_{02} Feb/90	O_2 Feb/90
TEST PIT #1					
AW 1-5	-0.10	160	20.7	169	19.7
AW 1-6	0.20	-	-	165	19.8
AW 1-4	0.50	-	-	155	19.8
AW 1-3	0.65	-	-	179	19.8
AW 1-2	0.75	-	-	177	19.9
AW 1-1	0.85	-	-	20.5	20.1
TEST PIT #2					
AW 2-3	0.45	-	-	140	19.7
AW 2-2	0.85	-	-	124	19.6
AW 2-1	0.90	-	-	180	19.6
TEST PIT #3					
AW 3-5	0.30	42	20.7	22	19.8
AW 3-4	0.45	50	20.7	18	19.8
AW 3-3	0.60	52	20.7	22	19.8
AW 3-2	1.00	53	20.7	22	19.8
AW 3-1	1.25	25	20.6	38	19.8
TEST PIT #4					
AW 4-6	-0.10	-	-	-	-
AW 4-5	0.10	-	-	-	-
AW 4-4	0.50	-	-	-	-
AW 4-3	0.65	-	-	-	-
AW 4-2	0.70	-	-	-	-
AW 4-1	1.00	-	-	-	-
TEST PIT #5					
AW 5-6	0.50	154	20.8	121	19.8
AW 5-5	0.75	138	20.7	95	19.9
AW 5-4	0.90			86	20.0
AW 5-2	1.20			109	20.4
AW 5-1	1.30			130	19.6
AW 5-3	1.30			98	20.1

TABLE 3.1-3 CONT'D
OXYGEN/CARBON DIOXIDE
CONCENTRATIONS IN THE TEST PIT

Sensor	Depth	CO_2 Oct 23/89	O_2 Oct 23/89	CO_2 Feb/90	O_2 Feb/90
TEST PIT #6					
AW 6-4	0.35	160	20.7	84	19.8
AW 6-3	0.50	125	20.7	116	19.7
AW 6-2	0.65	-	-	131	19.7
AW 6-1	0.80	141	20.7	125	19.7
TEST PIT #7					
7.10	0.00	88	20.8	58	20.4
7.20	0.30	71	20.6	50	20.2
7.30	0.60	81	20.4	51	20.0
7.40	0.90	67	20.1	47	19.9
7.50	1.20	61	19.9	47	19.8
7.60	1.50	59	19.7	70	19.7
7.70	1.80	80	19.6	52	19.7
7.80	2.10	61	19.6	50	19.6
7.90	2.40	58	19.6	52	19.6
7.10	2.70	659	19.6	48	19.5
7.11	3.00	51	19.7	42	19.5
7.12	3.30	64	19.7	39	19.4
7.13	3.60	41	19.7	24	19.5
7.14	3.90	38	19.7	25	19.5

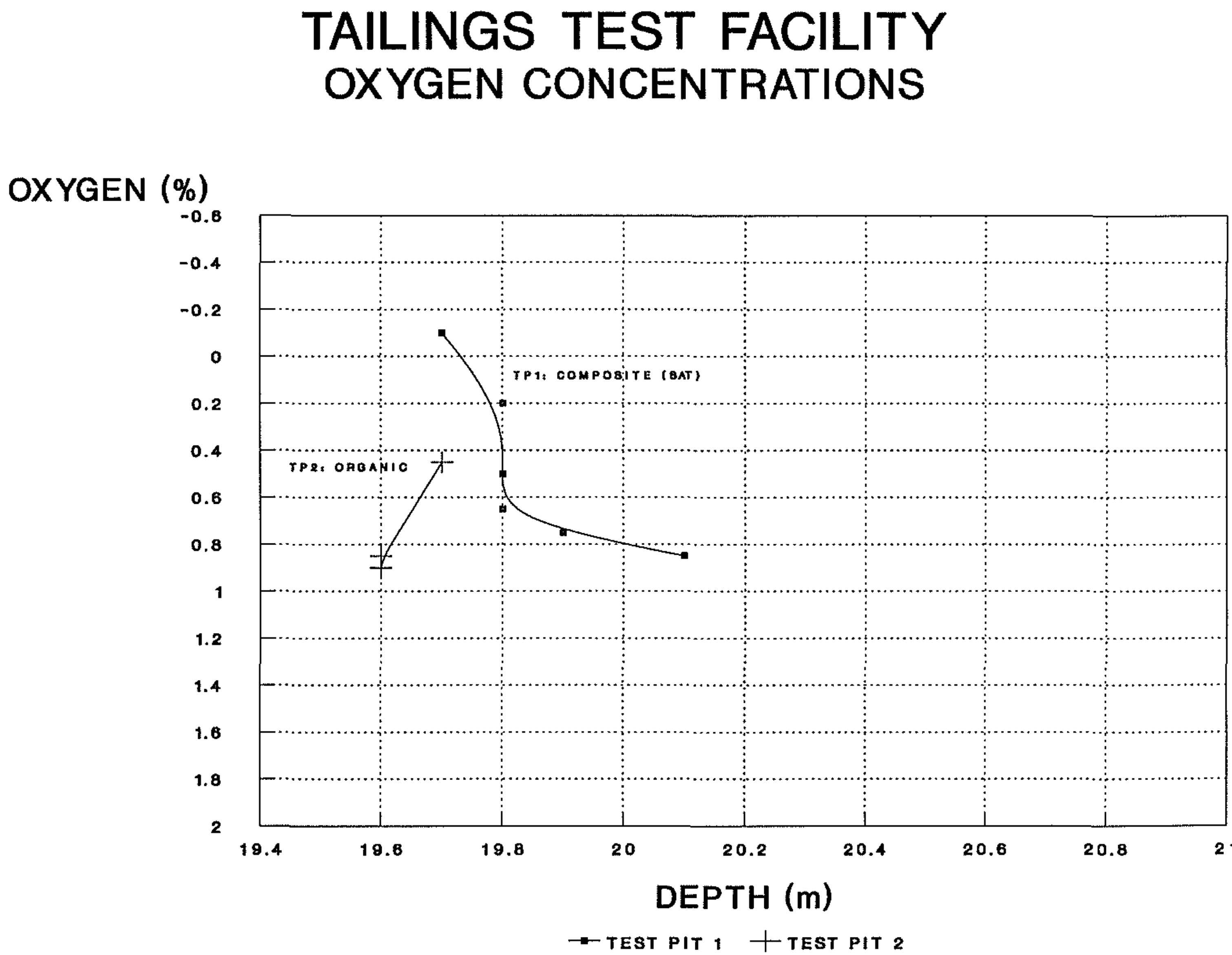


FIGURE 3.1-3: OXYGEN PROFILES (PART A)

TAILINGS TEST FACILITY
OXYGEN CONCENTRATIONS

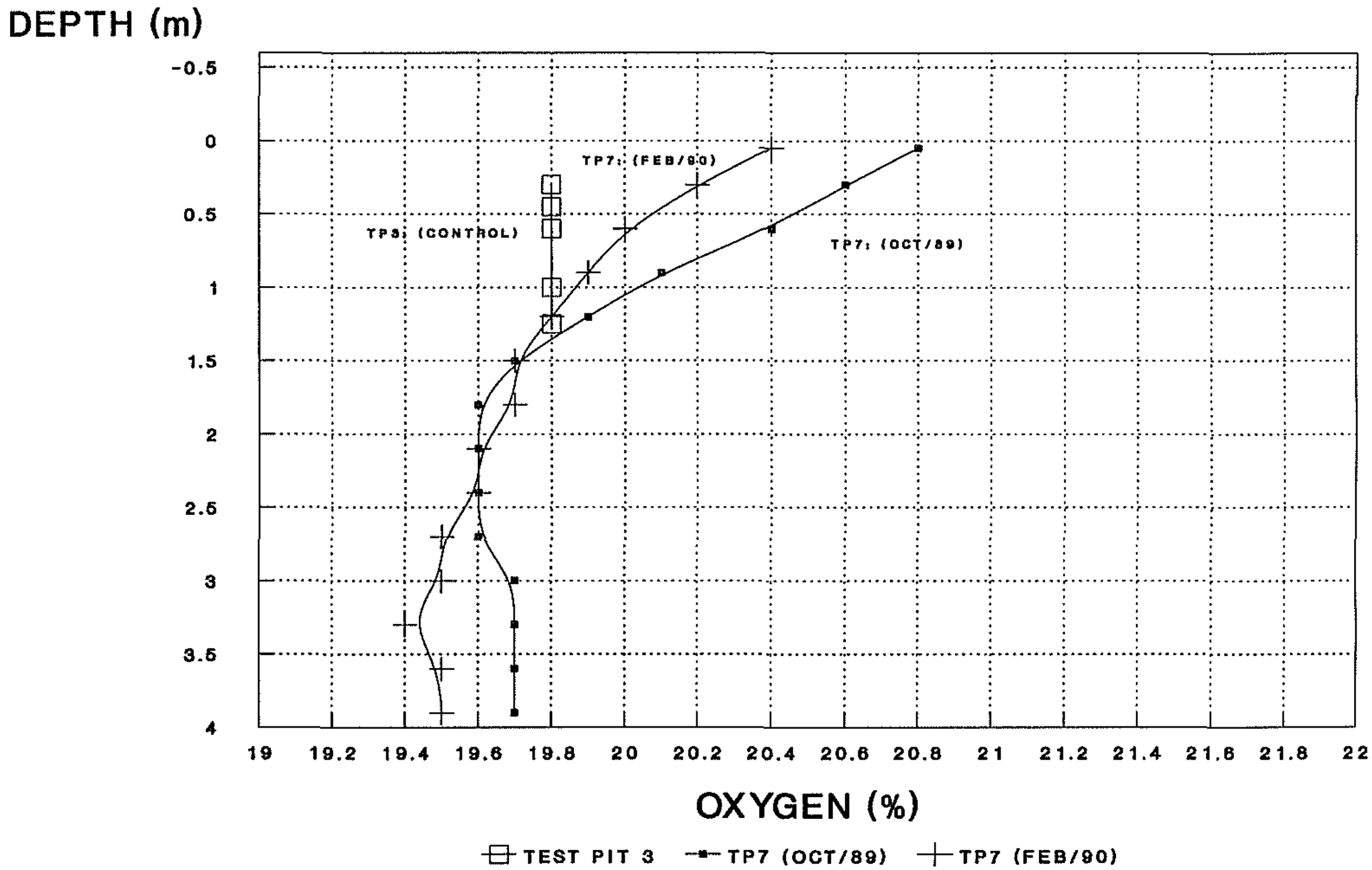


TABLE 3.1-3: OXYGEN PROFILES (PART B)

TAILINGS TEST FACILITY
OXYGEN CONCENTRATIONS

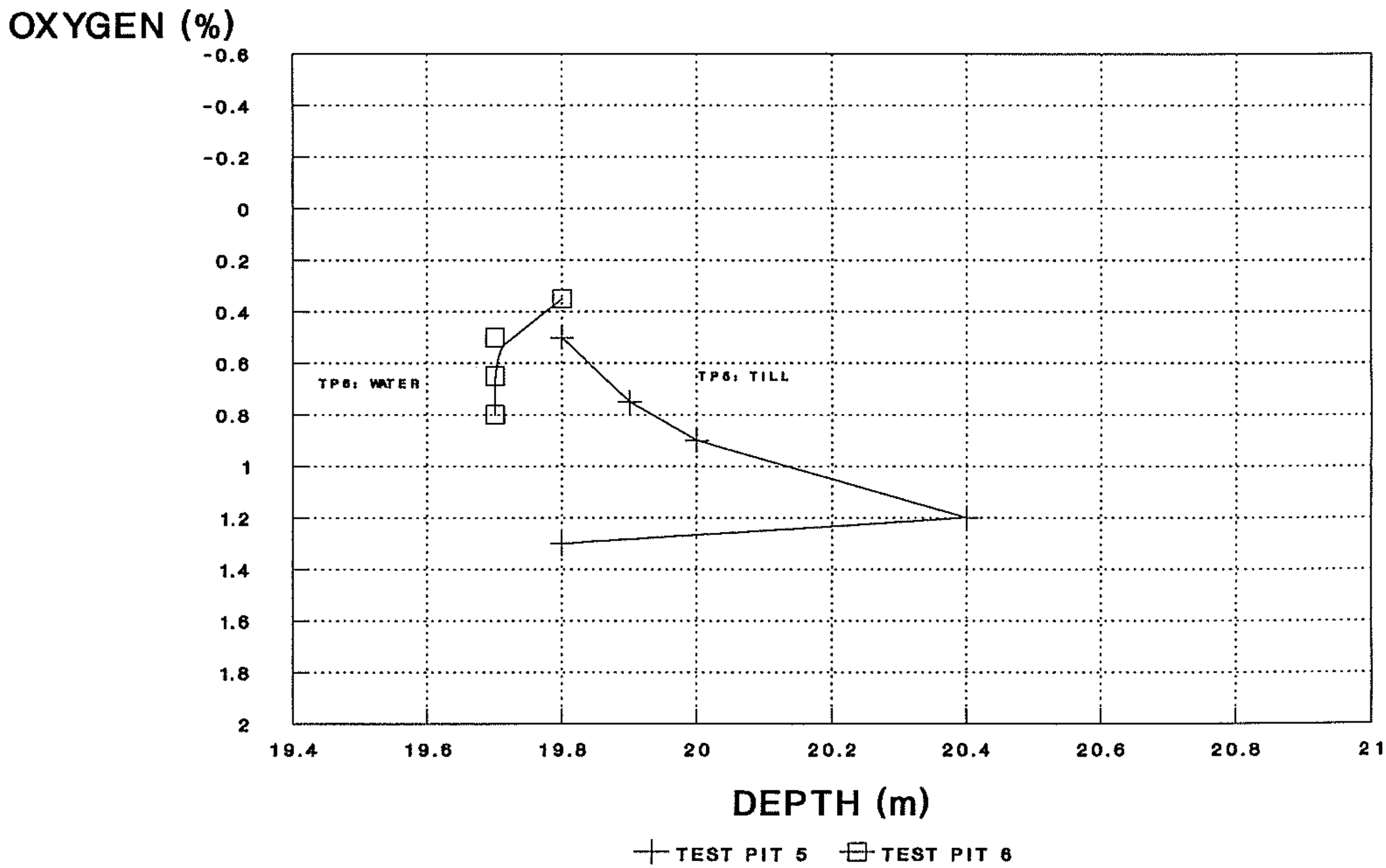


FIGURE 3.1-3: OXYGEN PROFILES (PART C)

TAILINGS TEST FACILITY
CARBON DIOXIDE CONCENTRATIONS

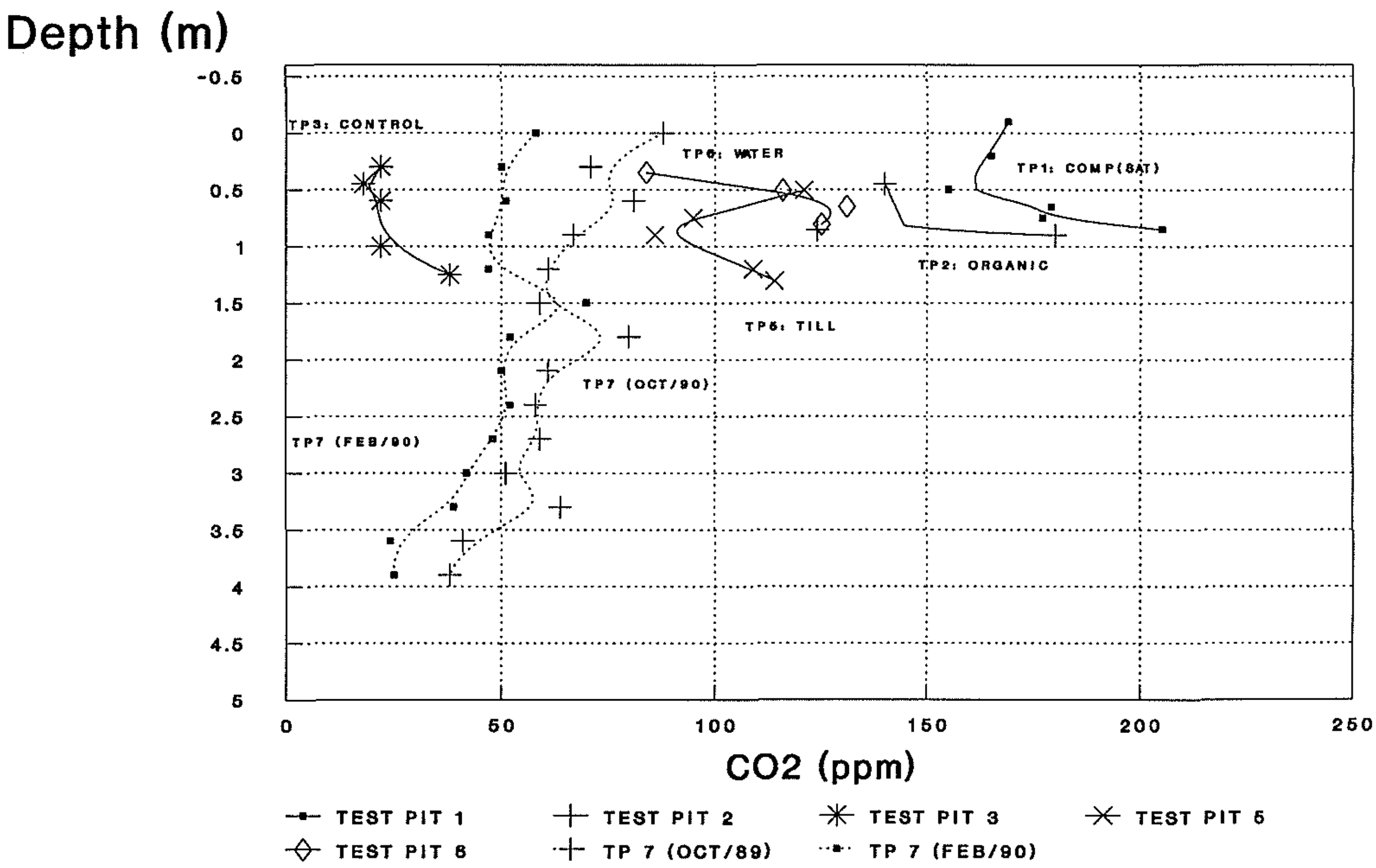


FIGURE 3.1-4: CO2 PROFILES (PART A)

TAILINGS TEST FACILITY
CARBON DIOXIDE CONCENTRATIONS

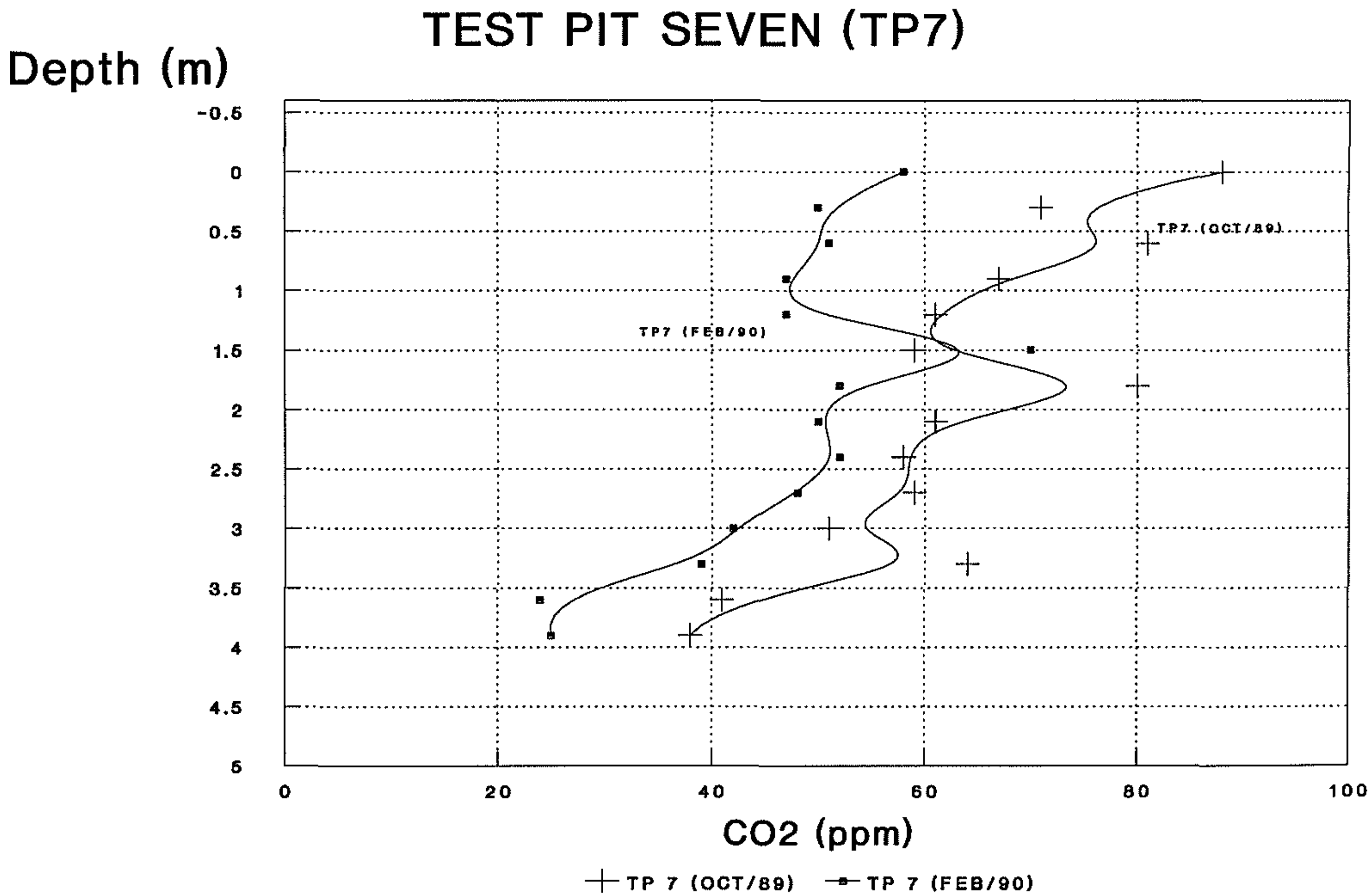


FIGURE 3.1-4: CO2 PROFILES (PART B)

TABLE 3.2-1 Page 1 of 3

CALCIUM, POTASSIUM, SODIUM, MAGNESIUM AND MANGANESE

Concentrations in the Pore Water (TAILINGS TEST FACILITY)

Sampler #	Date	Depth (m)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)
TEST PIT #1							
AW1-5	Oct-89	-0.10					
L1-5	Oct-89	0.15	250	16	71	8.90	310
AW1-6	Oct-89	0.20	140	11	16	1.09	280
AW1-4	Oct-89	0.50	320	14	40	4.60	280
L1-4	Oct-89	0.50					
L1-3	Oct-89	0.55					
L1-2	Oct-89	0.60					
AW1-3	Oct-89	0.65	490	25	100	3.10	250
AW1-2 DUP	Oct-89	0.75	340	14	61	0.77	280
AW1-2	Oct-89	0.75	350	13	63	0.53	270
AW1-1	Oct-89	0.85	360	14	62	1.71	300
L1-1	Oct-89	0.95	290	22	290	0.20	250
T1#PTRAP	Oct-89	2.00	320	14	86	2.70	230
AW1-5	Jul-89	-0.10					
AW1-6	Jul-89	0.20	155	11	20	0.96	1.22
AW1-4	Jul-89	0.50	442	15	43	5.3	1.28
AW1-3	Jul-89	0.65					
AW1-2	Jul-89	0.75	540	21	106	2.7	1.3
AW1-1 DUP	Jul-89	0.85	358	26	82	2.01	1.33
AW1-1	Jul-89	0.85	354	14	80	2.3	1.36
L1-1	Jul-89	0.95	199	22	50	0.35	10.2
AW1-4 DUP	Sep-88	0.50	620.0	20.0	115	4.40	240
AW1-4	Sep-88	0.50	620.0	20.0	120	4.40	250
L1-3	Sep-88	0.55	1020	44	530	1.62	220
L1-2	Sep-88	0.60	850	38	510	8.70	230
AW1-3	Sep-88	0.65	430.0	34.0	230	4.40	200
AW1-2	Sep-88	0.75	400.0	26.0	140	2.40	270
AW1-1	Sep-88	0.85	470.0	20.0	135	10.00	260
L1-1	Sep-88	0.95	36	14	10	0.02	210
T1#PTRAP	Sep-88	2.00	0	0	0	0.00	0
TEST PIT #2							
AW2-3	Oct-89	0.45	330	12	57	1.26	52
AW2-2	Oct-89	0.85	260	19	66	0.58	68
AW2-1	Oct-89	0.90	250	20	70	1.50	78
T2#PTRAP	Oct-89	2.00	200	23	97	1.35	140
AW2-3	Jul-89	0.45	234	11	42	1.27	7.2
L2-3	Jul-89	0.50					
AW2-2	Jul-89	0.85	520	22	176	1.18	12.4
AW2-1	Jul-89	0.90	168	19	58	1.7	10
L2-1	Jul-89	0.90	161	21	60	0.22	17.6
T2#PTRAP	Jul-89	2.00	9	20	81	0.97	15
AW2-3	Sep-88	0.45	320.0	16.0	86	5.00	130
AW2-2	Sep-88	0.85	52.0	12.0	16	0.82	140
AW2-1	Sep-88	0.90	12.0	8.0	2	0.20	120
T2#PTRAP	Sep-88	2.00	2.0	2.0	0	0.00	0

TABLE 3.2-1 Page 2 of 3

CALCIUM, POTASSIUM, SODIUM, MAGNESIUM AND MANGANESE

Concentrations in the Pore Water (TAILINGS TEST FACILITY)

Sampler #	Date	Depth (m)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)
TEST PIT #3							
AW3-5	Jul-89	0.30	600	13	206	10.8	6.6
AW3-4	Jul-89	0.45	500	12	148	7.5	7.4
L3-3	Jul-89	0.55	322	42	86	0.99	10.8
AW3-3	Jul-89	0.60	500	16	128	3.9	9.6
AW3-3 DUP	Jul-89	0.60	480	11	126	8.2	4.4
L3-1	Jul-89	0.90	364	24	144	1.48	14
AW3-2	Jul-89	1.00					
AW3-1	Jul-89	1.25	109	16	9	0.62	13.6
T3#PTRAP	Jul-89	2.00	254	21	87	5.3	9.6
AW3-5 DUP	Sep-88	0.30	370.0	10.0	86	6.20	88
AW3-5	Sep-88	0.30	350.0	12.0	82	6.20	80
AW3-4	Sep-88	0.45	390.0	14.0	84	5.00	88
AW3-3	Sep-88	0.60	310.0	16.0	62	2.20	80
AW3-1	Sep-88	1.25	180.0	10.0	16	0.82	98
T3#PTRAP	Sep-88	2.00	0	0	0	0.00	0
TEST PIT #4							
AW4-6	Oct-89	-0.10	350	14	63	0.86	330
L4-6	Oct-89	0.00	330	13	47	0.29	340
L4-5	Oct-89	0.05					
AW4-5	Oct-89	0.10	350	15	67	1.90	390
AW4-4	Oct-89	0.50	140	18	38	0.56	370
L4-4	Oct-89	0.55	160	19	46	0.40	350
L4-3	Oct-89	0.65	200	21	51	0.31	250
AW4-3	Oct-89	0.65	220	22	62	1.11	260
L4-2	Oct-89	0.70	160	26	38	0.16	240
AW4-2	Oct-89	0.70	250	25	93	1.14	190
L4-1	Oct-89	0.95	160	21	42	0.33	240
AW4-1	Oct-89	1.00	230	23	105	1.53	300
AW4-1 DUP	Oct-89	1.00	230	21	108	1.92	280
T4#PTRAP	Oct-89	2.00	326	12	84	4.50	250
AW4-6	Jul-89	-0.10	460	14	88	2.3	1.62
AW4-5	Jul-89	0.10	236	12	56	2.7	1.51
AW4-4	Jul-89	0.50	208	21	64	0.59	1.23
AW4-3	Jul-89	0.65	210	21	52	1.22	20
L4-3	Jul-89	0.65	0	0	0	0	0
L4-2	Jul-89	0.70	136	60	36	0	1.07
AW4-2 DUP	Jul-89	0.70	300	26	82	1.36	21
AW4-2	Jul-89	0.70	240	26	60	1.22	21.2
AW4-1	Jul-89	1.00	248	19	92	2.15	1.02
T4#PTRAP	Jul-89	2.00	312	7	58	3.3	12.8
AW4-6	Sep-88	-0.10	290.0	10.0	60	3.80	310
AW4-5	Sep-88	0.10	320.0	16.0	64	5.70	360
AW4-4	Sep-88	0.50	300.0	24.0	74	2.30	260
AW4-3 DUP	Sep-88	0.65	280.0	24.0	60	1.30	120
AW4-3	Sep-88	0.65	285.00	28.0	63	1.29	125
AW4-2	Sep-88	0.70	210.0	26.0	34	1.26	130
AW4-1	Sep-88	1.00	150.0	18.0	26	0.74	120
AW4-1 DUP	Sep-88	1.00	135.0	14.0	26	0.78	110
T4#PTRAP	Sep-88	2.00	0	0	0	0.00	0
T4#PTRAP	Sep-88	2.00	0	0	0	0.00	0

TABLE 3.2-1

CALCIUM, POTASSIUM, SODIUM, MAGNESIUM AND MANGANESE
Concentrations in the Pore Water (TAILINGS TEST FACILITY)

Sampler #	Date	Depth (m)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)
TEST PIT #5							
AW5-6	Oct-89	0.50	220	21	61	1.16	130
AW5-5	Oct-89	0.75					
AW5-4	Oct-89	0.90					
L5-1	Oct-89	1.00	190	23	65	0.09	170
AW5-2	Oct-89	1.25	6	13	1	0.00	140
AW5-1	Oct-89	1.30	8	11	2	0.05	120
AW5-3 DUP	Oct-89	1.30	10	16	3	0.03	150
AW5-3	Oct-89	1.30	8	15	1	0.01	150
L5-5	Jul-89	0.35	272	26	64	0.93	12
L5-4	Jul-89	0.50	82	28	26	0.24	15.8
AW5-6	Jul-89	0.50	308	26	88	1.23	10.6
L5-3	Jul-89	0.70	90	24	19	0.13	13.4
AW5-5	Jul-89	0.75	234	30	88	0.76	12
AW5-4	Jul-89	0.90	354	28	140	1.85	10.2
L5-1	Jul-89	1.00	234	28	98	0.29	13.8
AW5-2 DUP	Jul-89	1.25					
AW5-1	Jul-89	1.30	16	14	3	0.05	10.8
AW5-3 DUP	Jul-89	1.30	9	16	2	0.018	13
AW5-3	Jul-89	1.30	7	17	1	0.01	13
T5#PTRAP	Jul-89	2.00	312	7	56	3	12.2
AW5-6	Sep-88	0.50	64.0	18.0	8	0.28	105
AW5-2 DUP	Sep-88	1.25	8.0	8.0	0	0.04	84
AW5-2	Sep-88	1.25	8.70	9.4	1	0.05	100
AW5-3	Sep-88	1.30	10.0	10.0	0	0.06	86
AW5-1	Sep-88	1.30	6.0	4.0	0	0.04	76
AW5-5		0.75					
AW5-4		0.90					
TEST PIT #6							
AW6-4	Oct-89	0.35					
AW6-3	Oct-89	0.50					
AW6-2	Oct-89	0.65	400	17	102	0.91	50
AW6-1	Oct-89	0.80					
T6#PTRAP	Oct-89	2.00	270	15	192	34.00	54
AW6-4 DUP	Jul-89	0.35	318	14	114	22	4
AW6-4	Jul-89	0.35	460	18	171	36	4.8
AW6-3	Jul-89	0.50	540	20	265	4	8.6
AW6-3 DUP	Jul-89	0.50					
AW6-2	Jul-89	0.65	560	26	184	1.39	10.6
AW6-1	Jul-89	0.80	390	30	114	1.68	14.4
T6#PTRAP	Jul-89	2.00	382	14	134	10	5.8
AW6-4	Sep-88	0.35	540.0	14.0	160	10.00	86
AW6-4 DUP	Sep-88	0.35	320.00	11.0	127	17.00	68
AW6-3	Sep-88	0.50	680.0	12.0	240	7.50	64
AW6-2	Sep-88	0.65	360.0	24.0	125	1.58	145
AW6-1	Sep-88	0.80	44.0	12.0	10	0.36	130

TAILINGS TEST FACILITY
CALCIUM CONCENTRATIONS
SEPTEMBER, 1988

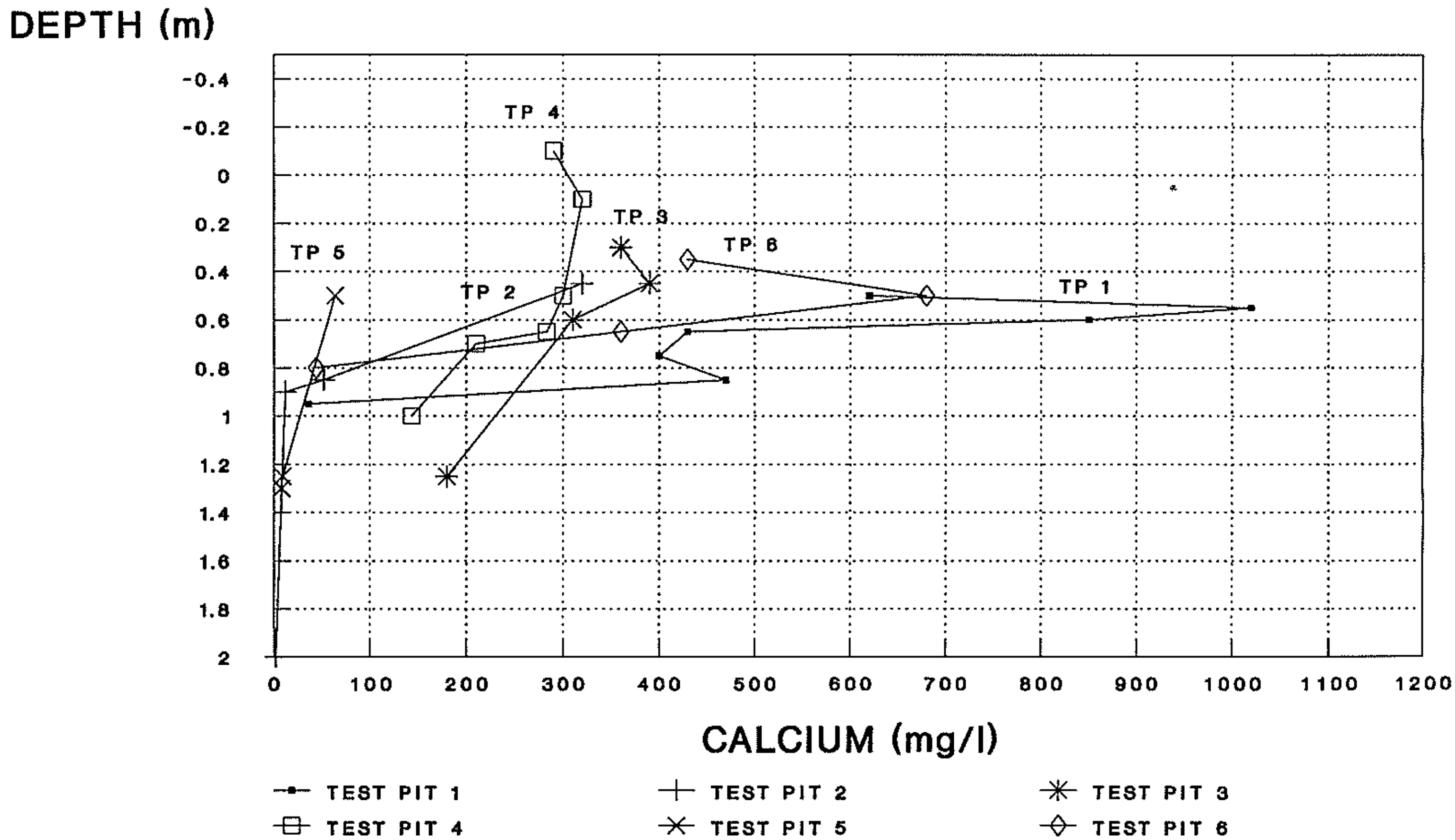


FIGURE 3.2-1: CALCIUM CONCENTRATIONS (PART A)

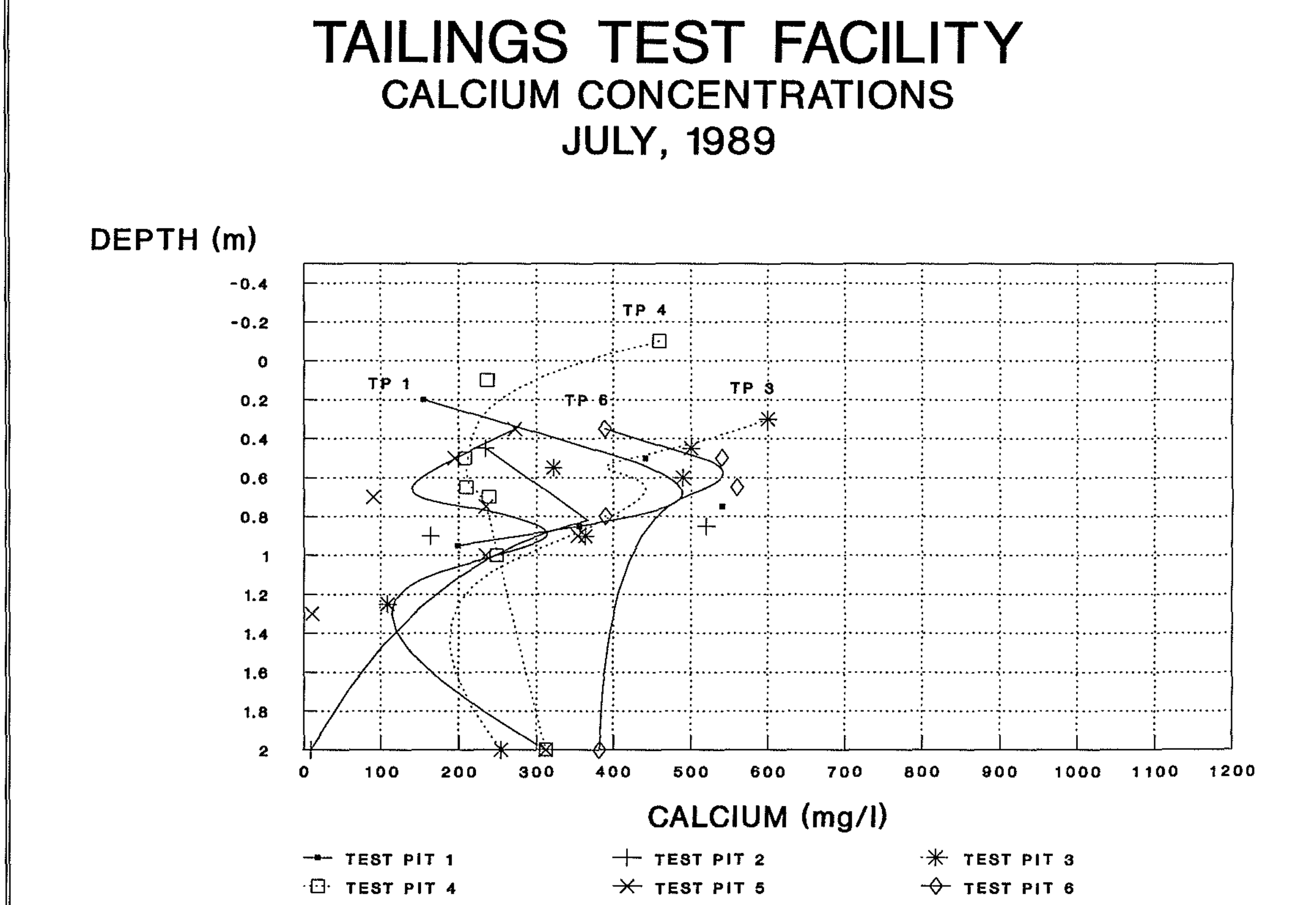


FIGURE 3.2-1: CALCIUM CONCENTRATIONS (PART B)

TAILINGS TEST FACILITY
CALCIUM CONCENTRATIONS
OCTOBER, 1989

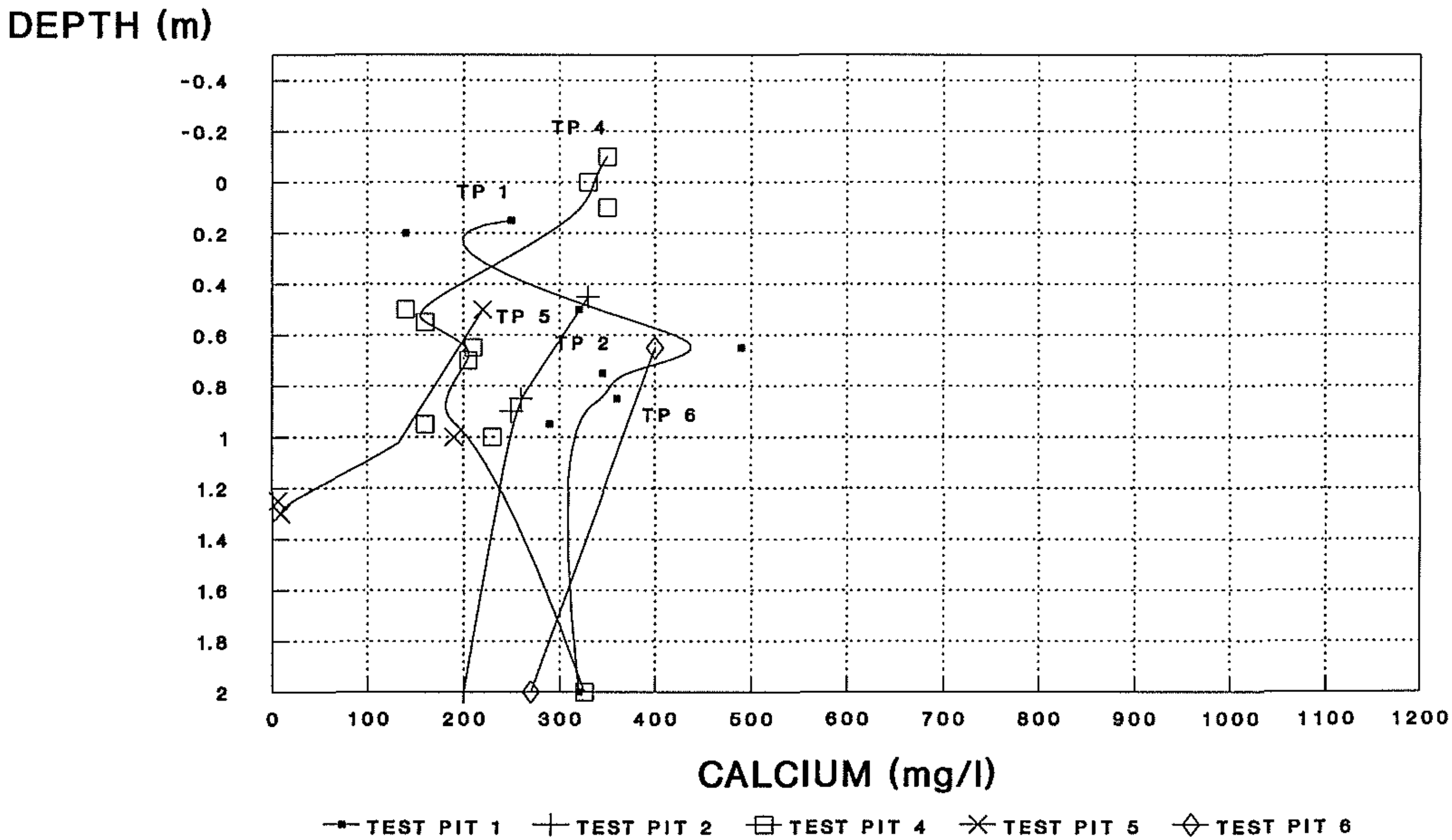


FIGURE 3.2-1: CALCIUM CONCENTRATIONS (PART C)

TABLE 3.3-1

CHLORINE, FLUORINE, NITRATES and SULPHATES

Concentrations in the Pore Waters (Tailings Test Facility)

Sampler #	Date	Depth (m)	Cl (mg/L)	Sulphates (mg/L)	F (mg/L)	Nitrates (mgN/L)
TEST PIT #1						
AW1-5	Oct-89	-0.10				
L1-5	Oct-89	0.15	0.0	1705	0.10	0.00
AW1-6	Oct-89	0.20	1.5	620	0.41	0.01
AW1-4	Oct-89	0.50	1.5	1490	0.35	0.01
L1-4	Oct-89	0.50				
L1-3	Oct-89	0.55				
L1-2	Oct-89	0.60				
AW1-3	Oct-89	0.65	1.7	1606	0.54	0.01
AW1-2 DUP	Oct-89	0.75				
AW1-2	Oct-89	0.75	0.7	1220	0.24	0.00
AW1-1	Oct-89	0.85	1.7	1770	0.13	0.00
L1-1	Oct-89	0.95	2.5	1540	1.10	0.01
T1#PTRAP	Oct-89	2.00	4.0	1370	0.70	0.00
AW1-5	Jul-89	-0.10				
AW1-6	Jul-89	0.20	2.9	661	0.33	0.03
AW1-4	Jul-89	0.50	1.6	1440	0.32	0.00
AW1-3	Jul-89	0.65				
AW1-2	Jul-89	0.75	2.1	1950	0.32	0.00
AW1-1 DUP	Jul-89	0.85	0.4	1494	0.17	0.00
AW1-1	Jul-89	0.85	4.1	1480	0.17	0.00
L1-1	Jul-89	0.95				
AW1-4 DUP	Sep-88	0.50	2.6	2250	0.45	0.02
AW1-4	Sep-88	0.50	2.6	2250	0.43	0.01
L1-3	Sep-88	0.55				0.00
L1-2	Sep-88	0.60	4.3	4200	0.62	0.00
AW1-3	Sep-88	0.65	7.7	1900	1.07	0.01
AW1-2	Sep-88	0.75	4.3	1950	0.55	0.01
AW1-1	Sep-88	0.85	6.7	2300	0.18	0.01
L1-1	Sep-88	0.95	7.7	420	3.72	0.00
T1#PTRAP	Sep-88	2.00	14.0	1	0.04	0.22
TEST PIT #2						
AW2-3	Oct-89	0.45	1.8	1171	0.16	0.00
AW2-2	Oct-89	0.85	1.8	912	0.64	0.00
AW2-1	Oct-89	0.90	1.8	885	0.78	0.02
T2#PTRAP	Oct-89	2.00	2.7	870	2.20	0.01
AW2-3	Jul-89	0.45	7.1	568	0.22	0.00
L2-3	Jul-89	0.50	3.5	635	0.52	0.00
AW2-2	Jul-89	0.85	4.1	860	0.63	0.00
AW2-1	Jul-89	0.90	5.2	700	0.91	0.00
L2-1	Jul-89	0.90	4.6	740	1.50	0.00
T2#PTRAP	Jul-89	2.00	3.5	840	2.70	0.00
AW2-3	Sep-88	0.45	4.8	1150	1.43	0.01
AW2-2	Sep-88	0.85	9.9	330	2.46	0.01
AW2-1	Sep-88	0.90	9.2	170	3.00	0.02
T2#PTRAP	Sep-88	2.00	7.8	1	0.04	0.01

TABLE 3.3-1

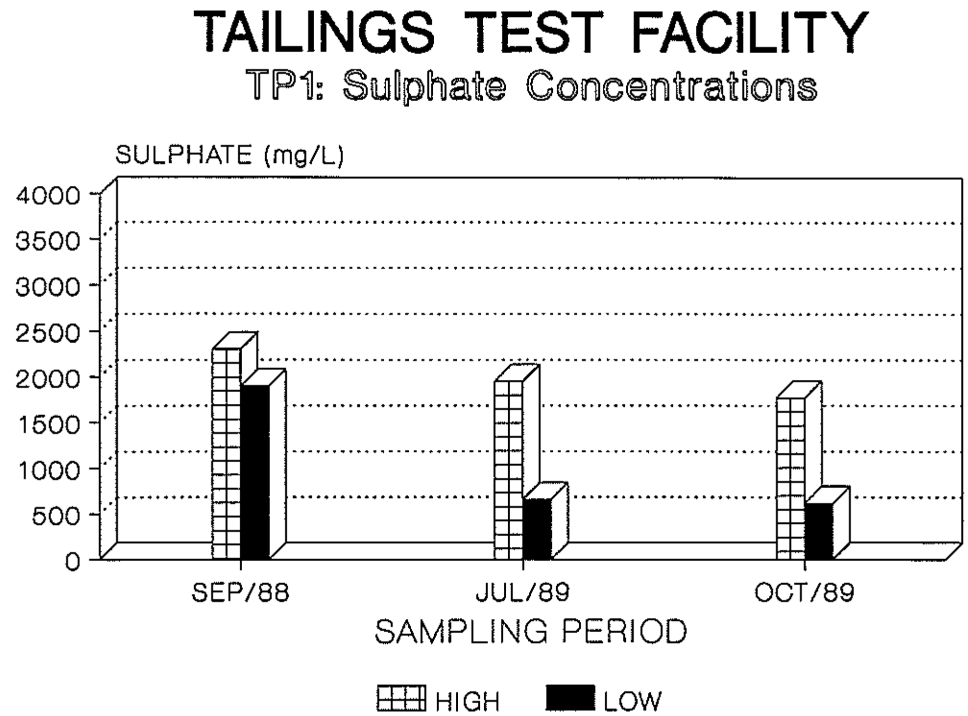
CHLORINE, FLUORINE, NITRATES and SULPHATES
Concentrations in the Pore Waters (Tailings Test Facility)

Sampler #	Date	Depth (m)	Cl (mg/L)	Sulphates (mg/L)	F (mg/L)	Nitrates (mgN/L)
TEST PIT #3						
AW3-5	Jul-89	0.30	1.7	2260	0.13	0.00
AW3-4	Jul-89	0.45	11.7	1108	0.33	0.00
L3-3	Jul-89	0.55				
AW3-3	Jul-89	0.60	2.1	835	0.63	0.00
AW3-3 DUP	Jul-89	0.60	1.9	1494	0.38	0.00
L3-1	Jul-89	0.90	1.5	1510	1.40	0.02
AW3-2	Jul-89	1.00				
AW3-1	Jul-89	1.25	5.8	487	1.60	0.00
T3#PTRAP	Jul-89	2.00	1.7	1000	0.28	0.00
AW3-5 DUP	Sep-88	0.30	6.0	1450	0.26	0.01
AW3-5	Sep-88	0.30	4.7	1700	0.23	0.01
AW3-4	Sep-88	0.45	6.5	1400	0.69	0.01
AW3-3	Sep-88	0.60	3.5	1100	1.23	0.01
AW3-1	Sep-88	1.25	6.2	450	0.53	0.01
T3#PTRAP	Sep-88	2.00	4.9	1	0.01	0.00
TEST PIT #4						
AW4-6	Oct-89	-0.10	1.1	1705	0.42	0.00
L4-6	Oct-89	0.00	3.2	1553	0.43	0.02
L4-5	Oct-89	0.05	0.0	1405	0.37	0.00
AW4-5	Oct-89	0.10	2.0	1640	0.26	0.00
AW4-4	Oct-89	0.50	1.5	1030	0.78	0.01
L4-4	Oct-89	0.55	1.6	1095	0.86	0.01
L4-3	Oct-89	0.65	2.0	1145	1.20	0.01
AW4-3	Oct-89	0.65	2.1	837	1.00	0.00
L4-2	Oct-89	0.70	3.2	861	1.40	0.01
AW4-2	Oct-89	0.70	14.5	940	0.84	0.00
L4-1	Oct-89	0.95	2.4	920	1.70	0.01
AW4-1	Oct-89	1.00	1.5	1540	0.47	0.00
AW4-1 DUP	Oct-89	1.00				
T4#PTRAP	Oct-89	2.00	3.3	1770	0.34	0.00
AW4-6	Jul-89	-0.10	23.3	1760	0.31	0.00
AW4-5	Jul-89	0.10	14.9	1053	0.39	0.00
AW4-4	Jul-89	0.50	1.7	2260	0.13	0.00
AW4-3	Jul-89	0.65	11.7	1108	0.33	0.00
L4-3	Jul-89	0.65				
L4-2	Jul-89	0.70				
AW4-2 DUP	Jul-89	0.70	1.9	1494	0.38	0.00
AW4-2	Jul-89	0.70	2.1	835	0.63	0.00
AW4-1	Jul-89	1.00	5.8	487	1.60	0.00
T4#PTRAP	Jul-89	2.00	3.3	1113	0.34	0.00
AW4-6	Sep-88	-0.10	2.4	2200	0.28	0.01
AW4-5	Sep-88	0.10	1.8	1900	0.30	0.01
AW4-4	Sep-88	0.50	3.8	1700	1.21	0.01
AW4-3 DUP	Sep-88	0.65	5.6	1200	1.04	0.01
AW4-3	Sep-88	0.65	33.5	1283	1.65	0.03

TABLE 3.3-1
Page 3 of 3

CHLORINE, FLUORINE, NITRATES and SULPHATES Concentrations in the Pore Waters (Tailings Test Facility)

Sampler #	Date	Depth (m)	Cl (mg/L)	Sulphates (mg/L)	F (mg/L)	Nitrates (mgN/L)
TEST PIT #5						
AW5-6	Oct-89	0.50				
AW5-5	Oct-89	0.75				
AW5-4	Oct-89	0.90				
L5-1	Oct-89	1.00				
AW5-2	Oct-89	1.25	1.8	235	3.40	0.00
AW5-1	Oct-89	1.30	1.4	181	3.60	0.01
AW5-3 DUP	Oct-89	1.30				
AW5-3	Oct-89	1.30	1.1	242	3.60	0.00
L5-5	Jul-89	0.35	11.8	955	1.20	0.00
L5-4	Jul-89	0.50				
AW5-6	Jul-89	0.50	6.7	1030	1.20	0.01
L5-3	Jul-89	0.70				
AW5-5	Jul-89	0.75	6.1	840	1.50	0.01
AW5-4	Jul-89	0.90	12.4	950	1.60	0.01
L5-1	Jul-89	1.00	16.5	888	2.00	0.00
AW5-2 DUP	Jul-89	1.25	3.2	167	3.80	0.00
AW5-1	Jul-89	1.30	2.3	153	2.30	0.00
AW5-3 DUP	Jul-89	1.30				
AW5-3	Jul-89	1.30	4.0	223	3.80	0.01
T5#PTRAP	Jul-89	2.00	2.1	334	1.70	0.00
AW5-6	Sep-88	0.50	7.8	340	2.79	0.01
AW5-2 DUP	Sep-88	1.25	7.4	140	4.25	0.01
AW5-2	Sep-88	1.25	14.8	181	4.60	0.15
AW5-3	Sep-88	1.30	7.5	110	4.27	0.01
AW5-1	Sep-88	1.30	8.8	115	3.99	0.01
AW5-5		0.75				
AW5-4		0.90				
TEST PIT #6						
AW6-4	Oct-89	0.35				
AW6-3	Oct-89	0.50				
AW6-2	Oct-89	0.65	1.5	1853	0.60	0.00
AW6-1	Oct-89	0.80				
T6#PTRAP	Oct-89	2.00	1.2	1970	0.39	0.00
AW6-4 DUP	Jul-89	0.35				
AW6-4	Jul-89	0.35	4.1	1775	0.12	0.02
AW6-3	Jul-89	0.50	3.4	2070	0.40	0.01
AW6-3 DUP	Jul-89	0.50	0.9	2446	0.08	0.01
AW6-2	Jul-89	0.65	8.1	1898	0.60	0.00
AW6-1	Jul-89	0.80	3.9	1400	1.10	0.03
T6#PTRAP	Jul-89	2.00	0.7	1250	0.38	0.00
AW6-4	Sep-88	0.35	4.8	1850	0.25	0.13
AW6-4 DUP	Sep-88	0.35	21.0	1815	0.20	0.76
AW6-3	Sep-88	0.50	3.5	3700	0.29	0.01
AW6-2	Sep-88	0.65	2.1	1450	0.90	0.01
AW6-1	Sep-88	0.80	6.8	300	3.40	0.01



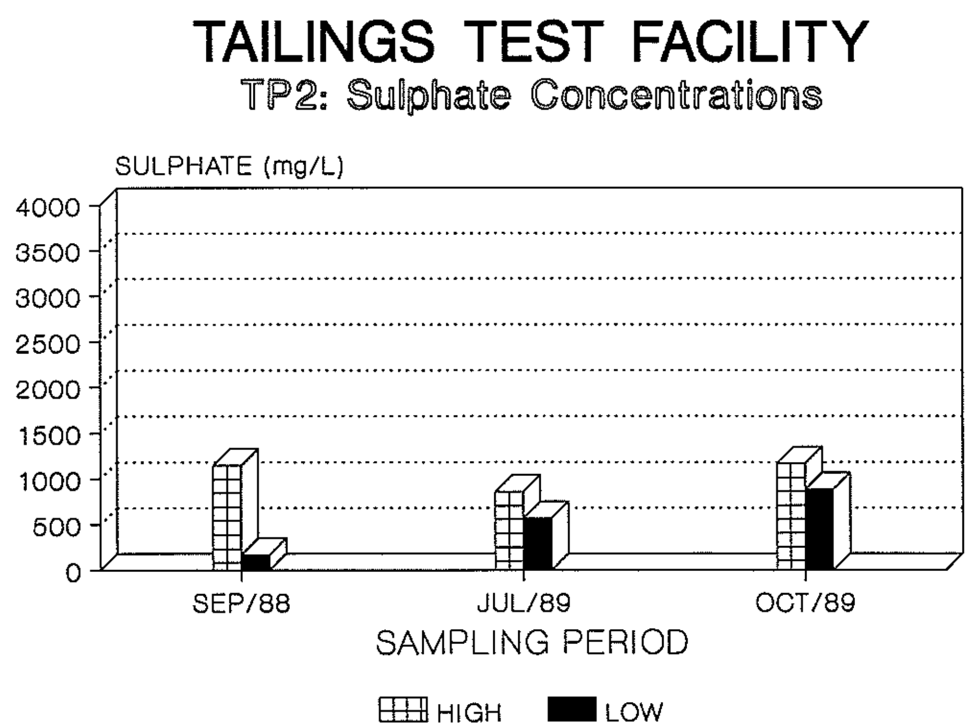
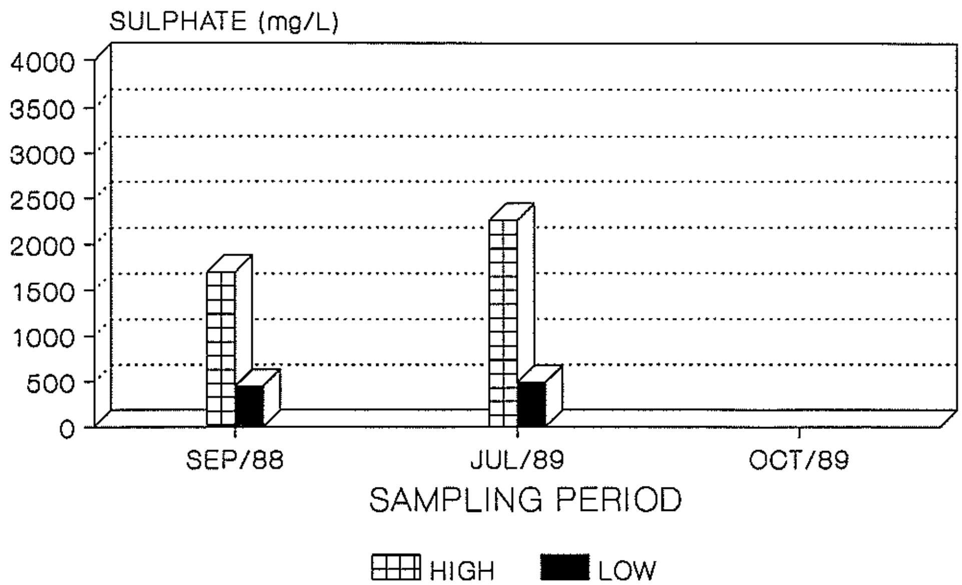


FIGURE 3.3-1 (Part A)

TAILINGS TEST FACILITY

TP3: Sulphate Concentrations



TAILINGS TEST FACILITY

TP4: Sulphate Concentrations

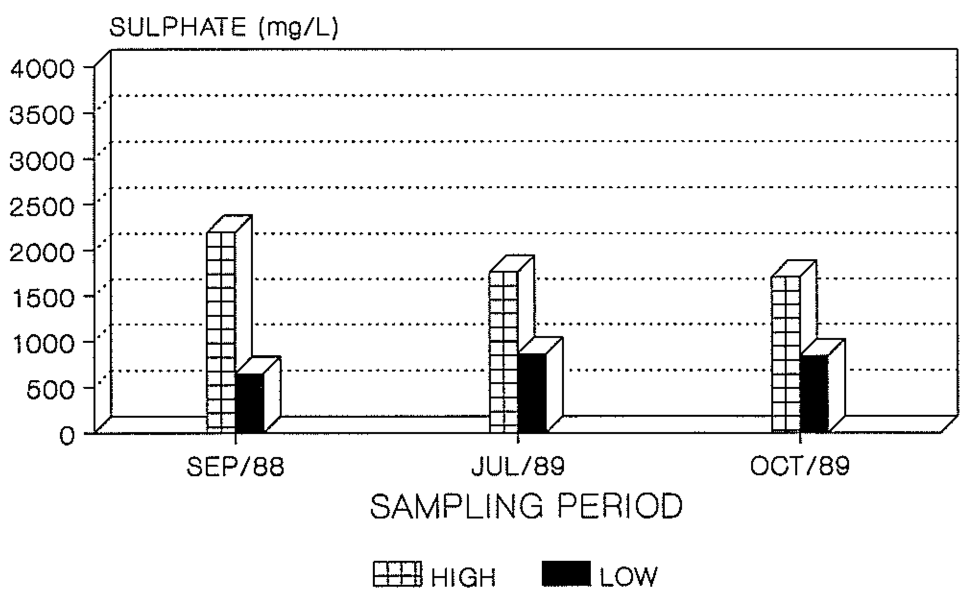


FIGURE 3.3-1 (Part B)

4.1.3 Alkalinity, Acidity and Total Inorganic Carbon

With the deposition of new tailings in 1987, the pH was approximately 9.6. Lime is added in the milling process prior to the tail discharge to both increase the pH of the tailings discharge and to provide a buffer against pH change in the deposited tailings.

Alkalinity is a measure of a system's ability to neutralize acid. Within each test pit, reductions in alkalinity are not as yet evident. However, the total amount of alkalinity that was initially present in the pore waters of each test pit was variable. This is particularly evident in near surface pore waters, where alkalinity between pits varies from 20 to 320 mg/L of CaCO3. At depth, variations are smaller, ranging from 20 to 235 mg/L of CaCO3. After completion of 1990 sampling and analysis, the evaluation of pH changes and metal mobility must consider the effects of the initial variations in buffering capacities between test pits.

In 1989, acidity concentrations were measured in the water samples collected from the test pits. Acidities ranged from 0 to 550 mg/L CaCO3 equivalents. The highest acidity was recorded in the control test pit (TP3). In general acidity concentrations were less than 100 mg/L CaCO3 equivalents, and too low to indicate a definite trend. The acidity data base is not sufficient as yet for a interpretation of results. Significant shifts in acidity in the tailings in the different test pits should provide a relative measure of the effectiveness of each cover type being tested.

The total inorganic carbon concentration in the tailings has been measured to differentiate between the sources of carbonate available to the tailings system. These concentrations will be considered during the 1990 evaluation of the carbonate depletion in the test pits.

4.1.4 Oxygen/Carbon dioxide

Oxygen and carbon dioxide profiles of each test pit are shown in Figures 3.1-3 and 3.1-4 (see pages 21 to 23, 24 and 25), respectively.

The measurements in the pre-1975 tailings of test area seven (TP7) show baseline oxygen (O_2) and carbon dioxide (CO_2) profiles for autumn and winter months. The oxygen concentration at the surface in October, 1989 was 20.7 percent. A gradual oxygen concentration depletion was measured from the surface to a depth of 1.8 metres. At 1.8 metres the oxygen concentration was 19.7 percent and remained at a constant 19.7 percent below 1.8 meters. The significance of such a small reduction in oxygen is not known, but it suggests that oxidation is not limited by oxygen availability. The concentration of carbon dioxide CO_2 at the surface of the old tailings (TP7) was 90 parts per million (ppm). At a depth of 1.2 metres, the CO_2 concentration was 60 ppm and remained at a constant 60 ppm below this depth.

In the unsaturated zone of the tailings, the depletion of oxygen with depth is in part a function of two processes: the oxidation rate of sulphides; and the rate of oxygen diffusion into the tailings. Oxygen diffusion is in turn dependent on temperature and the permeability of the tailings. Barometric pumping is responsible for convective transport of oxygen into the tailings.

The carbon dioxide concentration profiles are considered to reflect the chemical reaction rates of carbonates. Products of carbonate breakdown are gypsum and carbonic acid. Deposits of salts (or hardpan) are found in the old tailings test area. Depending on partial pressures within the pore spaces of the tailings, carbonic acid can then form carbon dioxide.

In the test pits of the test facility, the oxygen profiles as yet do not indicate concentration depletion patterns with depth. Oxygen concentrations in the test pits range from 19.6 to 20.3 percent. In October, 1989, the first complete set of oxygen concentration measurements was made. In 1990, with the addition of more oxygen concentration measurements, the oxygen profiles are expected to provide a mechanism to interpret the relative rates of oxidation in the tailings underlying the different cover materials of each test pit.

The carbon dioxide profiles from 1989, similar to the oxygen profiles, do not as yet indicate interpretable changes with depth. The carbon dioxide concentrations in the control test pit ranged from 30 to 40 ppm. In the remaining five test pits, the carbon dioxide concentrations ranged from 90 to 180 ppm. This significant difference in ranges is considered to reflect differences in chemical reaction rates within the tailings of the test pits. However, there is not as yet enough data to identify trends. In 1990, with additional data, the carbon dioxide profiles are expected to compliment the oxygen profiles in providing a mechanism to interpret the relative differences between the tailings in the different test pits.

4.2 Calcium, Potassium, Sodium, Magnesium, and Manganese

4.2.1 Calcium

The concentration of calcium in the pore water should reflect changes in the carbonate buffering potential of the tailings. Concentrations of calcium in 1988 and 1989 in the test pit tailings were quite variable. Calcium concentrations in the control test pit ranged from 110 to 390 mg/L in 1988. In 1989, concentrations ranged from 110 to 600 mg/L.

Three of the remaining test pits had similar increases in calcium concentration ranges in the tailings pore water. In 1988, calcium in TP2 ranged from 10 to 320 mg/L and in 1989, from 235 to 520 mg/L. In 1988, calcium in TP4 ranged from 135 to 320 mg/L and in from 135 to 469 mg/L. In 1988, calcium in TP5 ranged from 5 to 80 mg/L; in 1989 from 5 to 355 mg/L.

In test pits TP1 and TP6, the change in calcium concentrations from 1988 to 1989 did not follow a similar pattern. In 1988, the calcium concentration in TP1 ranged from 155 to 1020 mg/L; in 1989, from 140 to 540 mg/L. In 1988, the calcium concentration in TP6 ranged from 45 to 680 mg/L; in 1989, from 380 to 560 mg/L.

In 1987, calcium concentrations in the test pit tailings averaged 0.15 percent by weight with a 0.03 percent standard deviation. This deviation may be sufficient to account for the variations in calcium concentrations in the pore water in 1988 and 1989. Baseline alkalinity results also varied significantly between test pits. With the addition of 1990 test results, calcium concentration patterns should be more evident and the significance of initial calcium concentrations reduced.

4.2.2 Potassium, Sodium, Magnesium, and Manganese

Concentrations of potassium, sodium, magnesium, and manganese in the pore water of the test pits were relatively constant. These cation parameters are necessary in establishing the cation/ anion chemical balance of the pore water and will be reviewed in detail in 1990.

4.3 Chlorine, Fluorine, Nitrates, and Sulphates

4.3.1 Chlorine, Fluorine, and Nitrates

Concentrations of chlorine, fluorine and nitrates in the pore water of the test pits were relatively constant. These anion parameters are necessary in establishing the cation/ anion chemical balance of the pore water and will be reviewed in detail in 1990.

4.3.2 Sulphates

Sulphates are an important anion parameter. Rates of change in sulphate concentrations in the tailings pore water should reflect the rates of oxidation. Sulphate concentrations have not changed significantly from 1988 to 1989. However, sulphate concentration ranges are large. Concentrations range from approximately 200 to 2300 mg/L. In 1990, the more accurate gravimetric rather than turbidimetric sulphate analysis method should be used to reduce the possibility of analysis error.

4.4 Chromium, Copper, Iron, Nickel, Lead, and Zinc

A useful tailings cover must either inhibit tailings acidification or reduce the mobility of leached metal contaminants. Changes in metal concentrations in the pore water are therefore an important gauge of the abilities of a particular tailings cover.

4.4.1 Chromium, Copper, Nickel, and Lead

Chromium, copper, nickel and lead concentrations in pore water samples from 1988 and 1989 were very low and were generally at or below the analytical detection limits. Concentrations which exceeded the detection limits were below the Practical Quantitative Limits (PQL) for these parameters.
Iron and zinc concentrations in the pore water samples are high enough, however, for preliminary interpretation.

4.4.2 Iron

The differences in iron concentrations in the pore water from test pit to test pit are noticeable. In the control test pit (TP3), iron concentrations in the near surface tailings pore water ranged from 4 to 41 mg/L. At depth, the iron concentrations in the pore water ranged from 4 to 30 mg/L. Water from the test pit bottom drain had an iron concentration of 49 mg/L. All these values are low and are not indicative of any acid generation.

Iron concentrations in both the shallow and deep tailings pore water in the unsaturated composite covered test pit (TP4) were comparable to the concentrations in the control tailings pore water. Water from the test pit bottom drain had an iron concentration of 141 mg/L, which was approximately three times the concentration in the control pit drain. This may due to contamination from tailings blown into the pits prior to tailings placement in 1987.

Iron concentrations in the near surface tailings pore water of the saturated composite covered test pit (TP1) ranged from 2 to 16 mg/L. Iron concentrations at depth ranged from 1 to 105 mg/L. Water from the test pit bottom drain had an iron concentration of 119 mg/L. These results indicate that iron concentrations near the surface are much lower than control pit concentrations and at depth are higher than control pit concentrations. Again, the low concentrations are not considered to be significant relative to acid generation.

In the organic covered test pit (TP2), iron concentrations up to 88 mg/L were determined in the near surface tailings pore water, while less than 1 mg/L of iron was detected at depth. Water from the test pit bottom drain had an iron concentration of 29 mg/L. Thus, the surface concentrations are higher than the control pit concentrations, while concentrations at depth are similar or less than control pit concentrations. A similar pattern was noted in the water covered test pit (TP6). The water covered test pit (TP6), had iron concentrations in the near surface pore water ranging from 40 to 435 mg/L, and with depth, concentrations were less than 1 mg/L. Water from the test pit bottom drain had an iron concentration of 295 mg/L. Concentrations in near surface pore water and in the bottom drain water from TP6, though, were much higher than in the control pit, and at these concentrations may be reflecting acid generation in the surface layers.

In the till covered test pit (TP5), both the shallow and deep tailings pore water had iron concentrations of less than 2 mg/L. These concentrations were both significantly less than the control pit concentrations. Water from the test pit bottom drain had an iron concentration of 77 mg/L, which was higher than the control pit concentration, and this again may reflect the contamination of the base of the pit prior to tailings placement.

4.4.3 Zinc

Differences in zinc concentrations in the pore water from each test pit are, like iron concentrations, evident. Zinc concentration profiles for each test pit are shown in Figure 3.4-1, (see page 41).

In the control test pit (TP3), zinc concentrations in the near surface tailings pore water were 0.02 mg/L. At depth, the zinc concentrations in the pore water ranged from 0.02 to 0.11 mg/L. Water from the test pit bottom drain had an zinc concentration of 4.20 mg/L. This bottom drain value may be due to contamination of the pit base prior to tailings placement.

Zinc concentrations in both the shallow and deep tailings pore water in the unsaturated composite covered test pit (TP4) were comparable to the concentrations in the control tailings pore water. Water from the test pit bottom drain had an zinc concentration of 3.50 mg/L.

In the till covered test pit (TP5), both the shallow and deep tailings pore water had zinc concentrations of approximately 0.50 mg/L. Water from the test pit bottom drain had an iron concentration of 0.54 mg/L.

Zinc concentrations in the near surface tailings pore water of the saturated composite covered test pit (TP1) ranged from 0.02 to 0.13 mg/L. Zinc concentrations at depth ranged from 0.02 to 0.14 mg/L. Water from the test pit bottom drain had an zinc concentration of 0.05 mg/L.

In the organic covered test pit (TP2), zinc concentrations from 0.02 to 0.39 mg/L were determined in the near surface tailings pore water, while less than 0.02 mg/L of zinc was detected at depth. Water from the test pit bottom drain had an zinc concentration of 0.50 mg/L.

The water covered test pit (TP6), had zinc concentrations in the near surface pore water ranging from 0.02 to 32 mg/L, and at depth, the concentrations varied from 0.02 to 0.09 mg/L. Water from the test pit bottom drain had an zinc concentration of 4.8 mg/L.

The zinc concentrations from the shallow tailings pore water in the water covered test pit (TP6) are extremely high. These high values are 80 times the zinc concentrations in the other test pits. The water cover, as mentioned earlier, could not be maintained. The tailings were subject to alternating wet and dry cycles which tends to optimize metals leaching in the near surface tailings. Accelerated metal transport through the tailings does not, however, appear to have occurred.

The differences in zinc concentrations between other covered test pits and the control are not large. The saturated composite (TP1) had fairly constant zinc concentrations in the tailings pore water with depth, as did the till covered pit (TP5). Zinc concentrations are even lower in the till covered pit. The organic cover test pit displayed a reverse in zinc concentrations as compared to the control pit. Higher concentrations were found in the near surface tailings pore water than pore water at depth. The results all indicate little or no zinc leaching in the various pits, including the control pit. The only exception is the water cover pit which, due to failure of the water cover is displaying acid generation and zinc leaching. With the addition of 1990 data, trends should be more evident.

4.5 Analysis of Solids (Tailings) Samples

The 1989 chemical analysis results of the five tailings samples collected from the test pits provide an indication of the variability between the tailings in each test pit. Variability in metal concentrations, as shown in Table 3.5-1, (see page 42), are generally small. Some differences, though, are evident. The copper concentration in the tailings sample from the control test pit is 0.89 percent by weight. The concentrations in the remaining samples average 1.70 percent by weight. In 1990, an extensive solids sampling and chemical analysis is planned. The differences in concentrations of metals and sulphides in the tailings solids of the test pits will be considered when evaluating the covers test program in 1990.

In Table 3.5-2, (see page 43), the baseline chemical composition of the tailings in the test pits is presented. The more extensive solids sampling in 1990 is expected to reflect the variability indicated by the baseline analysis results.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In 1989, the Faro tailings covers test facility was sampled in July and October. Water samples were collected during both periods, and tailings solids samples were collected in October. Samples were shipped to B.C. Research for chemical analysis and characterization. Temperatures were recorded monthly from July, 1989, and oxygen/ carbon dioxide concentrations were measured in October, 1989.

The instrumentation, and the water and solids samplers continue to work within expectations.

Chemical results are encouraging, indicating very low rates of acid generation in all pits, with concentrations of select chemical parameters diverging from those found in the control test pit. Results indicate that changes can be detected in rates of pore water flushing or rates of acidification in the tailings of individual test pits. The low rates of oxidation and present data variability though, does create a problem in identifying and interpreting trends at this early stage. Two sampling periods are scheduled for 1990, and with their completion, five data sets from different periods will be available for interpretation. Based upon a review of the tailings covers test program to date, a more conclusive evaluation of the covers and their affects on the factors controlling acid generation should be possible.

The tailings covers test program has been designed to evaluate the effects of different cover types on rates of tailings acid generation and metal contaminant migration. This program is a part of the Faro Tailings Abandonment Plan Development Program (TAPDP) which will be completed in 1991. The 1990 field season, therefore, represents the last opportunity to collect information from the covers testing program for input into the Tailings Abandonment Plan. It will be possible to continue monitoring of the test pits in the long term which will provide data for future modifications of the Abandonment Plan.

Based upon our review of the covers testing program to date, and with consideration of the fact that all required sampling and analyses must be completed prior to the end of 1990, we recommend the following:

1. Temperature measurements should continue to be taken monthly from the thermistors in each of the seven test areas;

2. Oxygen and carbon dioxide concentration measurements should be taken monthly from sampling tubes in the unsaturated tailings zone of each of the seven test pits;

3. The flow rates from each of the bottom drains in each test pit should be measured every two weeks and at approximately the same time of day in each sampling period;

4. All air/water samples and lysimeters in the saturated tailings zone of each test pit should be sampled twice during 1990. June and September are the recommended sampling times.

5. Discontinue monitoring of piezometers;

6. The water from each bottom drain should be sampled monthly from spring thaw to fall freeze-up;

7. The pH, alkalinity and acidity of pore water from the air/water samplers, lysimeters and bottom drains should be determined monthly;

8. During the late summer or early fall, solid samples should be extracted from each of the horizontal sampling tubes in each test pit. In addition, three tailing samples should be collected from a vertical boring in the tailings of each test pit. Recommended sample depths are 0 to 0.2 m, 0.4 to 0.6 m and 0.8 to 1.0 m.

9. Surface and near surface tailings samples should be analyzed for T. Ferroxidans;

10. All tailings samples should be analyzed for chemical composition. Acid/base accounting and permeability testing should be completed on at least one tailings sample collected from each test pit;

11. Water samples should be analyzed for the same parameters as in 1988 and 1989, however, sulphates should be analyzed by the gravimetric method;

12. Samples should be split and sent to two laboratories for quality control/quality assurance. Samples blanks and spikes should be included as well;

13. Rates of evaporation, temperature and humidity should be measured as frequently as possible. (Daily temperature readings and bi-weekly evaporation rate measurements are recommended;

14. The water depth in the tailings in each pit should be measured weekly;

15. The tailings samplings extracted from vertical auger boring in each test pit should be analyzed for moisture content.

6.0 REFERENCES

Steffen, Robertson and Kirsten (B.C.) Inc., 1986, Report 60602, Faro Mine Tailings Abandonment Plan Development Program.

CRI, 1987, Faro Tailings Abandonment Plan Development Program, 1987 Progress Report

CRI, 1988, Tailings Abandonment Plan, Development Program, 1988 Progress Report.