



Curragh
Resources Inc.

VANGORDA PLATEAU DEVELOPMENT

REVIEW OF ALTERNATIVE ABANDONMENT PLANS AND WATER QUALITY PREDICTION METHODS

Prepared by:

**STEFFEN ROBERTSON AND KIRSTEN (B.C.) INC
CONSULTING ENGINEERS AND SCIENTISTS**

February 1990

REPORT 60609

**VANGORDA PLATEAU DEVELOPMENT
REVIEW OF ALTERNATIVE
ABANDONMENT PLANS AND
WATER QUALITY PREDICTION METHODS**

Prepared for:

CURRAGH RESOURCES INC.
177 Industrial Road
Whitehorse, Yukon
Y1A 2T8

Prepared by:

STEFFEN ROBERTSON AND KIRSTEN (B.C.) INC.
580 Hornby Street
Vancouver, B.C. V6C 3B6
Canada

FEBRUARY 1990

VANGORDA PLATEAU DEVELOPMENT REVIEW OF ALTERNATIVE ABANDONMENT PLANS AND WATER QUALITY PREDICTION METHODS

CONTENTS

1.0 INTRODUCTION	1-1
1.1 Background	1-1
1.2 Purpose and Scope	1-4
2.0 WATER QUALITY PREDICTION	2-1
2.1 Methodology	2-1
3.0 VANGORDA WASTE DUMP	3-1
3.1 Alternative 1.1	3-1
3.1.1 Description	3-1
3.1.2 Water Quality Predictions based on Original Flow and Concentration Distributions	3-3
3.2 Alternative 1.2	3-13
3.2.1 Description	3-13
3.2.2 Water Quality Predictions based on Original Flow and Concentration Distributions	3-14
3.3 Alternative 1.3 (Vangorda Waste Dump Original Scheme)	3-23
3.3.1 Description	3-23
3.3.2 Water Quality Predictions based on Original Flow and Concentration Distribution	3-24
3.4 Alternative 1.4	3-32
3.4.1 Description	3-32
3.4.2 Water Quality Predictions based on Original Flow and Concentration Distributions	3-33
3.5 Alternative 1.5	3-39
3.5.1 Description	3-39
3.5.2 Water Quality Predictions based on Original Flow and Concentration Distribution	3-40
3.6 Alternative 1.5.1	3-46
3.6.1 Description	3-46
3.6.2 Water Quality Predictions based on Original Flow and Concentration Distributions	3-46
3.7 Alternative 1.6	3-50
3.7.1 Description	3-50
3.7.2 Water Quality Predictions based on Original Flow Concentration and Distribution	3-51

3.8	Alternative 1.7	3-53
3.8.1	Description	3-53
3.8.2	Water Quality Predictions based on Original Flow and Concentration Distributions and Flows	3-54
3.9	Blending with Calcareous Phyllite or Limestone	3-60
3.10	Summary and Discussion	3-62
4.0	GRUM WASTE DUMP	4-1
4.1	Alternative 2.1	4-1
4.1.1	Description	4-1
4.1.2	Water Quality Predictions based on Original Flow and Concentration Distributions	4-1
4.2	Alternative 2.2 (Original Scheme)	4-7
4.2.1	Description	4-7
4.2.2	Water Quality Predictions based on Original Flow and Concentration Distributions	4-8
4.3	Alternative 2.3	4-11
4.3.1	Description	4-11
4.3.2	Water Quality Predictions based on Original Flow and Concentration Distributions	4-12
4.4	Alternative 2.4	4-17
4.4.1	Description	4-17
4.4.2	Water Quality Predictions based on Original Flow and Concentration Distributions	4-18
4.5	Summary and Discussion	4-24
5.0	VANGORDA PIT	5-1
5.1	Alternative 3.1 (Original Scheme)	5-1
5.1.1	Description	5-1
5.1.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-2
5.2	Alternative 3.2	5-4
5.2.1	Description	5-4
5.2.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-5
5.3	Alternative 3.3	5-11
5.3.1	Description	5-11
5.3.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-12

5.4	Alternative 3.4	5-18
5.4.1	Description	5-18
5.4.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-18
5.5	Alternative 3.5	5-22
5.5.1	Description	5-22
5.5.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-23
5.6	Alternative 3.6	5-28
5.6.1	Description	5-28
5.6.2	Water Quality Predictions based on Original Flow and Concentration Distributions	5-28
5.7	Summary and Discussion	5-32
6.0	ALTERNATIVE SCHEME COMBINATIONS	6-1
6.1	Alternative 1.4/2.4/3.1	6-2
6.1.1	Description	6-2
6.1.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-2
6.2	Alternative 1.4/2.4/3.2	6-7
6.2.1	Description	6-7
6.2.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-7
6.3	Alternative 1.5.1/2.2/3.5	6-11
6.3.1	Description	6-11
6.3.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-12
6.4	Alternative 1.5.1/2.2/3.2	6-17
6.4.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-18
6.5	Alternative 1.5.1/2.3/3.2	6-23
6.5.1	Description	6-23
6.5.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-23
6.6	Alternative 1.5/2.2/3.2	6-27
6.6.1	Description	6-27
6.6.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-27
6.7	Alternative 1.5/2.3/3.2	6-32
6.7.1	Description	6-32
6.7.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-32

6.8	Alternative 1.2/2.1/3.1 with treatment	6-36
6.8.1	Description	6-36
6.8.2	Water Quality Predictions based on Original Flow and Concentration Distributions	6-36
6.9	Summary and Discussion	6-40
7.0	WATER QUALITY PREDICTION ALTERNATIVES	7-1
7.1	General	7-1
7.2	Original Model	7-1
7.2.1	Metal Concentrations	7-1
7.2.2	Metal Concentration Distributions	7-5
7.2.3	Dump and Pit Wall Flow Estimates	7-7
7.2.4	Precipitation, Runoff, Infiltration and Percolation Estimates (Help Model)	7-10
7.3	Water Quality Prediction Alternatives	7-12
7.3.1	Variations in Annual Mean Monthly Concentrations	7-13
7.3.2	Variations in Monthly Metal Concentration Distributions	7-16
7.3.3	Pit Flow Variations	7-19
7.4	Summary and Discussion	7-19

LIST OF FIGURES

1.1	General Location Map	1-2
1.2	Vangorda Plateau Site Plan	1-3
3.1	Vangorda Waste Dump, Alternative 1.1; Plan & Sections	3-5
3.2	Vangorda Waste Dump, Alternative 1.1; Diversion Ditch Sections	3-6
3.3	Vangorda Waste Dump, Alternative 1.2; Plan	3-15
3.4	Vangorda Waste Dump, Alternative 1.2; Sections	3-16
3.5	Vangorda Waste Dump, Alternative 1.3; Plan	3-25
3.6	Vangorda Waste Dump, Alternative 1.3; Sections A-A' and B-B'	3-26
3.7	Vangorda Waste Dump, Alternative 1.3; Sections C-C' and D-D'-D"	3-27
3.8	Finger Drain and Sump, Typical Details	3-28
3.9	Vangorda Waste Dump, Alternative 1.4; Plan	3-34
3.10	Vangorda Waste Dump, Alternative 1.4; Sections	3-35
3.11	Vangorda Waste Dump, Alternative 1.5; Plan	3-41
3.12	Vangorda Waste Dump, Alternative 1.5; Section	3-42
3.13	Vangorda Waste Dump, Alternative 1.6; Plan & Section	3-52
3.14	Vangorda Waste Dump, Alternative 1.7; Plan	3-55
3.15	Vangorda Waste Dump, Alternative 1.7; Dump Cover Detail	3-56
4.1	Grum Waste Dump, Alternative 2.1; Plan	4-3
4.2	Grum Waste Dump, Alternative 2.2; Plan	4-9
4.3	Grum Waste Dump, Alternative 2.2; Section	4-10
4.4	Grum Waste Dump, Alternative 2.3; Plan	4-13
4.5	Grum Waste Dump; Alternative 2.4; Plan	4-19
4.6	Grum Waste Dump; Alternative 2.4; Section Through Sulphide Cell	4-20
5.1	Vangorda Pit, Alternative 3.1; Plan	5-1
5.2	Vangorda Pit, Alternative 3.2; Plan	5-6
5.3	Vangorda Pit, Alternative 3.2; Pit Section	5-7
5.4	Vangorda Pit, Alternative 3.3; Plan	5-13
5.5	Vangorda Pit, Alternative 3.3; Pit Section	5-14
5.6	Vangorda Pit, Alternative 3.4; Plan	5-20
5.7	Vangorda Pit, Alternative 3.4; Pit Section	5-21
5.8	Vangorda Pit, Alternative 3.5; Plan and Section	5-24
5.9	Vangorda Pit, Alternative 3.6; Plan	5-30
5.10	Vangorda Pit, Alternative 3.6; Section Showing Additional Excavation Required	5-31

6.1	Combination 1.5.1/ 2.4/ 3.5; Section Through In-Pit Dam	6-13
6.2	Combination 1.5.1/ 2.4/ 3.2; Section Through Vangorda Pit	6-19
6.3-6.4	Mean monthly Zinc Concentrations for Combination Alternatives	6-42
7.1	Results from Sulphide Waste Humidity Cell Tests	7-3
7.2	Results from Phyllite Waste Humidity Cell Tests	7-4
7.3	Assumed Zinc Concentration Distribution for Original Model	7-6
7.4	Assumed Seepage Flow Distribution for Pits and Waste Dumps in Original Model	7-8
7.5	Map of Faro Dumps and Pits	7-14
7.6	Actual Faro Pit Seepage Concentration Distribution	7-17
7.7	Actual Faro Waste Dump Concentration Distribution	7-18

LIST OF TABLES

3.1	Net Neutralization Potential and Quantities of Waste Rock	3-2
3.2	Water Quality Predictions - Alternative 1.1	3-7
3.2A	Water Quality Predictions - Alternative 1.1 with Treatment	3-10
3.3	Water Quality Predictions - Alternative 1.2	3-17
3.3A	Water Quality Predictions - Alternative 1.2 with Treatment	3-20
3.4	Water Quality Predictions - Alternative 1.3	3-29
3.5	Water Quality Predictions - Alternative 1.4	3-36
3.6	Water Quality Predictions - Alternative 1.5	3-43
3.7	Water Quality Predictions - Alternative 1.5.1	3-47
3.8	Water Quality Predictions - Alternative 1.7	3-57
3.9	Rock Blending Calculations	3-61
3.10	Summary of Water Quality Predictions from Vangorda Waste Dumps	3-63
4.1	Water Quality Predictions - Alternative 2.1	4-4
4.2	Water Quality Predictions - Alternative 2.3	4-14
4.3	Water Quality Predictions - Alternative 2.4	4-21
4.4	Summary of Water Quality Predictions from Grum Waste Dumps	4-25
5.1	Water Quality Predictions - Alternative 3.2	5-8
5.2	Water Quality Predictions - Alternative 3.3	5-15
5.3	Water Quality Predictions - Alternative 3.5	5-25
5.4	Summary of Water Quality Predictions For Vangorda Pit	5-33

6.1	Water Quality Predictions - Alternative 1.4/ 2.4/ 3.1	6-4
6.2	Water Quality Predictions - Alternative 1.4/2.4/3.2	6-8
6.3	Water Quality Predictions - Alternative 1.5.1/ 2.2/ 3.5	6-14
6.4	Water Quality Predictions - Alternative 1.5.1/2.2/3.2	6-20
6.5	Water Quality Predictions - Alternative 1.5.1/2.3./3.2	6-24
6.6	Water Quality Predictions - Alternative 1.5/2.2/3.2	6-29
6.7	Water Quality Predictions - Alternative 1.5/2.3.3.2	6-33
6.8	Water Quality Oredictions - Alternative 1.2/2.1/3.1 with Treatment	6-37
6.9	Summary of Water Quality Predictions for Alternative Combinations	6-41
7.1	Summary of Potential Contaminants Sources and Loading For Original Model	7-2
7.2	Vangorda Pit Wall Seepage as Derived From the Simplified Well Formula	7-9
7.3	Annual Mean Monthly Concentrations - Alternatives	7-15
7.4	Water Quality Predictions for Alternative Metal Concentration and Flow Distributions	7-23
7.5	Water Quality Predictions for Alternative Combinations for Worst Case Conditions	7-24



**VANGORDA PLATEAU DEVELOPMENT
REVIEW OF ALTERNATIVE
ABANDONMENT PLANS
AND
WATER QUALITY PREDICTION METHODS**

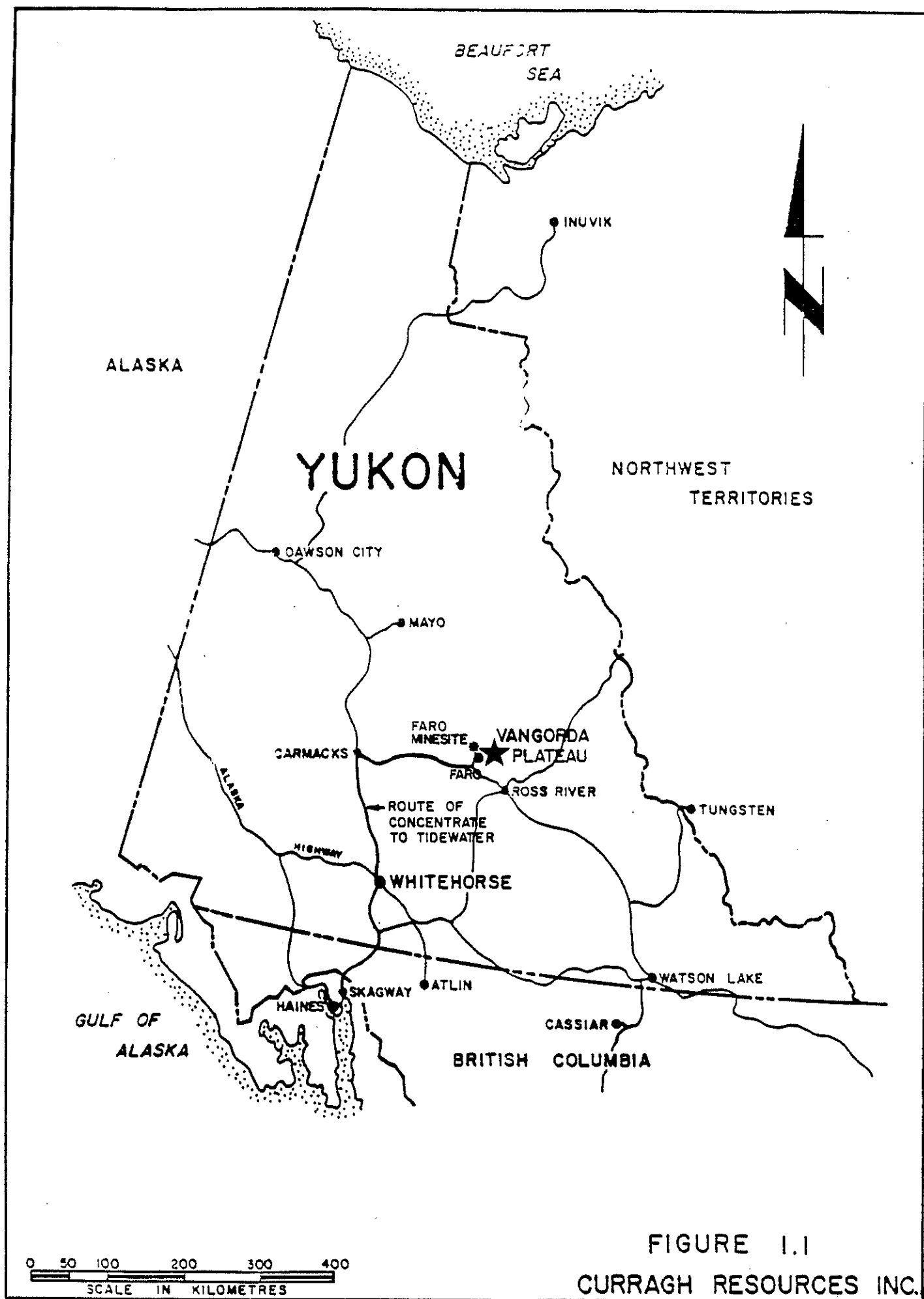
1.0 INTRODUCTION

1.1 Background

Curragh Resources is currently preparing plans for the development of additional orebodies on the Vangorda Plateau which is located about 16 km southeast of the existing Faro mine in the Yukon Territory as shown on Figure 1.1. The development will involve the mining of two open pits, Vangorda and Grum, producing a total of about 160 million tonnes of waste rock. In accordance with the Environmental Assessment and Review Process (EARP), an Initial Environmental Evaluation (IEE) Report has been prepared by Curragh. The IEE was submitted to the Regional Environmental Review Committee (RERC) in July, 1989 and is currently under review. As part of the review requirements, a decommissioning or abandonment plan for the development was also prepared by Curragh and is presented in the IEE report.

The current abandonment plan, which is presented on Figure 1.2 (foldout), involves the flooding of both pits and encapsulating the acid generating waste rock from the Vangorda pit with glacial till stripped from the mine site. Vangorda Creek, which is temporarily diverted during the operation phase of the development, would be re-diverted into the pit after abandonment. The current plan does not include till covers for the Grum waste dump, however a single till covered cell, located within the Grum dump, is planned to accommodate that portion of the acid generating waste rock from the Grum Pit which is not returned to the pit. These mitigative measures would be implemented as a means of reducing the impact of Acid Mine Drainage (AMD) from the waste rock and the pits, on the receiving waters in Vangorda Creek and the Pelly River.

In an attempt to evaluate the effectiveness of these mitigative measures, a Mass Loading/Water Balance model was derived for the proposed abandonment scheme. The model assumes an annual distribution of soluble metal concentrations which is combined with an estimated seepage flow distribution to produce an annual monthly metal loading for each of the main AMD contributors. Using stream flow data for Vangorda Creek at both the mine site and at Faro, resultant metal concentrations are calculated by the direct ratio of the loading divided by the flow.



This report presents an evaluation of alternative scenarios to the current abandonment plan including a water quality prediction for each alternative. The water quality prediction technique used was based on the mass loading/Water Balance Model presented in the IEE. A review of this technique is also included in this report.

1.2 Purpose and Scope

The purpose of this report is to respond to a number of comments by RERC members presented in writing and discussed at a meeting in Whitehorse on October, 1989. The major factors considered are (a) the alternatives for the mine plan and decommissioning measures and (b) details of the water quality model used to evaluate the environmental impact of the project. In the following sections a preliminary design has been prepared for each alternative and the benefits and disadvantages are discussed.

The approach used in the following evaluation considers the Vangorda waste dumps, the Vangorda pit, and the Grum waste dump as three distinct components of the abandonment plan. Preliminary designs and quantity estimates were prepared for each component alternative. The effectiveness of each alternative was assessed by estimating the impact of each scheme on the water quality in Vangorda Creek using the Mass Loading/Water Balance Model presented in the July, 1989 IEE. Alternatives to the current abandonment plans for the main Grum waste and the Grum pit were not reviewed because there are strong indications that these components would not contribute significantly to the AMD problem at Vangorda after abandonment.

Following review of the results from the first stage of the analysis, four alternative combinations of components were selected and their effectiveness on water quality impact was evaluated.

In light of more recent seep survey data from the existing Faro mine a review of the water quality prediction model was also completed. The Faro data and the analysis were not available when the original IEE was prepared. This review involved using different metal concentration and flow distributions in the Mass Loading/Water Balance model and evaluating the water quality predictions using the current abandonment plan as a base.



2.0 WATER QUALITY PREDICTION

2.1 Methodology

The Water Balance/ Metal loading model which is presented in the IEE was developed for the Vangorda/ Grum mine site to predict the water quality of Vangorda Creek after mine decommissioning. The model assumes that the mine site is divided into hydrological areas comprising waste dumps and open pits, and metal loading is calculated for each area, based on estimated flow rates and metal concentrations. The metal loadings from each area are then combined to determine mean monthly metal concentrations in Vangorda Creek at various locations downstream of the mine. To compare the water quality impacts of each alternative mitigative measure, changes to the existing model were made to reflect the measures considered. In order to evaluate the impact of each alternative on the water quality in Vangorda Creek compared to the original scheme, no changes to flow or concentration distributions were made to the original scheme. During the course of the study, however, the surface area of the sulphide and phyllite cells for the base case (Alternative 1.3/2.2/3.1) were changed from 20.8 ha and 22.5 ha to 18 ha and 25 ha, respectively. These adjustments to surface area were made to more accurately represent the surface area of the waste rock. The original model, presented in the July 1989 IEE was used as a base case for the comparison of alternative scenarios in order to maintain continuity between reports. It should not be inferred that the original model represents the only valid set of assumptions.

Water quality predictions for alternative abandonment plans for each of the main components (Vangorda Dumps, Vangorda Pits and Grum dumps) based on the original model parameters, are discussed in Section 3 to 5. In Section 6, water quality predictions, based on the original model, are presented for alternative combination schemes. A worst case scenario for both the original scheme and the alternative combinations have also been derived and are presented in Section 7.

Parameters in the model that were adjusted to reflect the mitigative measures for each alternative include surface area of dumps, the annual mean monthly metal concentrations and flows. Several methods were used in the original model to estimate flow rates and metal concentrations. Infiltration, runoff and evapotranspiration were determined using the "Hydrologic Evaluation of Land Fill Performance" (HELP Version II) computer model, and pit wall seepage rates were calculated from the Simple Well formula. The predicted levels of zinc concentration in the leachate or seepage from the waste rock dumps and the open pit walls were based on Humidity Cell test results and preliminary measurements of water quality from the Faro operation. Seasonal variations in metal concentrations, as indicated by early Faro water quality data, were also incorporated into the model. A more detailed discussion of the assumptions used in the original model is presented in Section 7 of this report. The sensitivity to changes in flow and concentration distributions is also examined in Section 7, based on the more complete analysis of the seep data which indicated a diversity of seasonal profiles of seepage quality.

Background zinc levels in Vangorda Creek, both at Faro townsite and at the Vangorda minesite, have

not been included in the analysis. Consequently, to assess total impact on the creek, the background loading must be added to the net impact from the project. Using mean monthly flows (1864 dam^3) and the mean annual baseline zinc concentrations (.016 mg/L) at Faro Townsite (V08), the background loading was estimated to be about 30 kilograms per month. At a location just below the minesite (V10), the baseline or background loading was estimated to be 11 kilograms per month based on a flow of 577 dam^3 per month and a zinc concentration of .019 mg/L. This implies that there are several existing sources within the catchment below the minesite that contribute to the zinc loading in Vangorda Creek. The model however conservatively assumes that the contributing loading from the minesite remains constant without attenuation.

3.0 VANGORDA WASTE DUMP

The first component considered in the overall Vangorda Plateau abandonment plan is the disposal of the waste material from Vangorda Pit. This waste comprises 3,081,000 bank cubic metres (bcm) of till overburden, 1,173,000 bcm sulphide waste rock, and 2,132,000 bcm phyllite waste rock. For calculation purposes a bulking factor of 1.3 has been assumed. Seven alternatives for disposing of this waste have been considered and are presented below. These alternatives reference only the Vangorda waste dump component of the abandonment plan and would be combined with the original scheme for the Grum Waste Dump and Vangorda Pit to form the overall abandonment plan.

The designs presented for each alternative in this and subsequent sections are conceptual and further work would be required for any final design. Waste rock quantities used to size the different structures are summarized in Table 3.1.

3.1 Alternative 1.1

3.1.1 Description

Alternative 1.1 assumes the following features for abandonment of the Vangorda Waste dump:

1. All waste rock from Vangorda Pit placed in Vangorda Creek, downstream of pit;
2. Vangorda Creek diverted around pit and waste rock dump;
3. No segregation or selective placement of waste;
4. No cover on dump;

All waste rock from Vangorda pit would be placed, unsegregated, in a single waste dump as shown on Figure 3.1. The waste rock would be left uncovered. A permanent diversion dam and ditch would be constructed to divert Vangorda Creek around the pit and the waste dump.

The diversion dam would have a crest elevation of 1185 metres, with the diversion ditch invert at elevation 1182.5 m. It is assumed that the dam would be constructed with rockfill shells around a central till core, as shown in Figure 3.1. The dam would include a blanket drain, and may also require filter layers between the till and the rockfill, and between the rockfill and the blanket drain.

It is assumed that the diversion ditch would consist of an open channel lined with rip-rap, with drop structures at intervals as required. Typical sections are shown in Figure 3.2. The ditch was designed to accommodate of flows upto 20.5 cubic meters per second which represents a 500 year design flood based on recent work completed by SRK (BC). The advantages of this alternative include: (a) no segregation of the waste rock; (b) full flexibility in waste rock placement; (c) no construction of till

TABLE 3.1 : NET NEUTRALIZATION POTENTIAL AND QUANTITIES OF WASTE ROCK

Effective NP Grum Cal. Phy.	104	KG CaCO ₃ /t
Effective NP V. Sulphides	(691)	KG CaCO ₃ /t
Effective NP Limestone	1,000	kg CaCO ₃ /t
Volume of Vangorda Sulphides	1,173,000	cu.m (bank)
Weight of Vangorda Sulphides	3,392,700	tonnes
Volume of Vangorda Sul. & Phy.	3,305,000	cu.m (bank)
Weight of Vangorda Sul. & Phy.	9,552,770	tonnes
Effective NP V. Sul. & Phy.....	(266)	KG CaCO ₃ /t
Effective NP of V. Phyllites	(32)	KG CaCO ₃ /t
Volume of Van. Phyllite	2,132,000	cu.m (bank)
Weight of V. Phyllite.....	6,160,070	tonnes
Effective NP Grum Sulphides	(364)	KG CaCO ₃ /t
Volume of Grum Sulphides	2,237,108	cu.m (bank)
Weight Of Grum Sulphides	6,346,794	tonnes
Weight of Grum Altered Phy.	2,162,843	tonnes
Volume of Grum Altered Phy.	762,356	cu.m (bank)
ENP of Grum Sul. & Alt. PHy.	(280)	KG CaCO ₃ /t
Weight of Grum Sul. & Alt. Phy.....	8,509,637	tonnes
Volume of Grum sulphides returned to pit(Alt 2.2 & 2.4).....	607,700	cu.m (bank)
Volume of Grum sulphides returned to pit(Alt 2.2 & 2.4).....	760,000	cu.m (loose)
Weight of Grum sulphides returned to pit(Alt 2.2 & 2.4).....	1,728,939	tonnes
Volume of Vangorda Overburden.....	3,080,000	cu.m (loose)
Weight of Vangorda Overburden (Till).....	6,470,000	tonnes
Rock Swell Factor.....	1.3	

berms and covers; (d) short, level or downhill haulage; (e) the size of the dump is reduced by filling in an existing valley and (f) supervisory costs related to selective mining and placement of the waste are avoided. Conversely, there is no mitigation to restrict the generation or migration of acid mine drainage. Treatment would be the only method of AMD control. Because the dump catchment area is relatively large, the amount of drainage to be treated would be significant. Other problems include the control of seepage from the diversion ditch into the pit. The disadvantage of non-selective placement of waste rock is that it would be difficult to extract if sulphide waste was able to be processed at a profit for the contained gold, silver and copper. This disadvantage could be overcome, however, with appropriate design and mining practice.

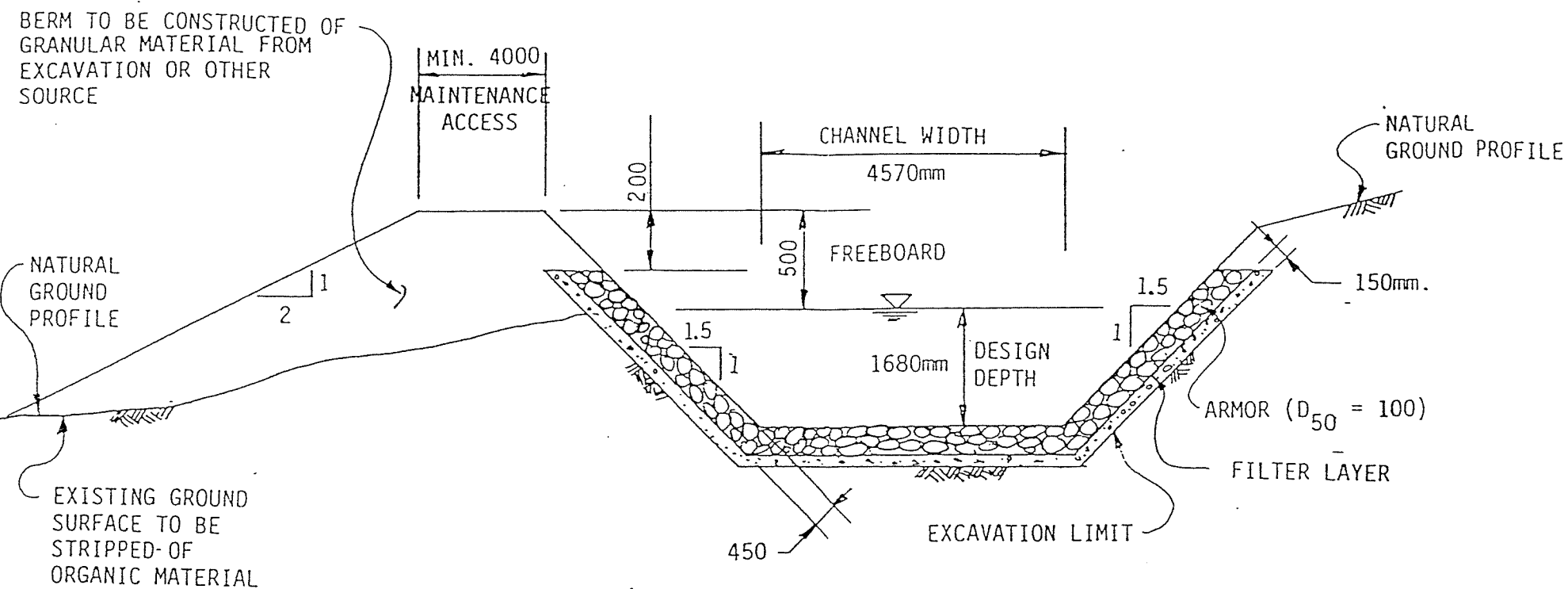
Estimated construction quantities have been prepared for this alternative and are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Diversion Dam		
Foundation Excavation	cu.m	1,000.00
Foundation Preparation	ha	1.80
Till - Haul/ Place / Compact	cu.m	105,000.00
Haul Road Constr.	km	1.5
Rock - Haul/place	cu.m	60,000.00
Blanket Drains - Haul/Place	cu.m	600.00
Spillway Excavation	cu.m	20,000.00
Spillway Riprap/Haul/place	cu.m	10,000.00
Diversion Trench		
Trench Excavation	cu.m	60,000.00
Erosion Protection (Riprap)	cu.m	26,000.00

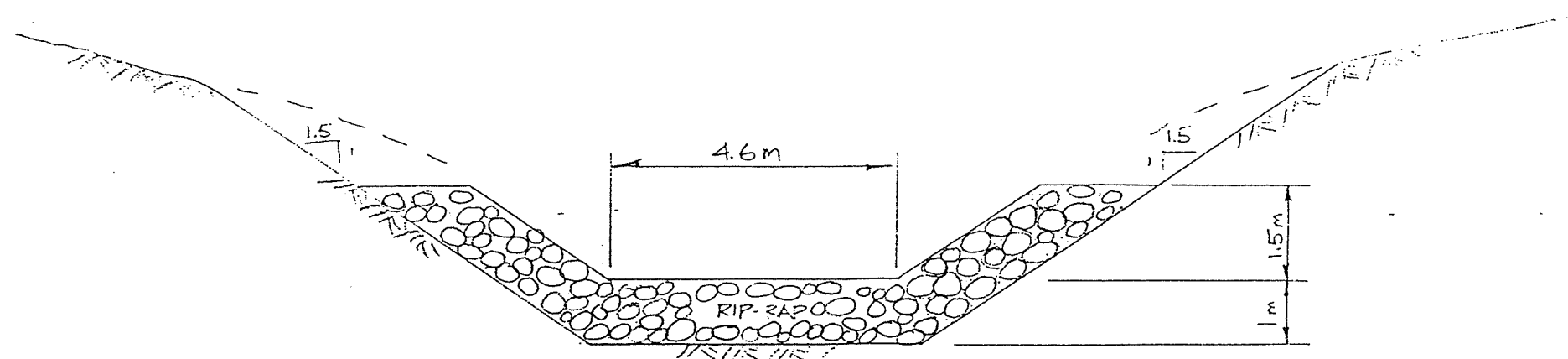
3.1.2 Water Quality Predictions based on Original Flow and Concentration Distributions

The water quality predictions for Alternative 1.1 are presented in Table 3.2. The model assumes that placement of Vangorda rock waste into Vangorda Creek without till or synthetic covers would result in zero runoff, maximising infiltration through the rock dump. This increased infiltration results in a predicted mean monthly zinc concentration of 0.38 mg/L in Vangorda Creek below the mine site and 0.12 mg/L at Faro. These concentrations represent an increase of about 70 percent over the original scheme. The peak monthly concentrations are 1.91 and 0.92 mg/L in Vangorda Creek below the mine site and at Faro respectively. This design would permit runoff and collected seepage from the catchment between the diversion dam and the flooded pit to pass through the dump. The resultant loading from this runoff is expected to be small and has not been included in the model. The acid generation under the conditions assumed in this scenario would continue unabated and would likely result in higher concentrations than those predicted by merely increasing the infiltration rate. To accommodate this condition in the model, the dump was assumed to consist totally of sulphide rock.

The above results assume that there is no collection or treatment of the AMD before discharge into Vangorda Creek. A second condition was also analysed which included treatment with a 90 percent collection efficiency and a treatment plant effluent limitation of 0.5 mg/L. The predicted water quality for this condition is presented on Table 3.2A.



SECTION C-C' *
(NTS)



SECTION D-D'

(after Hydrocon Engineering (Continental) Ltd. drawing
10-7.2-5, Nov. 79)

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE	DEC. 1989
ALTERNATIVE 1.1 DIVERSION DITCH SECTIONS		PROJ. NO.	60609
		APPROVED	
		NO.	3.2
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers			

TABLE 3.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.1

VANGORDA DUMP IN VANGORDA CREEK WITHOUT SEGREGATION AND WITHOUT TILL COVERS
SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	26.8	ha
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha
Mean Annual Precipitation	=	539.0	mm
Mean Annual Evaporation	=	337.3	mm
Upper Till Cover Thickness	=	2.00	m
Lower Till Cover Thickness	=	1.00	m
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec
Waste Rock Hydraulic Conductivity	=	.006	cm/sec
Drainage layer Hydraulic Conductivity	=	.006	cm/sec
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha
Grum Sulphide Cell Area	=	6.0	ha
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha
Catchment Area between Pits	=	266.4	ha

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	2.62
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	3.82
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.01
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.61
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.42
Vangorda Infiltration	1.76	4.62	28.89	133.39	61.51
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	26.57
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	3.86
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.58
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				216.85	100.00

TABLE 3.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Waste	dam^3	1.10	1.10	1.13	3.17	10.32	12.36	7.25	6.26	5.24	4.22	2.15	1.13	4.62	55.42
Dump Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00
	Zn kg	8.81	13.22	28.20	158.47	412.51	370.53	181.30	156.46	130.94	105.42	25.80	9.03	133.39	1600.69
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	15	119	131	77	66	53	37	15	12	46	552
	Zn mg/l	1.69	2.28	4.07	13.85	5.45	4.07	3.93	3.75	3.77	3.71	2.12	0.98	4.34	
	Zn kg	16.08	19.79	38.80	206.92	650.27	532.21	302.60	247.65	199.43	135.82	31.29	11.64	199.38	2392.51
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	41	38	45	65	537	614	358	305	244	171	67	57	212	2544
	Zn mg/l	0.43	0.58	0.93	3.44	1.31	0.96	0.91	0.88	0.89	0.86	0.51	0.24	1.02	
	Zn kg	17.56	21.70	42.03	222.35	700.79	591.53	325.86	268.15	217.36	146.70	34.51	13.69	216.85	2602.24
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
	dam^3	95	86	99	116	1447	1755	974	814	659	466	197	165	573	6873
	Zn mg/l	0.19	0.25	0.43	1.91	0.48	0.34	0.33	0.33	0.33	0.32	0.18	0.08	0.38	
	Zn kg	18	22	42	222	701	592	326	268	217	147	35	14	216.85	2602.24
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.07	0.09	0.17	0.92	0.15	0.10	0.10	0.10	0.10	0.10	0.05	0.03	0.12	
	Zn kg	18	22	42	222	701	592	326	268	217	147	35	14	216.85	2602.24
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0004	0.0008	0.0036	0.0006	0.0003	0.0003	0.0004	0.0004	0.0003	0.0002	0.0001	0.0006	
	Zn kg	18	22	42	222	701	592	326	268	217	147	35	14	216.85	2602.24

TABLE 3.2A: WATER QUALITY PREDICTION ALTERNATIVE 1.1 WITH WATER TREATMENT

PAGE 1 OF 3

VANGORDA DUMP IN VANGORDA CREEK WITHOUT SEGREGATION AND WITHOUT SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER
ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	26.8	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.3	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	266.4	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	2.62
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	3.82
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.01
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.61
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.42
Vangorda Sulphide Cell Infiltration.	1.76	4.62	28.89	133.39	61.51
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	26.57
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	3.86
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.58
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				216.85	100.00

TABLE 3.2A: WATER QUALITY PREDICTION ALTERNATIVE 1.1 WITH WATER TREATMENT

PAGE 2 OF 3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	1.10	1.10	1.13	3.17	10.32	12.36	7.25	6.26	5.24	4.22	2.15	1.13	4.62	55.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00
	Zn kg	8.81	13.22	28.20	158.47	412.51	370.53	181.30	156.46	130.94	105.42	25.80	9.03	133.39	1600.69
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.2A: WATER QUALITY PREDICTION ALTERNATIVE 1.1 WITH WATER TREATMENT

PAGE 3 OF 3

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	15	119	131	77	66	53	37	15	12	46	552
Discharge	Zn mg/l	1.69	2.28	4.07	13.85	5.45	4.07	3.93	3.75	3.77	3.71	2.12	0.98	4.34	
Vangorda	Zn kg	16.08	19.79	38.80	206.92	650.27	532.21	302.60	247.65	199.43	135.82	31.29	11.64	199.38	2392.51
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	41	38	45	65	537	614	358	305	244	171	67	57	212	2544
Discharge	Zn mg/l	0.43	0.58	0.93	3.44	1.31	0.96	0.91	0.88	0.89	0.86	0.51	0.24	1.02	
Vangorda & Grum	Zn kg	17.56	21.70	42.03	222.35	700.79	591.53	325.86	268.15	217.36	146.70	34.51	13.69	216.85	2602.24
Treated Mine	dam^3	37	34	41	58	483	553	323	275	220	154	60	52	191	2289
Effluent Water	Zn mg/l	0.43	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.24	0.49	
(90% of Volume)	Zn kg	15.80	16.96	20.38	29.05	241.58	276.52	161.27	137.33	110.00	76.91	30.22	12.32	94.03	1128.33
Untreated Mine	dam^3	4	4	5	6	54	61	36	31	24	17	7	6	21	254
Effluent Water	Zn mg/l	0.43	0.58	0.93	3.44	1.31	0.96	0.91	0.88	0.89	0.86	0.51	0.24	1.02	
(10% of Volume)	Zn kg	1.76	2.17	4.20	22.23	70.08	59.15	32.59	26.81	21.74	14.67	3.45	1.37	21.69	260.22
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	95	86	99	116	1447	1755	974	814	659	466	197	165	573	6873
	Zn mg/l	0.19	0.22	0.25	0.44	0.22	0.19	0.20	0.20	0.20	0.20	0.17	0.08	0.20	
	Zn kg	18	19	25	51	312	336	194	164	132	92	34	14	115.71	1388.55
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.07	0.08	0.10	0.21	0.07	0.06	0.06	0.06	0.06	0.06	0.05	0.03	0.06	
	Zn kg	18	19	25	51	312	336	194	164	132	92	34	14	115.71	1388.55
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0003	0.0005	0.0008	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.00	
	Zn kg	18	19	25	51	312	336	194	164	132	92	34	14	115.71	1388.55

3.2 Alternative 1.2

3.2.1 Description

Alternative 1.2 for abandonment of the Vangorda waste dump has the following highlights:

- All waste rock from Vangorda Pit placed in dump east of Vangorda Creek;
- No permanent diversion of Vangorda Creek;
- No waste segregation or selective placement;
- No covers on dump;
- Collection and treatment required.

All waste rock from Vangorda pit would be placed, unsegregated, in a single waste dump on the ridge south of the pit as shown on Figures 3.3 and 3.4. Since this dump lies outside of the Vangorda Creek gully, no permanent diversion of Vangorda Creek would be required. However, a small diversion ditch would be constructed above the dump to intercept and divert runoff. The dump would be left uncovered. Sections of the embankment and diversion ditches assumed for this study are shown in Figure 3.4. Further work would be required to ensure that the size of these ditches and the collection pond are adequate.

Construction quantities for this alternative are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Collection Ditches		
Excavation	cu.m	12,800.00
Clearing and Grubbing	ha	3.20
Erosion Protection (riprap)	cu.m	2,000.00
Collection pond		
Clearing and Grubbing	ha	1.00
Foundation Excavation	cu.m	1,900.00
Till- Haul/Place/ Compact	cu.m	18,600.00
Diversion Trench		
Trench Excavation	cu.m	3,200.00
Erosion Protection (Riprap)	cu.m	500.00

3.2.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Alternative 1.2 considers the placement of all Vangorda rock waste into unsegregated waste dumps located east of Vangorda Creek and south of the Vangorda pit. No till covers or geo-membranes would be used in this alternative, and because of the dump configuration, surface area of the dump would be larger than the dump surface area in Alternative 1.1. The areas for Alternative 1.2 and 1.1 are 37.1 and 26.8 hectares respectively.

The water quality predictions for Alternative 1.2 are presented in Table 3.3. The model assumes that placement of Vangorda rock waste into uncovered and unsegregated dumps would result in zero surface runoff from the dumps, maximizing infiltration. This increased infiltration results in a predicted annual mean monthly zinc concentration of 0.47 mg/L in Vangorda Creek below the mine site and 0.14 mg/L at Faro. These concentrations are approximately twice the values predicted for the original scheme and are higher than concentrations predicted for Alternative 1.1. The zinc loading would increase by 110 percent. The peak monthly concentrations which occurs in April are 2.41 and 1.18 mg/L in Vangorda Creek below the mine site and at Faro respectively. As for Alternative 1.1, an analysis was completed for the option to collect and treat. Drainage from the dump would be carried by collection ditches to a pond formed behind an earth fill embankment, as shown in Figure 3.3. The water quality prediction for this treatment alternative is presented on Table 3.3A.

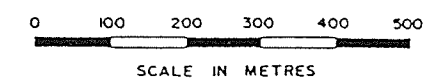


ALTERNATIVE 1.2

- Construct dry dump southwest of pit (above Vangorda Creek)
- No waste segregation
- No covers
- Collect and treat drainage

KEY

-  UNSEGREGATED WASTE ROCK
-  WATER



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE NOV 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.2 PLAN		PROJ NO 60609
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		APPROVED NO
		3.3

TABLE 3.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2

VANGORDA UNSEGREGATED DUMP EAST OF CREEK AND SOUTH OF PIT - NO TILL COVER

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	37.1	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.1	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	256.1	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	2.12
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	3.09
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.01
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.49
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.34
Vangorda Waste Dump Infiltration	2.43	6.39	28.89	184.66	68.87
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	21.49
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	3.12
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.47
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				268.12	100.00

TABLE 3.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Waste	dam^3	1.52	1.52	1.56	4.39	14.28	17.11	10.04	8.66	7.25	5.84	2.97	1.56	6.39	76.71
Dump Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00
	Zn kg	12.20	18.30	39.03	219.37	571.05	512.93	250.99	216.59	181.26	145.94	35.71	12.50	184.66	2215.88
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	16	123	135	80	68	55	38	16	12	48	573
	Zn mg/l	1.96	2.73	4.98	16.58	6.57	4.98	4.66	4.50	4.55	4.61	2.65	1.22	5.25	
	Zn kg	19.47	24.88	49.64	267.82	808.81	674.62	372.29	307.78	249.75	176.34	41.21	15.11	250.64	3007.70
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	42	38	46	66	541	619	361	308	246	173	68	58	214	2565
	Zn mg/l	0.50	0.70	1.16	4.31	1.59	1.19	1.10	1.07	1.09	1.09	0.65	0.30	1.25	
	Zn kg	20.95	26.79	52.86	283.25	859.33	733.94	395.55	328.28	267.69	187.22	44.43	17.16	268.12	3217.43
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
	dam^3	95	86	99	118	1451	1760	977	816	661	467	198	165	575	6894
	Zn mg/l	0.22	0.31	0.53	2.41	0.59	0.42	0.40	0.40	0.40	0.40	0.22	0.10	0.47	
	Zn kg	21	27	53	283	859	734	396	328	268	187	44	17	268.12	3217.43
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.09	0.11	0.22	1.18	0.19	0.12	0.13	0.12	0.12	0.13	0.06	0.04	0.14	
	Zn kg	21	27	53	283	859	734	396	328	268	187	44	17	268.12	3217.43
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0005	0.0010	0.0046	0.0008	0.0004	0.0004	0.0005	0.0005	0.0004	0.0002	0.0002	0.0005	
	Zn kg	21	27	53	283	859	734	396	328	268	187	44	17	268.12	3217.43

TABLE 3.3A: WATER QUALITY PREDICTION - ALTERNATIVE 1.2 WITH TREATMENT

PAGE 1 OF 3

VANGORDA UNSEGREGATED DUMP EAST OF CREEK AND SOUTH OF PIT - NO T

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	37.1	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.1	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	256.1	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	2.12
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	3.09
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.01
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.49
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.34
Vangorda Sulphide Cell Infiltration.	2.43	6.39	28.89	184.66	68.87
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	21.49
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	3.12
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.47
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				268.12	100.00

TABLE 3.3A: WATER QUALITY PREDICTION - ALTERNATIVE 1.2 WITH TREATMENT

PAGE 2 OF 3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	1.52	1.52	1.56	4.39	14.28	17.11	10.04	8.66	7.25	5.84	2.97	1.56	6.39	76.71
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00
	Zn kg	12.20	18.30	39.03	219.37	571.05	512.93	250.99	216.59	181.26	145.94	35.71	12.50	184.66	2215.88
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.3A: WATER QUALITY PREDICTION - ALTERNATIVE 1.2 WITH TREATMENT

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	16	123	135	80	68	55	38	16	12	48	573
Discharge	Zn mg/l	1.96	2.73	4.98	16.58	6.57	4.98	4.66	4.50	4.55	4.61	2.65	1.22	5.25	
Vangorda	Zn kg	19.47	24.88	49.64	267.82	808.81	674.62	372.29	307.78	249.75	176.34	41.21	15.11	250.64	3007.70
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	42	38	46	66	541	619	361	308	246	173	68	58	214	2565
Discharge	Zn mg/l	0.50	0.70	1.16	4.31	1.59	1.19	1.10	1.07	1.09	1.09	0.65	0.30	1.25	
Vangorda & Grum	Zn kg	20.95	26.79	52.86	283.25	859.33	733.94	395.55	328.28	267.69	187.22	44.43	17.16	268.12	3217.43
Treated Mine	dam^3	37	34	41	59	487	557	325	277	222	155	61	52	192	2308
Effluent Water	Zn mg/l	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.50	
(90% of Volume)	Zn kg	18.71	17.15	20.58	29.60	243.36	278.65	162.52	138.41	110.91	77.64	30.60	15.44	95.30	1143.57
Untreated Mine	dam^3	4	4	5	7	54	62	36	31	25	17	7	6	21	256
Effluent Water	Zn mg/l	0.50	0.70	1.16	4.31	1.59	1.19	1.10	1.07	1.09	1.09	0.65	0.30	1.25	
(10% of Volume)	Zn kg	2.09	2.68	5.29	28.33	85.93	73.39	39.55	32.83	26.77	18.72	4.44	1.72	26.81	321.74
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	95	86	99	118	1451	1760	977	816	661	467	198	165	575	6894
	Zn mg/l	0.22	0.23	0.26	0.49	0.23	0.20	0.21	0.21	0.21	0.21	0.18	0.10	0.21	
	Zn kg	21	20	26	58	329	352	202	171	138	96	35	17	122.11	1465.31
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.09	0.08	0.11	0.24	0.07	0.06	0.06	0.06	0.06	0.07	0.05	0.04	0.07	
	Zn kg	21	20	26	58	329	352	202	171	138	96	35	17	122.11	1465.31
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0003	0.0005	0.0009	0.0003	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	
	Zn kg	21	20	26	58	329	352	202	171	138	96	35	17	122.11	1465.31

3.3 Alternative 1.3 (Vangorda Waste Dump Original Scheme)

3.3.1 Description

Alternative 1.3 is the original scheme presented in the IEE, Stage II Report (July 1989). The abandonment plan would require the mine to:

- Construct dump east of Vangorda Creek below pit;
- Segregate and selectively place sulphide and phyllite waste;
- Construct till berms around each waste type to form two cells. Cover waste with 3 metre thick layer of till. Provide rock drains with air return control;
- Internal till layers to limit water infiltration.

Construction quantities for this alternative are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Berms and Internal Layer		
Foundation Preparation	ha	59.00
Till Placement	cu.m	2,170,000.00
Dump Cover (Lower 1m)		
Till Haul	cu.m	396,000.00
Till Placement and Compaction	cu.m	396,000.00
Dump Cover (Upper 2m)		
Till Haul	cu.m	804,000.00
Till Placement	cu.m	804,000.00
Rock Drain		
Supply & Install Blanket	cu.m	6,000.00
Supply & Install Finger Drains	cu.m	1,350.00
Supply & Install 60 mil HDPE	sq.m	350.00
Supply & Place Bedding	cu.m	120
Selective Placement of Waste	cu.m	4,296,500.00
Erosion Protection (vegetation)	ha	59.00

The dump configuration is shown in plan on Figure 3.5, and in section on Figures 3.6 and 3.7. Waste from Vangorda pit would be segregated into sulphide and phyllite waste. The sulphide and phyllite would be placed in separate cells and till overburden and waste rock from the pit would be used to construct till/rock berms around the cells. Rock drains designed to control air entry into the dump would be provided to prevent pore water pressures building up behind the berms. A detail of one on

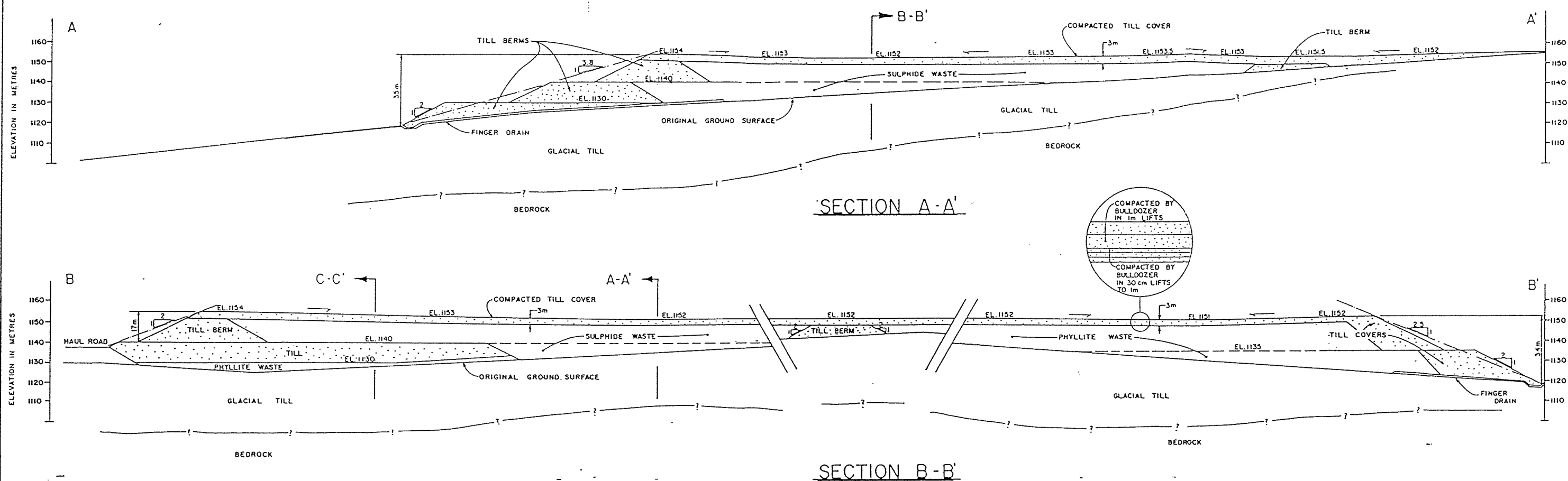
these drains is provided in Figure 3.8. Finally, a cover of compacted till, 3 metres thick, would be placed over the entire dump. Erosion control would consist of hydroseeding the till cover to promote a vegetative cover.

Separating the waste into two isolated cells allows relatively easy access to the sulphide waste should it become economically worthwhile to process that material as ore at a later date. However the main reason the sulphide waste is segregated is to reduce the surface area of the dump so as to limit the exposure to water and to simplify effluent management. The till covers and berms help restrict water infiltration into the dump, thereby reducing the amount of AMD flowing from the dumps. They may also prove effective at limiting of oxygen infiltration into the dump reducing AMD generation.

3.3.2 Water Quality Predictions based on Original Flow and Concentration Distribution

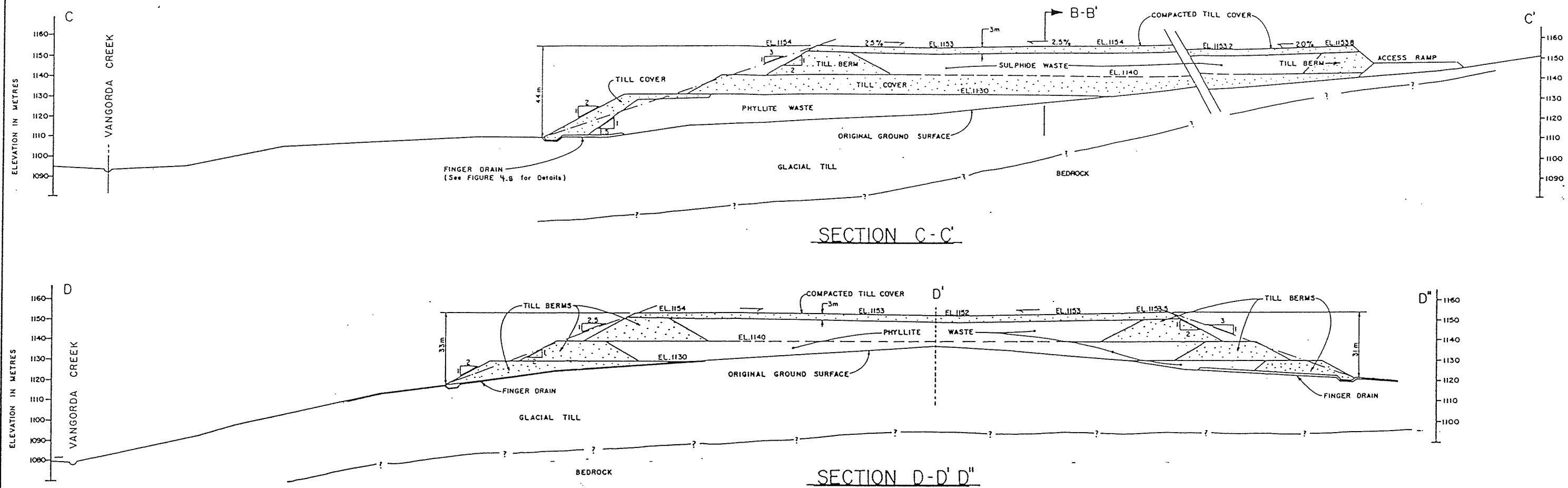
Alternative 1.3 is the abandonment plan for the Vangorda Dumps as presented in the July 1989 IEE. In this alternative the Vangorda sulphide and phyllite rock waste is placed in separate waste dump cells and covered with till. Dump areas are 18 and 25 hectares respectively. The primary function of the till cover is to increase surface runoff and reduce infiltration into the waste rock dumps. The model assumes that runoff would be about 35 percent of total precipitation with 10 percent infiltration. These figures were derived from the HELP model which is discussed in more detail in Section 7.0.

The water quality predictions for Alternative 1.3 are presented in Table 3.4. The model predicts an annual mean monthly zinc concentration of 0.22 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The peak monthly concentrations are 1.05 and 0.52 mg/L in Vangorda Creek below the mine site and at Faro respectively.



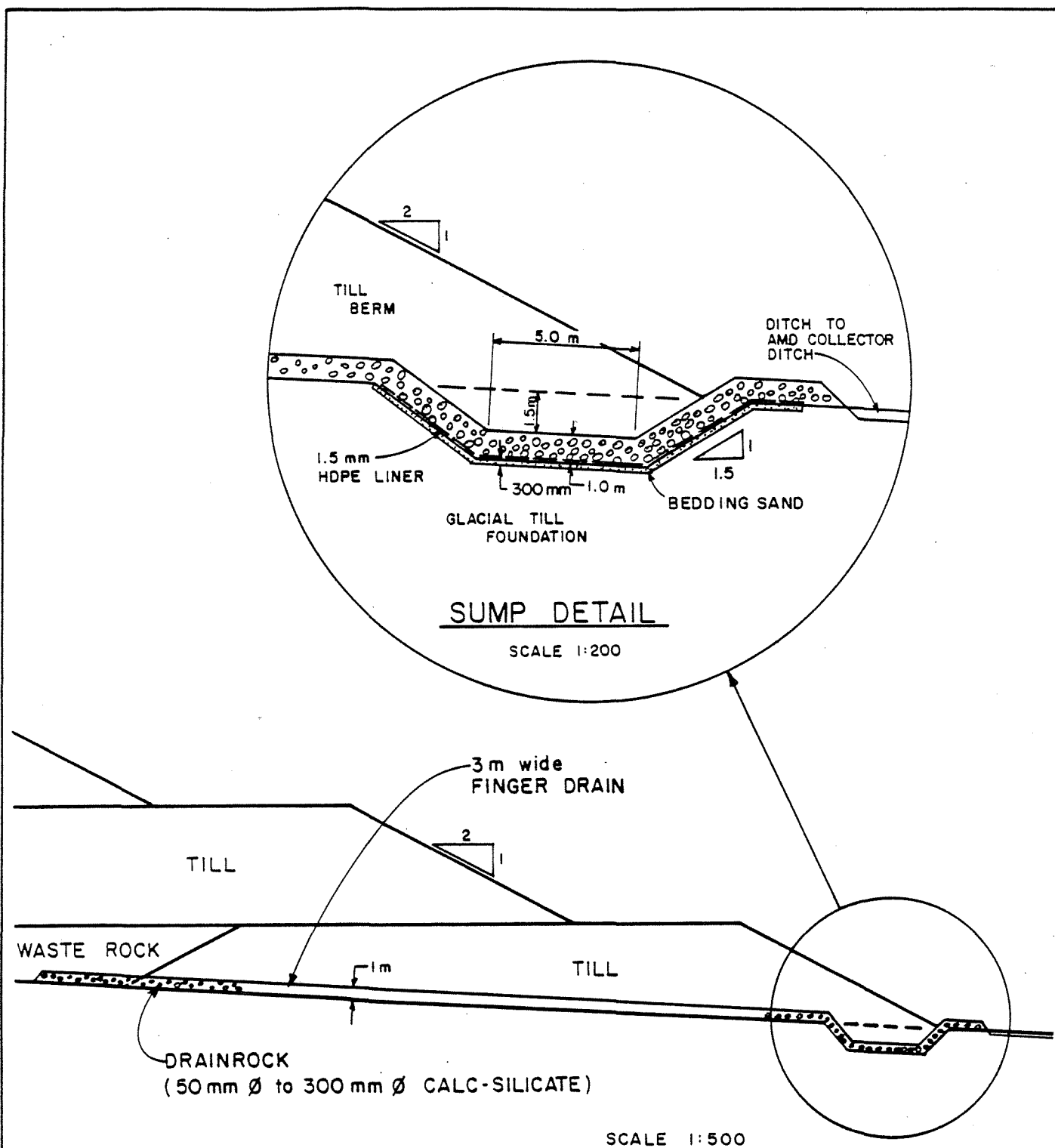
SCALE - 1:2000

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.3 SECTIONS A-A' AND B-B'		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO. 3.6



SCALE - 1:2000

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.3 SECTIONS C-C' AND D-D' D''		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		N.O. 3.7



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
FINGER DRAIN & SUMP TYPICAL DETAILS		PROJ. NO. 60609
		APPROVED
		NO. 3.8
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

TABLE 3.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.3

TILL COVERS ON SULPHIDE AND PHYLLITE CELLS

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	18.0	ha	(Original Area was 20.75)ha)
Vangorda Phyllite Cell Waste Dump Catchment Area	-	25.0	ha	(Original Area was 22.5)ha)
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha	
Mean Annual Precipitation	-	539.0	mm	
Mean Annual Evaporation	-	337.1	mm	
Upper Till Cover Thickness	-	2.00	m	
Lower Till Cover Thickness	-	1.00	m	
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	-	.006	cm/sec	
Drainage layer Hydraulic Conductivity	-	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha	
Grum Sulphide Cell Area	-	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha	
Catchment Area between Pits	-	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam ³)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	4.46
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	6.49
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.02
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.04
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.71
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	19.48
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.06
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	14.92
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.08
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	45.19
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.56
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.99
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				127.51	100.00

TABLE 3.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.08	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
	Zn mg/l	1.01	1.32	2.11	6.27	2.93	1.88	2.14	1.99	1.90	1.66	0.96	0.43	2.19	
	Zn kg	10.13	11.99	21.12	109.86	372.83	272.86	180.72	143.37	109.90	66.45	15.50	5.70	110.04	1320.43
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	42	38	46	67	545	629	366	311	249	174	68	59	216	2595
	Zn mg/l	0.28	0.37	0.53	1.87	0.78	0.53	0.56	0.53	0.51	0.44	0.27	0.13	0.59	
	Zn kg	11.60	13.90	24.34	125.29	423.35	332.18	203.98	163.87	127.83	77.33	18.72	7.75	127.51	1530.15
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6924
	Zn mg/l	0.12	0.16	0.24	1.05	0.29	0.19	0.21	0.20	0.19	0.16	0.09	0.05	0.22	
	Zn kg	12	14	24	125	423	332	204	164	128	77	19	8	127.51	1530.15
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.05	0.06	0.10	0.52	0.09	0.05	0.06	0.06	0.06	0.05	0.03	0.02	0.07	
	Zn kg	12	14	24	125	423	332	204	164	128	77	19	8	127.51	1530.15
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0002	0.0002	0.0005	0.0020	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0004	
	Zn kg	12	14	24	125	423	332	204	164	128	77	19	8	127.51	1530.15

3.4 Alternative 1.4

3.4.1 Description

Alternative 1.4 would require the mine to:

- Construct dump east of Vangorda Creek below pit moving sulphide cell out of ravine;
- Segregate and selectively place sulphide and phyllite waste;
- Construct till berms around each waste type to form two separate cells; Cover waste with 3 metre thick layer of till; Provide rock drains with air return control.

This proposal is similar to Alternative 1.3, with the exception that the sulphide cell has been moved out of the ravine. This allows establishment of a spillway at the southwest end of the pit, if required and would allow for possible development of the ravine as a bio-engineered passive wetland for water treatment. The configuration of the dump is shown in plan on Figure 3.9 and in section on Figure 3.10.

Construction quantities estimated for this scheme are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Berms and Internal Layer		
Foundation Preparation	ha	56.30
Till Placement	cu.m	2,370,000.00
Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Rock Drain		
Supply & Install Blanket	cu.m	6,000.00
Supply & Install Finger Drains	cu.m	1,350.00
Supply & Install 60 mil HDPE	sq.m	350.00
Supply & Place Bedding	cu.m	120
Selective Placement of Waste	cu.m	4,296,500.00
Erosion Protection	ha	56.30

3.4.2 Water Quality Predictions based on Original Flow and Concentration Distributions

The Vangorda sulphide and phyllite rock waste for this scheme is also placed in separate waste dump cells and covered with till. Dump areas for the sulphide and phyllite cells are 12 and 28 hectares respectively. Runoff and infiltration represent about 35 and 10 percent of the total precipitation respectively.

The water quality predictions for Alternative 1.4 are presented in Table 3.5. The model predicts an annual mean monthly zinc concentration of 0.21 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The monthly concentration peaks are 1.00 and 0.49 mg/L in Vangorda Creek below the mine site and at Faro, respectively.

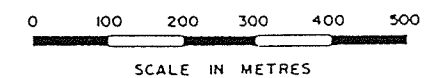


ALTERNATIVE 1.4

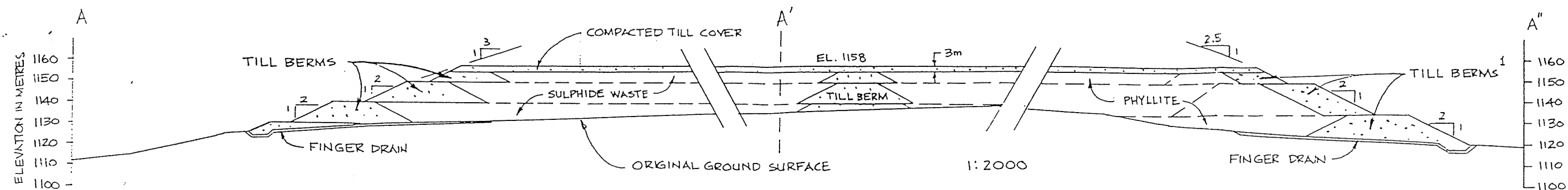
- Construct dump east of Vangorda Creek and below pit, but keep sulphides out of ravine (allows establishment of spillway from southwest end of pit)
- Segregate and selectively place sulphide and phyllite waste
- Construct till berms around each waste type to form two cells. Cover waste with 3 metre thick layer of till. Provide rock drains with air return control

KEY

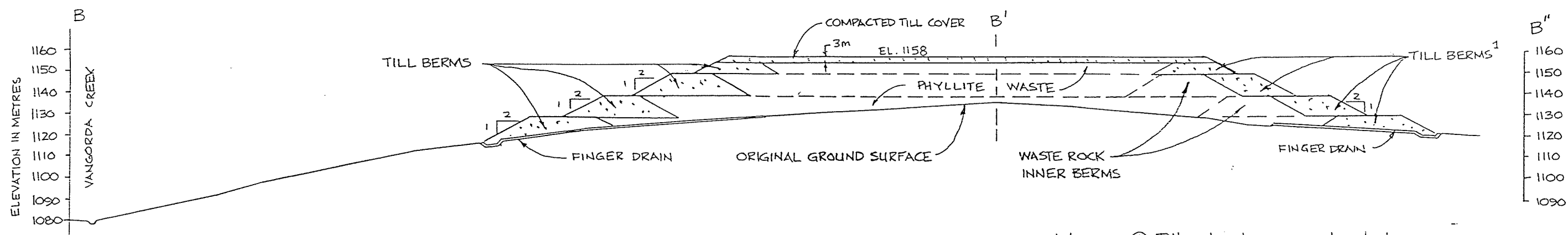
 TILL COVER AND BERMS



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.4 PLAN		PROJ NO 60609
		APPROVED
		NO 3.9
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		



SECTION A-A' A''



SECTION B-B' B''

Notes: ① Till outer berms constructed simultaneously with wasterock inner berms as shown.

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC.1989
VANGORDA WASTE DUMP ALTERNATIVE 1.4 SECTIONS		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		N.O. 3.10

TABLE 3.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4

TILL COVERS ON SULPHIDE AND PHYLLITE CELLS

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	12.4	ha
Vangorda Phyllite Cell Waste Dump Catchment Area	-	27.6	ha
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha
Mean Annual Precipitation	-	539.0	mm
Mean Annual Evaporation	-	337.1	mm
Upper Till Cover Thickness	-	2.00	m
Lower Till Cover Thickness	-	1.00	m
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec
Waste Rock Hydraulic Conductivity	-	.006	cm/sec
Drainage layer Hydraulic Conductivity	-	.006	cm/sec
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha
Grum Sulphide Cell Area	-	6.0	ha
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha
Catchment Area between Pits	-	253.3	ha

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	4.67
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	6.80
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.02
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.09
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.74
Vangorda Sulphide Cell Infiltration.	0.23	0.60	28.60	17.11	14.06
Vangorda Sulphide Cell Runoff	0.75	1.96	0.03	0.05	0.04
Vangorda Phyllite Cell Infiltration.	0.51	1.33	15.77	21.00	17.25
Vangorda Phyllite Cell Runoff	1.66	4.36	0.03	0.12	0.10
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	47.33
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.87
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.03
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				121.75	100.00

TABLE 3.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.16	0.16	0.17	0.42	1.29	1.54	0.92	0.81	0.68	0.56	0.30	0.17	0.60	7.18
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.29	1.94	4.34	21.08	51.57	46.11	22.94	20.15	17.05	13.95	3.57	1.39	17.11	205.37
Vangorda Sulphide	dam^3	0.29	0.26	0.29	1.24	3.99	6.20	3.35	2.77	2.25	1.60	0.70	0.58	1.96	23.53
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.06	0.12	0.25	0.07	0.06	0.05	0.02	0.01	0.01	0.05	0.63
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.94	2.87	3.42	2.04	1.79	1.52	1.24	0.66	0.39	1.33	15.98
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.08	2.87	4.64	33.78	66.01	47.90	28.59	25.11	18.22	17.38	5.30	1.16	21.00	252.04
Vangorda Phyllite	dam^3	0.65	0.59	0.65	2.76	8.88	13.80	7.45	6.16	5.02	3.57	1.57	1.29	4.36	52.37
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.55	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.41
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	17	126	143	84	71	57	39	16	13	50	596
	Zn mg/l	0.98	1.27	1.98	6.04	2.82	1.79	2.07	1.92	1.82	1.57	0.91	0.39	2.10	
	Zn kg	9.64	11.39	19.59	103.51	355.73	256.49	173.04	136.63	103.90	61.79	14.38	5.18	104.27	1251.27
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	42	38	46	67	544	627	365	310	249	174	68	59	216	2587
	Zn mg/l	0.27	0.35	0.50	1.78	0.75	0.50	0.54	0.51	0.49	0.42	0.26	0.12	0.56	
	Zn kg	11.12	13.30	22.81	118.94	406.25	315.81	196.30	157.13	121.84	72.67	17.61	7.23	121.75	1461.00
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.17	0.07	0.06	0.22	
	dam^3	95	86	99	119	1454	1768	981	819	663	468	198	166	576	6917
	Zn mg/l	0.12	0.15	0.23	1.00	0.28	0.18	0.20	0.19	0.18	0.16	0.09	0.04	0.21	
	Zn kg	11	13	23	119	406	316	196	157	122	73	18	7	121.75	1461.00
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.05	0.06	0.09	0.49	0.09	0.05	0.06	0.06	0.06	0.05	0.02	0.01	0.07	
	Zn kg	11	13	23	119	406	316	196	157	122	73	18	7	121.75	1461.00
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0002	0.0002	0.0004	0.0019	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.00	
	Zn kg	11	13	23	119	406	316	196	157	122	73	18	7	121.75	1461.00

3.5 Alternative 1.5

3.5.1 Description

Alternative 1.5 is described as follows:

- Segregate waste rock into sulphide and phyllite;
- Place phyllite waste in dump on ridge southwest of pit;
- Place sulphide waste in pit under water cover (at end of operations);
- Construct till berms around phyllite cell; Cover cell with 3 m thick till layer; Provide rock drains with air return control;
- Store sulphide waste in temporary stockpile during operations; Blend sulphide with limestone or calcareous phyllite.

Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Phyllite Cell Berm Construction		
Foundation Preparation	ha	48.50
Till Placement	cu.m	2,200,000.00
Phyllite Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Phyllite Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Rock Drain		
Supply & Install Blanket	cu.m	6,000.00
Supply & Install Finger Drains	cu.m	1,350.00
Supply & INstall 80 mil HDPE	sq.m	350.00
Selective Placement of Waste	cu.m	4,296,500.00
Erosion Protection(vegetation)	ha	48.50
Replacement of Sul. Waste into Vangorda Pit	cu.m	1,540,149.00
Clean up Stockpile Area	ha	20.00

Phyllite waste would be placed in a single dump as shown in Figure 3.11. This phyllite cell would be contained by till berms as shown in Figure 3.12 and would be covered with a layer of compacted till 3 metres thick. The sulphide waste would be placed in a temporary stockpile during operations,

then returned to the pit prior to the planned flooding of Vangorda Pit to El. 1122.5 after abandonment.

Placing the sulphide waste in the pit under water prevents oxidation of the sulphide rock and reduces the likelihood of acid generation. The phyllite would remain a potential source of AMD, but the till berms and covers would reduce the migration of AMD significantly.

To suppress the flushing of AMD products from the sulphide waste that would be temporarily stockpiled during operations, blending with limestone or acid consuming calcareous phyllite would be required.

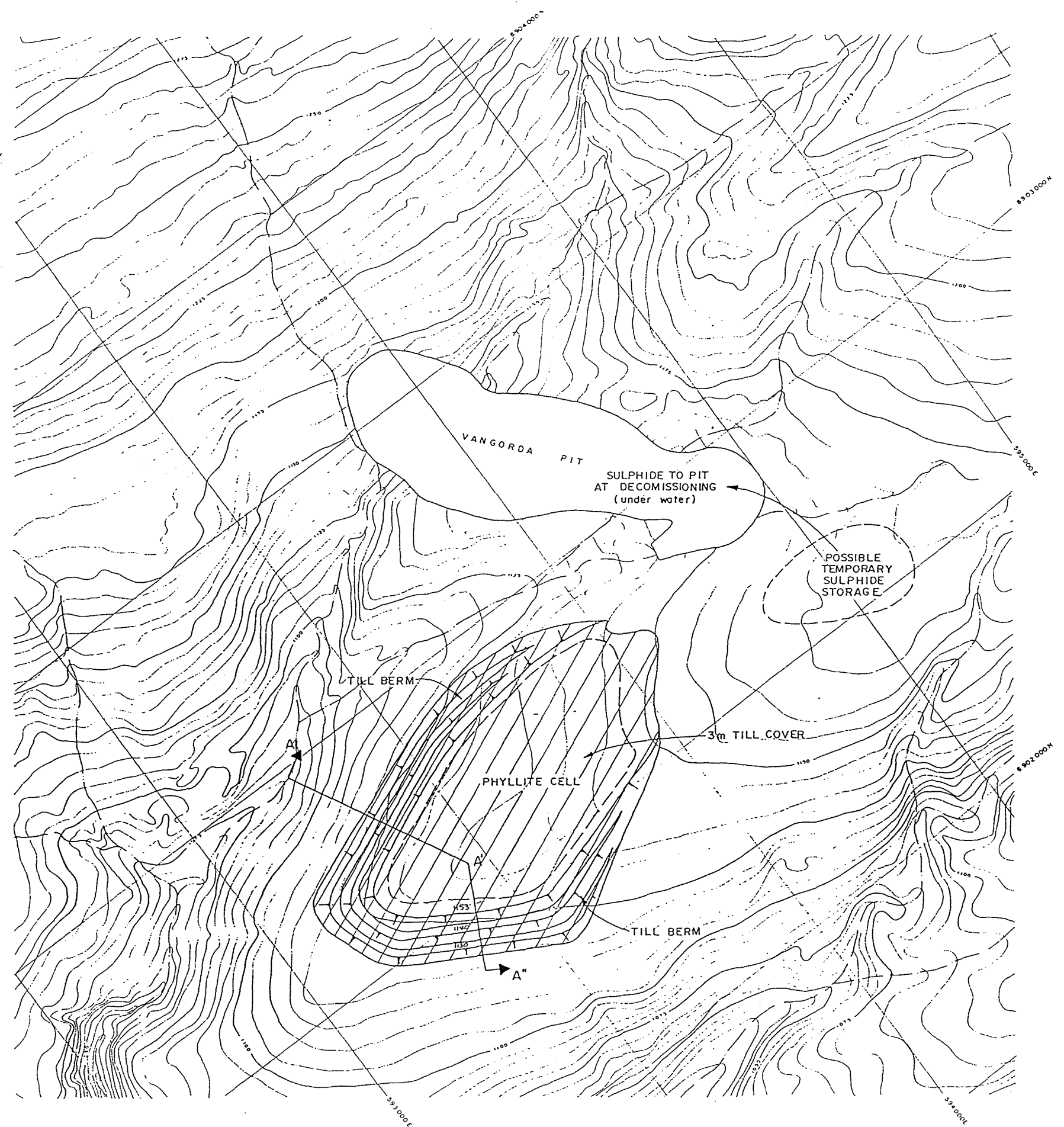
There is also an additional cost associated with rehandling the sulphide waste back into the pit. The site of the temporary sulphide stockpile would also have to be cleaned up after abandonment to ensure that no potentially acid-generating material is left behind.

3.5.2 Water Quality Predictions based on Original Flow and Concentration Distribution

In this alternative the sulphide rock waste is stockpiled during the mining operation and upon completion of mining, the sulphide is returned to the pit. The sulphide would be below 1122.5 metres in the pit and so would be submerged. A phyllite rock waste cell would still be created in this option. The area of the phyllite cell would be 28 hectares.

Water quality predictions for this alternative are shown in Table 3.6. The model predicts a mean monthly zinc concentration of 0.18 mg/L in Vangorda Creek below the mine site and 0.06 mg/L at Faro. The peak monthly concentrations which occur in April are 0.84 and 0.41 mg/L in Vangorda Creek below the mine site and at Faro respectively. In comparison with the base case removal of the sulphide waste cell reduces zinc loading in Vangorda Creek by about 18 percent.

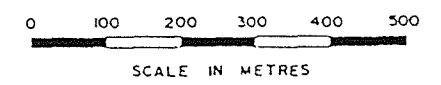
During construction of these dumps, it is assumed that errant loads of sulphide waste would not be placed in the phyllite cell. In the event that some sulphide loads are inadvertently deposited into the phyllite cell, the assumed metal concentrations in the phyllite cell leachate in the model was increased to compensate.



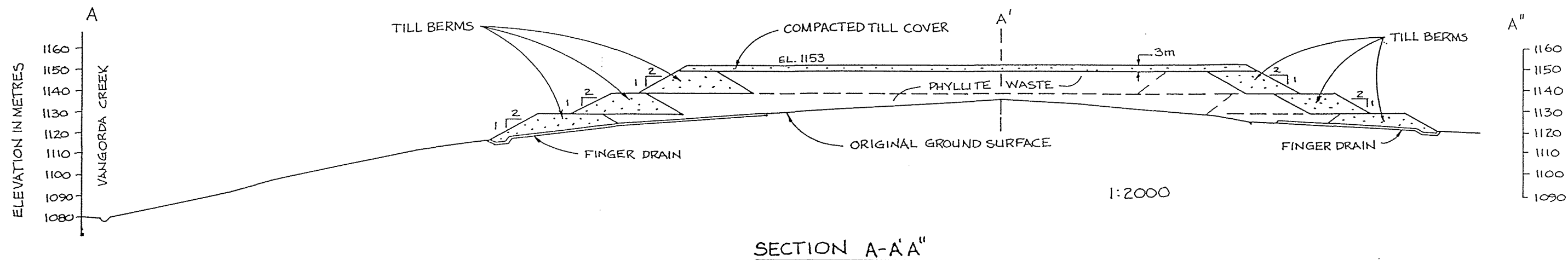
ALTERNATIVE 1.5

- Return sulphide waste and low-grade and oxidized ore to pit beneath water
- Place phyllite in separate dump with till berms and 3 metre thick till cover. Provide rock drains with air return control
- Stockpile and blend sulphide waste with limestone or calcareous phyllite during operations
- Clean up stockpile area

KEY
 TILL COVER AND BERMS



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE NOV 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.5 PLAN		PROJ NO 606 629
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO 3.11



CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.5 SECTION		PROJ. NO. 60609
		APPROVED
		N.O. 3.12
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

TABLE 3.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5

VANGORDA SULPHIDE RETURNED TO PIT UNDERWATER AND PHYLLITE ENCAPSULATED

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	0.0	ha
Vangorda Phyllite Cell Waste Dump Catchment Area	-	28.0	ha
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha
Mean Annual Precipitation	-	539.0	mm
Mean Annual Evaporation	-	337.1	mm
Upper Till Cover Thickness	-	2.00	m
Lower Till Cover Thickness	-	1.00	m
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec
Waste Rock Hydraulic Conductivity	-	.006	cm/sec
Drainage layer Hydraulic Conductivity	-	.006	cm/sec
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha
Grum Sulphide Cell Area	-	6.0	ha
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha
Catchment Area between Pits	-	265.2	ha

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	5.42
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	7.90
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.02
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.26
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.86
Vangorda Sulphide Cell Infiltration.	0.00	0.00	26.69	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.51	1.35	15.77	21.31	20.31
Vangorda Phyllite Cell Runoff	1.68	4.43	0.03	0.12	0.11
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	54.94
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	7.97
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.20
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				104.89	100.00

TABLE 3.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.95	2.91	3.47	2.07	1.82	1.54	1.26	0.67	0.39	1.35	16.21
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.09	2.91	4.70	34.27	66.97	48.60	29.00	25.47	18.48	17.64	5.37	1.18	21.31	255.69
Vangorda Phyllite	dam^3	0.66	0.59	0.66	2.80	9.01	14.00	7.56	6.25	5.09	3.62	1.59	1.31	4.43	53.13
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.56	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.43
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	9	9	9	16	121	136	79	68	54	37	15	12	47	566
	Zn mg/l	0.89	1.11	1.62	5.34	2.52	1.55	1.89	1.72	1.60	1.29	0.73	0.30	1.85	
	Zn kg	8.37	9.49	15.32	82.86	305.00	210.84	150.45	116.79	87.07	48.07	10.88	3.80	87.41	1048.94
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	41	38	45	65	538	620	361	307	246	172	67	58	213	2557
	Zn mg/l	0.24	0.30	0.41	1.51	0.66	0.44	0.48	0.45	0.43	0.34	0.21	0.10	0.49	
	Zn kg	9.84	11.40	18.54	98.29	355.52	270.16	173.71	137.29	105.01	58.95	14.10	5.85	104.89	1258.67
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
	dam^3	95	86	99	117	1449	1760	977	816	661	466	197	165	574	6887
	Zn mg/l	0.10	0.13	0.19	0.84	0.25	0.15	0.18	0.17	0.16	0.13	0.07	0.04	0.18	
	Zn kg	10	11	19	98	356	270	174	137	105	59	14	6	104.89	1258.67
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.04	0.05	0.08	0.41	0.08	0.04	0.05	0.05	0.05	0.04	0.02	0.01	0.06	
	Zn kg	10	11	19	98	356	270	174	137	105	59	14	6	104.89	1258.67
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0002	0.0004	0.0016	0.0003	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.00	
	Zn kg	10	11	19	98	356	270	174	137	105	59	14	6	104.89	1258.67

3.6 Alternative 1.5.1

3.6.1 Description

Alternative 1.5.1 is the same as Alternative 1.5 except that all of the Vangorda waste would be placed back into the pit. All waste rock would be blended with calcareous limestone or phyllite and stored in a temporary stockpile during operations. At abandonment all of the waste rock would be returned to the pit under water and the stockpile area cleaned up to remove any remaining acid generating material.

The storage volume of the pit below the natural water level (El. 1122.5 m), however, may not be sufficient to store all of the waste rock, depending on the bulking factor assumed. It may be necessary to construct an in-pit dam to raise the water level so that all of the waste remains under water or the surplus may be hauled to the Grum Pit.

Construction quantities estimated for this alternative are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Waste	cu.m	4,296,500.00
Replacement of All Waste into Vangorda Pit	cu.m	4,360,947.50
Clean up Stockpile Area	ha	43.00

3.6.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions for this alternative are shown in Table 3.7. The model predicts an annual mean monthly zinc concentration of 0.15 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations are 0.56 and 0.27 mg/L in Vangorda Creek below the mine site and at Faro respectively. Removal of both the Vangorda sulphide and phyllite waste cell greatly reduces zinc concentrations in Vangorda Creek. The significance of the phyllite waste is evident through comparison of Alternatives 1.5 and 1.5.1. The phyllite, although having lower acid generating potential, is more abundant and thus has a significant impact on the water quality of Vangorda Creek.

TABLE 3.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1

VANGORDA SULPHIDE AND PHYLLITE WASTE RETURNED TO VANGORDA PIT

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	-	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha	
Mean Annual Precipitation	-	539.0	mm	
Mean Annual Evaporation	-	294.3	mm	
Upper Till Cover Thickness	-	2.00	m	
Lower Till Cover Thickness	-	1.00	m	
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	-	.006	cm/sec	
Drainage layer Hydraulic Conductivity	-	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha	
Grum Sulphide Cell Area	-	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha	
Catchment Area between Pits	-	293.2	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	6.81
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	9.92
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.03
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.59
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.08
Vangorda Sulphide Cell Infiltration.	0.00	0.00	26.69	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	69.04
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	10.02
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.51
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				83.46	100.00

TABLE 3.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
Dec-89															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

Dec-89

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge	dam^3	8	8	8	12	109	118	70	60	48	32	13	11	41	496
	Zn mg/l	0.86	0.87	1.26	4.12	2.18	1.37	1.74	1.53	1.44	0.94	0.44	0.24	1.59	
	Zn kg	7.27	6.57	10.61	48.45	237.76	161.68	121.30	91.19	68.49	30.40	5.49	2.61	65.98	791.82
Mine Effluent Discharge	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge	dam^3	40	37	44	61	527	602	351	299	239	167	65	56	207	2488
	Zn mg/l	0.22	0.23	0.31	1.04	0.55	0.37	0.41	0.37	0.36	0.25	0.13	0.08	0.40	
	Zn kg	8.74	8.48	13.83	63.88	288.27	221.00	144.56	111.69	86.43	41.28	8.71	4.66	83.46	1001.54
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.03	0.03	0.04	0.04	0.54	0.65	0.36	0.30	0.24	0.17	0.07	0.06	0.21	
	dam^3	94	85	98	113	1437	1743	967	808	654	461	195	163	568	6818
	Zn mg/l	0.09	0.10	0.14	0.56	0.20	0.13	0.15	0.14	0.13	0.09	0.04	0.03	0.15	
	Zn kg	9	8	14	64	288	221	145	112	86	41	9	5	83.46	1001.54
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.04	0.04	0.06	0.27	0.06	0.04	0.05	0.04	0.04	0.03	0.01	0.01	0.04	
	Zn kg	9	8	14	64	288	221	145	112	86	41	9	5	83.46	1001.54
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0003	0.0010	0.0003	0.0001	0.0001	0.0002	0.0002	0.0001	0.0000	0.0000	0.00	
	Zn kg	9	8	14	64	288	221	145	112	86	41	9	5	83.46	1001.54

3.7 Alternative 1.6

3.7.1 Description

Alternative 1.6 would include:

- The placement of all waste rock from Vangorda Pit behind an engineered embankment in Vangorda Creek and allow to flood;
- Provision for a spillway adjacent to the dam for Vangorda Creek;
- Construct wetland environment on top of waste rock.

Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Dam Construction in Vangorda Creek		
Foundation Excavation	cu.m	125,000.00
Foundation Preparation	ha	18.00
Till - Haul/ Place/ Compact	cu.m	680,000.00
Filter - Haul/Place/Compact	cu.m	190,000.00
Rockfill - Haul/Place	cu.m	1,000,000.00
Piezometers	No.	20.00
Settlement Markers	No.	20.00
Emergency Spillway		
Excavation	cu.m	17,000.00
Erosion Protection (Riprap)	cu.m	5,400.00
Wetland Environment	ha	30.00

The embankment, dump and spillway locations are shown in Figure 3.13. The embankment which would have a crest elevation of 1125 m, with the surface of the waste rock at 1121.5 m. The waste rock would be covered by 1 m of water in which a wetland environment would be cultivated.

The embankment section in Figure 3.13 illustrates a conceptual design for the embankment which would consist of a rock shell surrounding a central core of fine-grained glacial till. A filter layer would be constructed between the core and the downstream rockfill shell, and between the downstream rockfill shell and the underlying foundation soils. Both the upstream and downstream slopes have been assumed at 4 horizontal to 1 vertical. This is conservative and it may be possible to use steeper slopes to reduce the volume of dam fill. The rockfill used in the downstream shell would be non-acid

generating. However, the upstream rockfill shell could be constructed with potentially acid generating rock, provided it was submerged shortly after placement.

The advantage of this alternative is that it essentially eliminates acid generation in the Vangorda waste material by keeping it submerged. Blending will not be required since the waste can be dumped directly into the impoundment without the need for temporary stockpiles. It also eliminates the need for double handling of the waste.

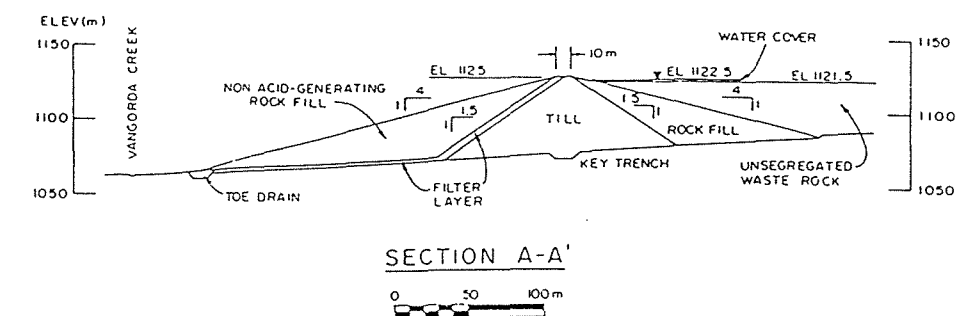
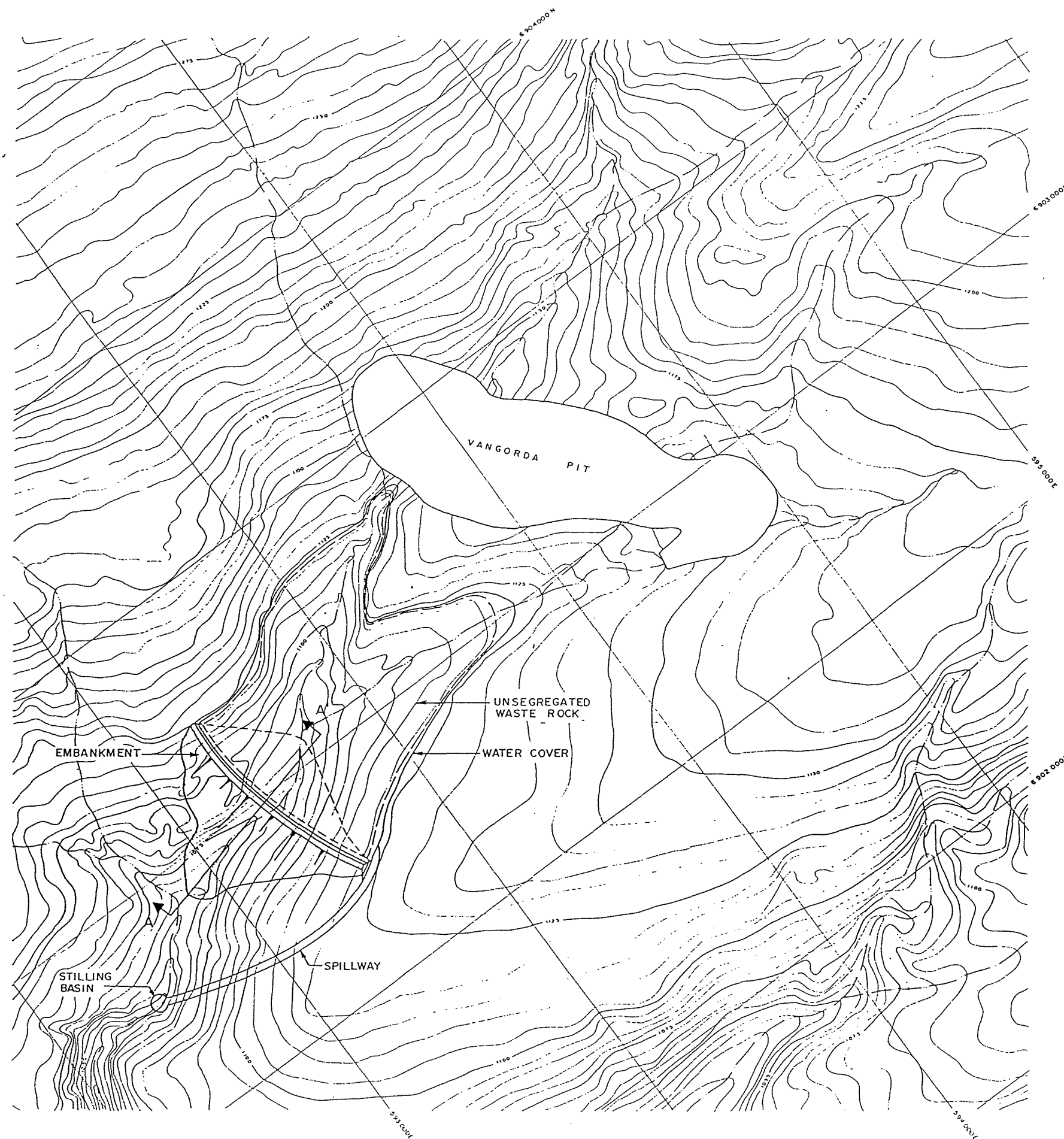
Though no treatment would be required for water draining from the Vangorda waste in this alternative, treatment may still be required for drainage from other components in the Vangorda Plateau abandonment plan.

3.7.2 Water Quality Predictions based on Original Flow Concentration and Distribution

Alternative 1.6 is similar in design to Alternative 1.1, in that all Vangorda rock waste is placed in the Vangorda Creek valley. However, in Alternative 1.6 a dam would be constructed which will enable a water cover or wetlands to be established over the rock waste.

Water quality predictions are considered to be identical to predictions for Alternative 1.5.1 where all Vangorda rock waste would be returned to Vangorda pit and covered with water. The model predicts a mean monthly zinc concentration of 0.15 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations would be 0.56 and 0.27 mg/L in Vangorda Creek below the mine site and at Faro respectively.

For alternatives 1.6 and 1.5.1 the model assumes that the loading from the Vangorda waste is eliminated by removing the source. In practice, it is likely that some zinc will still be leached from the waste. For the purposes of this report and considering the limited data base from which the model was developed, further refinement of the model at this stage to incorporate these modifications was not considered appropriate.



ALTERNATIVE 1.6

- Place all waste rock from Vangorda Pit behind an engineered embankment in Vangorda Creek and allow to flood
- Provide spillway for Vangorda Creek
- Construct wetland environment on top of waste rock

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE NOV 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.6 PLAN AND SECTION		PROJ NO 60609
		APPROVED NO
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		3.13

3.8 Alternative 1.7

3.8.1 Description

As shown on Figure 3.14, Alternative 1.7 is the same as Alternative 1.3, except that the dump cover includes a synthetic membrane. Construction of the cover would firstly include a layer of compacted till, one metre thick, placed over the waste rock as shown on Figure 3.15. This till layer would provide a bedding layer for the HDPE membrane, and also function as an infiltration barrier. A 0.3 meter thick drainage layer of permeable sand or gravel, would be placed over the membrane once it has been installed on top of the till. This would prevent water from ponding on the membrane surface which may result in seeps through any punctures in the membrane. Finally, a layer of moderately compacted till, 1.5 metres thick, would be placed over the drainage layer, and the surface seeded with vegetation. This final till layer is to protect the underlying layers from erosion and insulate against frost penetration.

Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Waste	cu.m	4,296,500.00
Berm Construction		
Foundation Preparation	ha	59.00
Till Placement	cu.m	2,170,000.00
Dump Cover(1m.)		
Till Haul	cu.m	400,000.00
Till Placement and Compaction	cu.m	400,000.00
Geomembrane Liner		
Supply & Place Drainage Layer	cu.m	120,000.00
Supply and Install 80mil HDPE membrane	sq.m	400,000.00
Haul/Place/Compact Till cover(1.5m)	cu.m	600,000.00
Rock Drain		
Supply & Install Blanket	cu.m	6,000.00
Supply & Install Finger Drains	cu.m	1,350.00
Supply & Place Bedding	cu.m	120.00
Supply & Install 80 mil HDPE	sq.m	350.00
Erosion Protection	ha	59.00

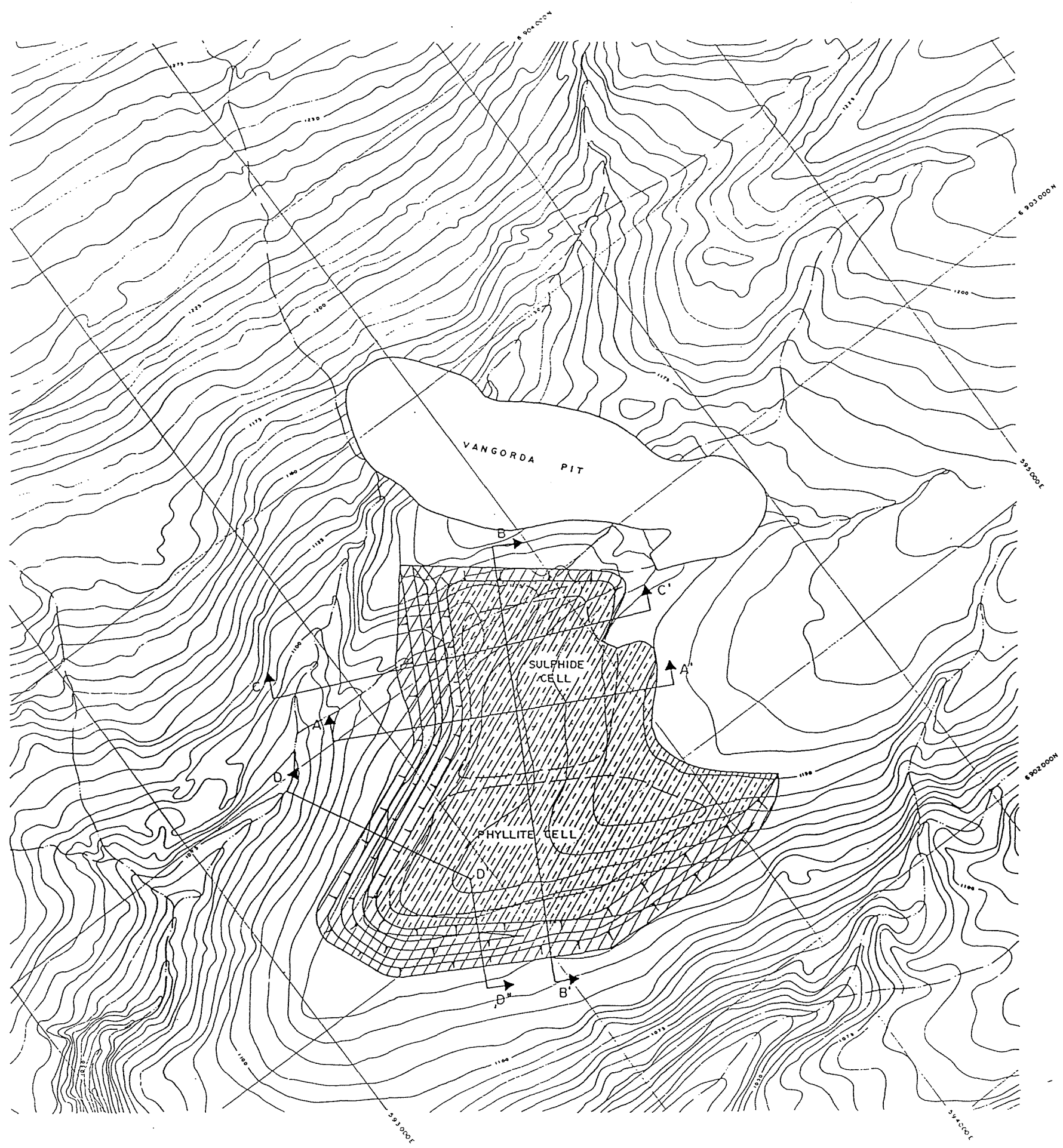
This cover design is considered more effective than a simple till cover. Its effectiveness, however, would depend on the care taken during installation. Particular care must be taken in preparing the

bedding surface for the liner and in placing the drainage layer over it. All large or sharp rocks would have to be removed from surface of the lower till layer. If this proves too difficult, a layer of bedding sand (0.15 m to 0.3 m thick) should be placed under the membrane to prevent a puncture failure. Alternatively, a layer of geotextile could be placed under the membrane. Geotextile could also be used in place of sand and gravel for the drainage layer overlying the membrane. Currently technology indicates that HDPE liner has a limited design life and would most likely be replaced every 50 years.

3.8.2 Water Quality Predictions based on Original Flow and Concentration Distributions and Flows

Alternative 1.7 is similar to the base case (Alternative 1.3) in that sulphide and phyllite waste cells would be constructed. Instead of till covers, however, synthetic geomembranes would reduce dump infiltration and increase surface runoff. Using the geomembrane, the runoff is estimated to increase from 35 percent to 44 percent and infiltration is estimated to decrease from 10 percent to 1 percent of total precipitation. The geomembrane would also improve oxygen deprivation within the dump and consequently slow the acid generation reaction.

Water quality predictions for this alternative are shown in Table 3.8. The model predicts a mean monthly zinc concentration of 0.16 mg/L in Vangorda Creek below the mine site and 0.05 mg/L at Faro. The peak monthly concentrations are 0.64 and 0.31 mg/L in Vangorda Creek below the mine site and at Faro respectively. It is expected that the geomembrane would result in a 29 percent decrease in mean monthly zinc loading concentrations compared with the original scheme.



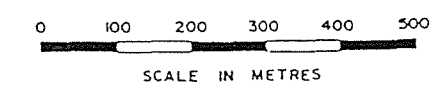
ALTERNATIVE 1.7

- Construct dump east of Vangorda Creek below pit
- Segregate and selectively place sulphide and phyllite waste
- Construct till berms around each waste type to form two cells.
- Cover entire dump with engineered cover using HDPE membrane.
- Provide rock drains with air return control
- Internal till layers to limit water infiltration

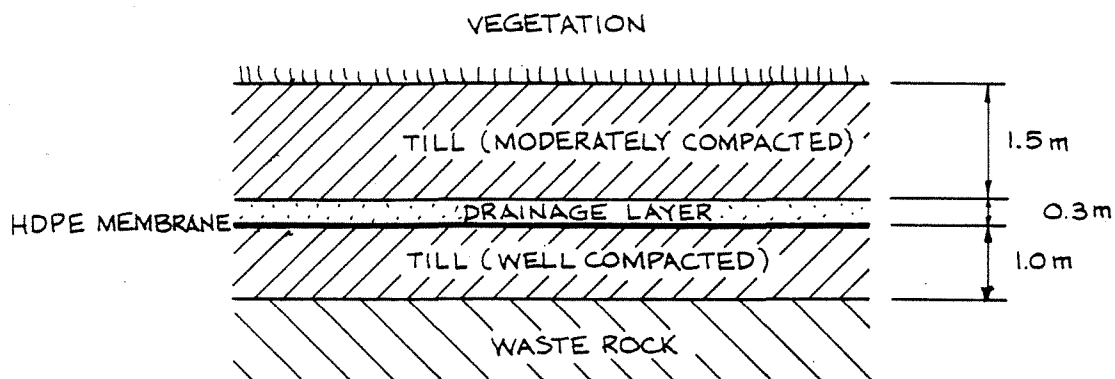
KEY

 TILL COVER AND BERMS

 HDPE MEMBRANE



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE NOV 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.7 PLAN		PROJ NO 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO 3.14



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
VANGORDA WASTE DUMP ALTERNATIVE 1.7 DUMP COVER DETAIL		PROJ. NO. 60609
		APPROVED
		NO. 3.15
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

TABLE 3.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.7

SYNTHETIC LINER OVER ONE METER TILL COVERS ON SULPHIDE AND PHYLLITE CELLS

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	18.0	ha
Vangorda Phyllite Cell Waste Dump Catchment Area	-	25.0	ha
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha
Mean Annual Precipitation	-	539.0	mm
Mean Annual Evaporation	-	337.1	mm
Upper Till Cover Thickness	-	2.00	m
Lower Till Cover Thickness	-	1.00	m
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec
Waste Rock Hydraulic Conductivity	-	.006	cm/sec
Drainage layer Hydraulic Conductivity	-	.006	cm/sec
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha
Grum Sulphide Cell Area	-	6.0	ha
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha
Catchment Area between Pits	-	250.3	ha

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	6.23
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	9.08
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.03
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.45
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.99
Vangorda Sulphide Cell Infiltration.	0.06	0.15	27.78	4.26	4.67
Vangorda Sulphide Cell Runoff	1.36	3.56	0.03	0.10	0.11
Vangorda Phyllite Cell Infiltration.	0.08	0.21	15.37	3.28	3.59
Vangorda Phyllite Cell Runoff	1.88	4.95	0.03	0.13	0.15
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	63.16
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	9.16
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.38
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				91.23	100.00

TABLE 3.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.7

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.06	0.06	0.07	0.12	0.30	0.35	0.22	0.20	0.18	0.15	0.09	0.07	0.15	1.84
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	27.78	0.00
	Zn kg	0.44	0.66	1.63	5.82	11.82	10.40	5.47	5.08	4.44	3.80	1.09	0.52	4.26	51.17
Vangorda Sulphide	dam^3	0.53	0.48	0.53	2.25	7.25	11.26	6.08	5.02	4.09	2.91	1.28	1.06	3.56	42.73
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.00	0.01	0.11	0.22	0.45	0.12	0.10	0.08	0.03	0.01	0.01	0.10	1.15
Vangorda Phyllite	dam^3	0.08	0.08	0.09	0.16	0.41	0.48	0.30	0.28	0.25	0.21	0.13	0.09	0.21	2.56
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.37	0.00
	Zn kg	0.23	0.61	1.09	5.82	9.44	6.74	4.25	3.95	2.96	2.95	1.01	0.27	3.28	39.33
Vangorda Phyllite	dam^3	0.73	0.66	0.73	3.13	10.07	15.63	8.44	6.98	5.69	4.04	1.78	1.47	4.95	59.35
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.16	0.30	0.63	0.17	0.14	0.11	0.04	0.02	0.01	0.13	1.60
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 3.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.7

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	17	127	146	85	72	58	40	16	13	50	603
	Zn mg/l	0.81	0.89	1.36	3.46	2.04	1.23	1.55	1.39	1.31	0.94	0.48	0.25	1.47	
	Zn kg	7.95	7.86	13.33	60.36	259.54	179.90	131.31	100.46	76.08	37.22	7.62	3.43	73.76	885.08
Mine Effluent Discharge Grum	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent Discharge Vangorda & Grum	dam^3	41	38	46	67	545	630	366	311	249	174	68	59	216	2595
	Zn mg/l	0.23	0.26	0.36	1.13	0.57	0.38	0.42	0.39	0.38	0.28	0.16	0.09	0.42	
	Zn kg	9.43	9.77	16.56	75.79	310.06	239.22	154.57	120.96	94.02	48.10	10.84	5.48	91.23	1094.80
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.17	0.07	0.06	0.22	
	dam^3	95	86	99	119	1455	1770	982	820	664	469	198	166	577	6924
	Zn mg/l	0.10	0.11	0.17	0.64	0.21	0.14	0.16	0.15	0.14	0.10	0.05	0.03	0.16	
	Zn kg	9	10	17	76	310	239	155	121	94	48	11	5	91.23	1094.80
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.04	0.04	0.07	0.31	0.07	0.04	0.05	0.05	0.04	0.03	0.01	0.01	0.05	
	Zn kg	9	10	17	76	310	239	155	121	94	48	11	5	91.23	1094.80
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0002	0.0003	0.0012	0.0003	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0003	
	Zn kg	9	10	17	76	310	239	155	121	94	48	11	5	91.23	1094.80

3.9 Blending with Calcareous Phyllite or Limestone

Blending the sulphide and phyllite waste rock with either calcareous phyllite or limestone was also considered as an option. To assess the viability of this option, the ratio of the neutralization potential divided by acidity potential of the blended rock was calculated for an assumed volume of blending rock or limestone. Results of the analysis are presented in Table 3.9. These results indicate that to obtain a low risk ratio of 3 using calcareous phyllite, approximately 90 million tonnes of the calcareous rock would be needed. In contrast, to achieve a high risk ratio of 1, would require 25 million tonnes of calcareous rock. The cost to implement this blending operation would be prohibitive and was not considered a viable option.

TABLE 3.9: ROCK BLENDING CALCULATIONS

ROCK TYPE	VOLUME	NEUTRAL. POTENTIAL	ACIDITY POTENTIAL	NP/AP
VANGORDA SULPHIDE	(tonnes)	(Kg CaCO ₃ /tonne)	(Kg CaCO ₃ /tonne)	
4A	1,130,900	3.88	263.50	0.01
4C	741,660	9.77	742.00	0.01
4E and 4EC	1,520,140	208.50	1200.00	0.17
TOTAL	3,392,700	97	788	0.12
CALC. PHY. LIMESTONE	90,000,000 8,500,000	113.61 900.00	10.03 1.00	11.33 900.00
BLENDING RK. w/CALC. PHY. w/L.STONE	93,392,700 11,892,700	113.00 670.88	38.28 225.43	2.95 2.98
CALC. PHY. LIMESTONE	55,000,000 5,500,000	113.61 900.00	10.03 1.00	11.33 900.00
BLENDING RK. w/CALC. PHY. w/L.STONE	58,392,700 8,892,700	112.64 593.59	55.21 301.14	2.04 1.97
CALC. PHY. LIMESTONE	25,000,000 2,500,000	113.61 900.00	10.03 1.00	11.33 900.00
BLENDING RK. w/CALC. PHY. w/L.STONE	28,392,700 5,892,700	111.61 437.59	102.96 453.95	1.08 0.96

3.10 Summary and Discussion

A total of ten alternative schemes were considered for the abandonment of the Vangorda Waste rock. A summary of the predicted mean annual monthly and peak monthly zinc concentrations in Vangorda Creek at the minesite and at Faro for each alternative is presented in Table 3.10.

The mean monthly zinc concentrations at Faro vary from 0.04 mg/L for alternatives 1.6 and 1.5.1 to 0.14 mg/L for Alternative 1.2. It is most likely that water treatment would be required after abandonment and in perpetuity for Alternatives 1.1 and 1.2 for which very little AMD mitigation is proposed. The lowest predicted peak monthly concentration of 0.27 mg/L would result from Alternatives 1.5.1 and 1.6 and for nine months of the year the predicted mean monthly zinc level would not exceed 0.05mg/L. By comparison, the predicted peak monthly zinc level for the original scheme is 0.52 mg/L and the mean monthly zinc level exceeds 0.05 mg/L in seven months of the year. The changes in zinc loading from each of the Vangorda waste dump alternative components compared to the base case (1.3/2.2/3.1) is presented as follows:

<u>Alternative</u>	<u>Monthly Zinc Loading</u>	<u>Loading Change (%)</u>
1.1	133	+200
1.2	185	+320
1.3	44	0
1.4	38	-5
1.5.1	0	-100
1.5	21	-48
1.6	0	-100
1.7	8	-82

TABLE 3.10 : SUMMARY OF WATER QUALITY PREDICTIONS FROM VANGORDA WASTE DUMP

ALTERNATIVE	DUMP AREAS	VANGORDA PIT SEEPAGES A1/A2/A3	VANGORDA CRK. BELOW MINE		WATER QUALITY IN VANGORDA CREEK AT FARO (ZINC)					
			MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE * FROM ALT.1.3 (+/-)	CHANGE FROM ALT.1.3 (%)
VANGORDA WASTE DUMPS	(ha)	(l/s)								
ALT. 1.1 – Waste in Vangorda Ck., unsegr.	27/0	1.25/0.50/2.25	0.38	1.91	217	702	0.12	0.92	89	70%
ALT. 1.1 – With Treatment	27/0	1.25/0.50/2.25	0.20	0.44	116	336	0.06	0.21	-12	-9%
ALT. 1.2 – Waste on Ridge, uncovered	37/0	1.25/0.50/2.25	0.47	2.41	268	861	0.14	1.18	141	110%
ALT. 1.1 – With Treatment	37/0	1.25/0.50/2.25	0.21	0.49	122	352	0.07	0.24	-6	-4%
ALT. 1.3 – Waste on Ridge, Covered Cells	18/25	1.25/0.50/2.25	0.22	1.05	128	423	0.07	0.52	0	0
ALT. 1.3 – Waste on Ridge, Covered Cells	21/23	1.25/0.50/2.25	0.22	1.07	130	430	0.07	0.54	2	1%
ALT. 1.4 – As for ALT. 1.3 but out of ravine	12/27	1.25/0.50/2.25	0.21	1.00	122	406	0.07	0.49	-6	-5%
ALT. 1.5 – Partial return of Waste to pit	0/28	1.25/0.50/2.25	0.18	0.84	105	356	0.06	0.41	-23	-18%
ALT. 1.5.1 – Total Return of waste to pit	0/0	1.25/0.50/2.25	0.15	0.56	84	288	0.04	0.27	-44	-34%
ALT. 1.6 – Waste Behind Dam in Ck., Flooded	0/0	1.25/0.50/2.25	0.15	0.56	84	288	0.04	0.27	-44	-34%
ALT. 1.7 – Till Cover with Geomembrane	18/25	1.25/0.50/2.25	0.16	0.64	91	310	0.05	0.31	-37	-29%

* Mean Monthly Zinc Loading



4.0 GRUM WASTE DUMP

The mitigative measures for decommissioning of the Grum Waste dump presented in the July 1989, IEE include the construction of a till covered cell for the sulphide waste. As the remaining waste from the Grum pit is considered to be non acid generating, no mitigative measures are considered for this material. This original scheme is referred to in this report as Alternative 2.2. Several alternatives to this scheme have been considered and are presented below.

The waste material from Grum Pit comprises 13,300,000 bank cubic metres of till overburden, 2,237,000 bank cubic metres of sulphide waste rock (which is potentially highly acid generating), and 52,463,000 bank cubic metres of calcareous and non-calcareous phyllite waste (ranging from acid-consuming to potentially mildly acid generating). In the alternatives considered, emphasis is placed on control of acid drainage from the sulphide waste. The large volumes of waste rock in the Grum dumps presents a very different problem from the Vangorda dumps as options such as till covers become prohibitively expensive.

4.1 Alternative 2.1

4.1.1 Description

Alternative 2.1 requires

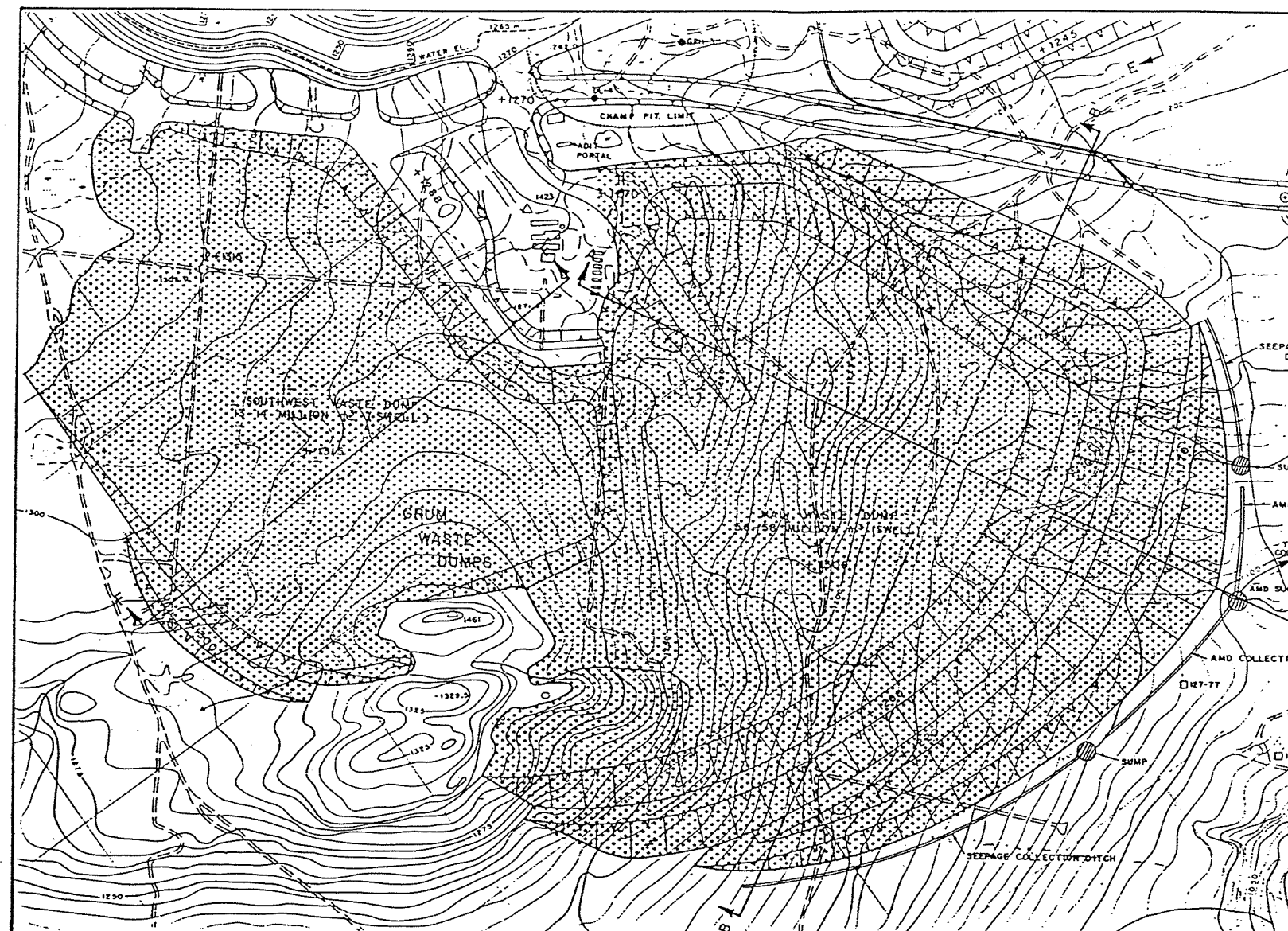
- No segregation or selective placement of Grum waste.
- No dump covers.
- No sulphide waste returned to pit.

Alternative 2.1 considers the placement of all waste from Grum pit, unsegregated, into the dumps shown in Figure 4.1. These dumps would remain uncovered and drainage would most likely be collected and treated.

4.1.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Alternative 2.1 investigates the effects of developing an unsegregated and uncovered waste rock dump at the Grum mine site. The total area of the dump would encompass 141 hectares, and being uncovered, it is assumed there would be zero surface runoff. The model assumes that the sulphides waste would be homogeneously scattered throughout the dump.

Water quality predictions for this alternative are shown in Table 5.1. The model predicts a mean monthly zinc concentration of 0.40 mg/L in Vangorda Creek below the mine site and 0.12 mg/L at Faro. The annual monthly concentration peaks are 1.53 and 0.75 mg/L in Vangorda Creek below the mine site and at Faro respectively. This alternative results in a zinc concentration increase of 79 percent above the base scheme is due mainly to the unsegregated uncovered sulphide waste.



SCALE 1:10 000

ALTERNATIVE 2.1

- No segregation or selective placement of Grum waste.
- No dump covers.
- No sulphide waste returned to pit.



UNSEGREGATED WASTE ROCK

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.1 PLAN		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		N.O. 4.1

TABLE 4.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.1

UNSEGREGATED GRUM WASTE DUMP

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	18.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	25.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.0	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	0.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.86	23.27	4.92	114.40	50.19
Grum Sulphide cell Infiltration	0.00	0.00	28.89	0.00	0.00
Grum Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.58
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.40
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	10.90
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.03
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	8.35
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.05
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	25.28
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	3.67
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.55
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				227.92	100.00

TABLE 4.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
Jan-90															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.45	4.45	5.94	7.29	49.13	68.03	41.03	34.42	27.67	22.27	7.29	7.29	23.27	279.28
Infiltration	Zn mg/l	1.93	1.93	1.93	9.62	5.77	7.69	3.85	3.85	3.85	1.93	1.93	1.93	4.92	
	Zn kg	8.57	8.57	11.43	70.09	283.50	523.16	157.78	132.35	106.40	42.87	14.03	14.03	114.40	1372.80
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 4.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.1

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
Discharge	Zn mg/l	1.01	1.32	2.11	6.27	2.93	1.88	2.14	1.99	1.90	1.66	0.96	0.43	2.19	
Vangorda	Zn kg	10.13	11.99	21.12	109.86	372.83	272.86	180.72	143.37	109.90	66.45	15.50	5.70	110.04	1320.43
Mine Effluent	dam^3	32	29	36	49	417	483	281	239	191	134	52	46	166	1989
Discharge	Zn mg/l	0.28	0.31	0.33	1.46	0.71	1.11	0.58	0.57	0.58	0.33	0.28	0.32	0.71	
Grum	Zn kg	9.00	9.12	11.99	71.80	294.92	534.06	162.07	136.50	110.78	44.87	14.82	14.71	117.89	1414.63
Mine Effluent	dam^3	42	38	46	67	544	628	366	311	249	174	68	59	216	2592
Discharge	Zn mg/l	0.46	0.55	0.72	2.73	1.23	1.28	0.94	0.90	0.89	0.64	0.44	0.35	1.06	
Vangorda & Grum	Zn kg	19.12	21.11	33.10	181.67	667.75	806.92	342.79	279.87	220.67	111.32	30.32	20.41	227.92	2735.06
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
Below Minesite	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6922
	Zn mg/l	0.20	0.24	0.33	1.53	0.46	0.46	0.35	0.34	0.33	0.24	0.15	0.12	0.40	
	Zn kg	19	21	33	182	668	807	343	280	221	111	30	20	227.92	2735.06
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.08	0.09	0.14	0.75	0.14	0.13	0.11	0.10	0.10	0.08	0.04	0.04	0.12	
	Zn kg	19	21	33	182	668	807	343	280	221	111	30	20	227.92	2735.06
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0004	0.0006	0.0029	0.0006	0.0004	0.0003	0.0004	0.0004	0.0003	0.0002	0.0002	0.0004	
	Zn kg	19	21	33	182	668	807	343	280	221	111	30	20	227.92	2735.06

4.2 Alternative 2.2 (Original Scheme)

4.2.1 Description

Alternative 2.2 would require the mine to:

- Segregate waste rock and selectively place sulphide waste;
- Deposit part of sulphide waste within Grum Pit (1.7 million tonnes);
- Place remainder in cell in main dump (4.6 million tonnes);
- 3 m thick till cover over sulphide cell, with 1 m thick internal till layers (no till berms).

Construction quantities estimated for this plan are presented below:

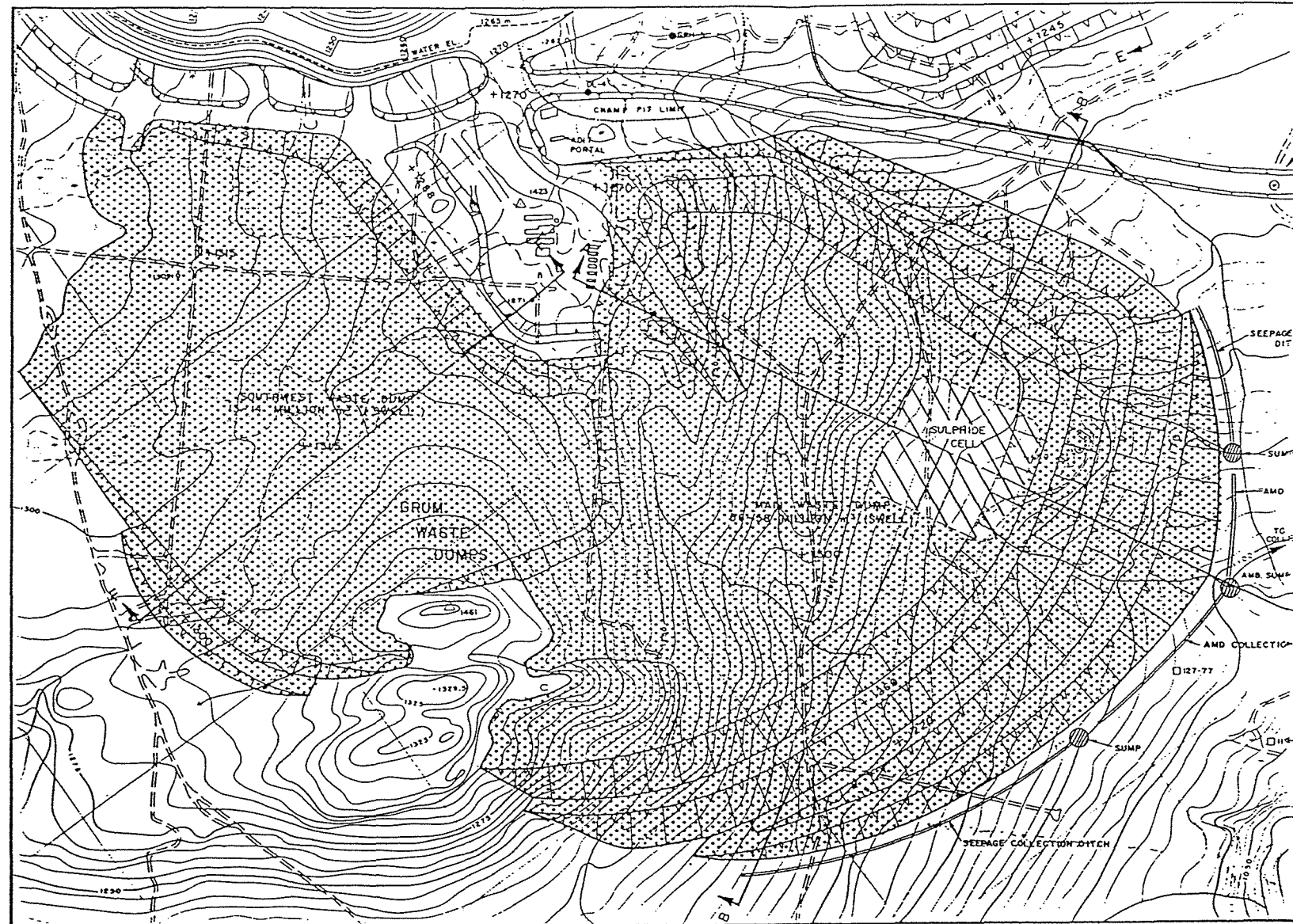
CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Sulphide Waste	1cu.m	2,908,240.40
Sulphide Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Sulphide Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Internal Till Layers(1m)		
Till Haul	cu.m	104,000.00
Till Placement	cu.m	104,000.00
Replacement of Sul. Waste into Grum Pit	1cu.m	760,000.00
Erosion Protection of Till Cover	ha	5.20

This scheme, which was originally proposed for disposal of the Grum Waste in the IEE, Stage II Report (July 1989), is shown in plan on Figure 4.2. The plan involves segregating the sulphide waste from the remaining waste rock. Most of this sulphide waste (4.6 million tonnes) would be placed in the sulphide cell shown in Figure 4.2, while the remainder (1.7 million tonnes) would be returned to the Grum pit, under water. The sulphide waste cell would be underlain by calcareous phyllite to provide some buffering action for any acid drainage from the cell. The sulphide cell would be constructed in three lifts, with a layer of compacted till placed over each lift, as shown on Figure 4.3. The first two till layers would be 1 metre thick, with the final cover 3 metres thick. This till cover and internal till layers will help to reduce water infiltration into the cell. The remaining sulphide waste to be returned to the pit would be blended with limestone or calcareous phyllite and placed in a temporary stockpile during operations.

4.2.2 Water Quality Predictions based on Original Flow and Concentration Distributions

For purposes of computing flows the areas of the sulphide cell and the total main Grum dump would be 6 and 135 hectares, respectively. Infiltration through the covered sulphide cell was estimated to be 10 percent of the total precipitation compared to 37 percent for the uncovered dump.

Water quality predictions for this alternative are identical to Alternative 1.3 and are shown in Table 3.4. The model predicts a mean monthly zinc concentration of 0.22 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The monthly concentration peaks are 1.05 and 0.52 mg/L in Vangorda Creek below the mine site and at Faro respectively.



SCALE 1:10 000

ALTERNATIVE 2.2

- Segregate waste rock and selectively place sulphide waste;
- Return part of sulphide waste to Grum Pit (1.7 million tonnes);
- Place remainder in cell in main dump (4.6 million tonnes);
- 3 m thick till cover over sulphide cell, with 1 m thick internal till layers (no till berms).

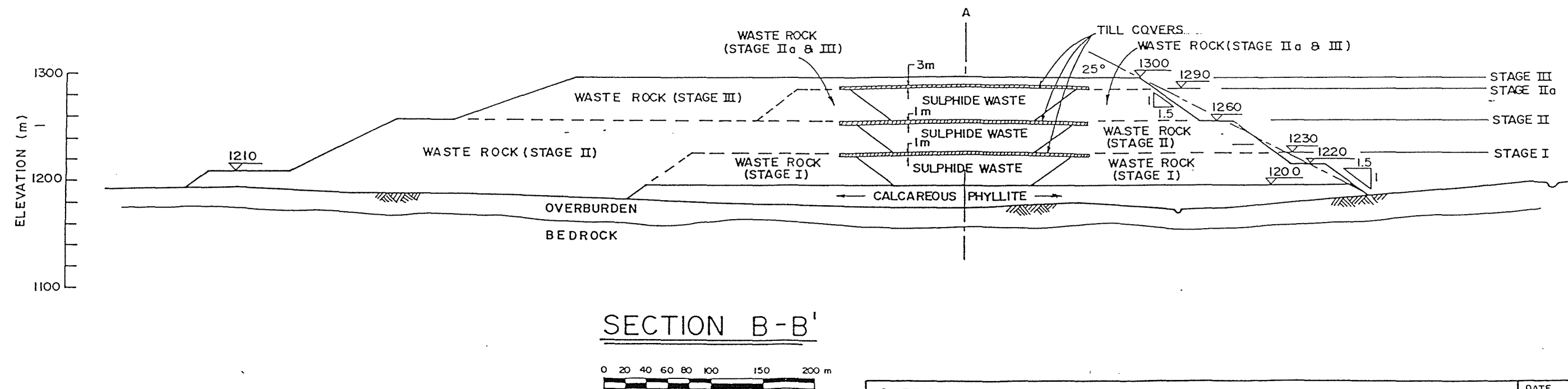
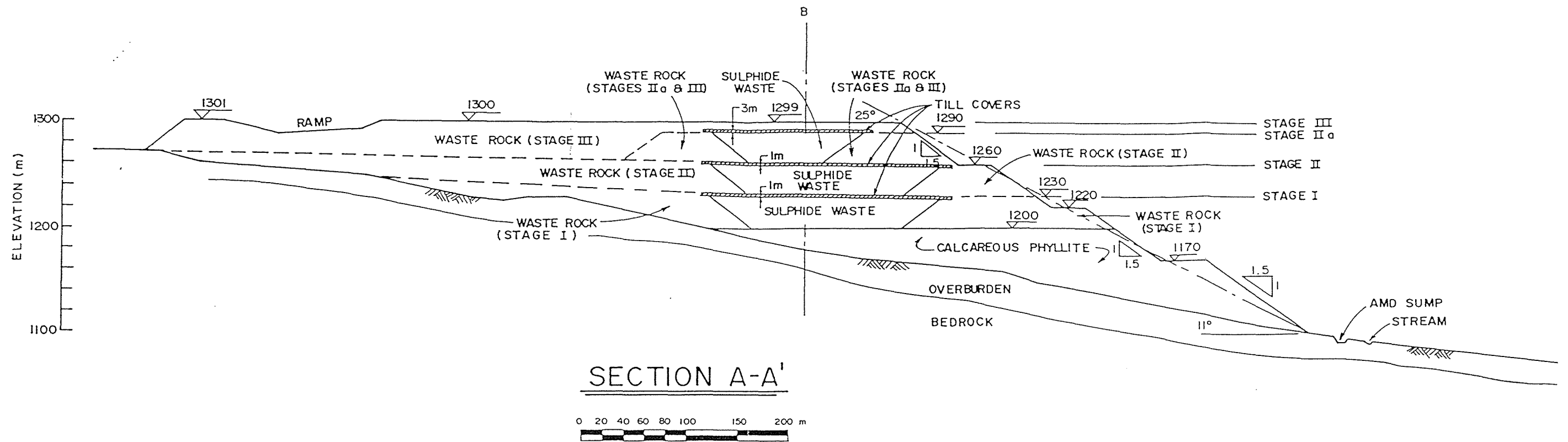


WASTE ROCK



SULPHIDE CELL

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.2 PLAN		PROJ. NO. 60609
		APPROVED
		N.O. 4.2
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		



CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.2 SECTIONS		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO. 4.3

4.3 Alternative 2.3

4.3.1 Description

Alternative 2.3 is described as follows:

- Segregate sulphide and altered phyllite waste during operations;
- Blend sulphide and altered phyllite with limestone and place in temporary stockpile;
- Return sulphide and altered phyllite to Grum pit (under water).

Construction quantity estimates for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Stockpiling of Grum Sul. and Altered Phy. Waste	1cu.m	3,670,595.97
Replacement of All Grum Sulphide and Altered Phy. to Grum Pit	1cu.m	3,670,595.97
Clean up Stockpile Area	ha	10.00

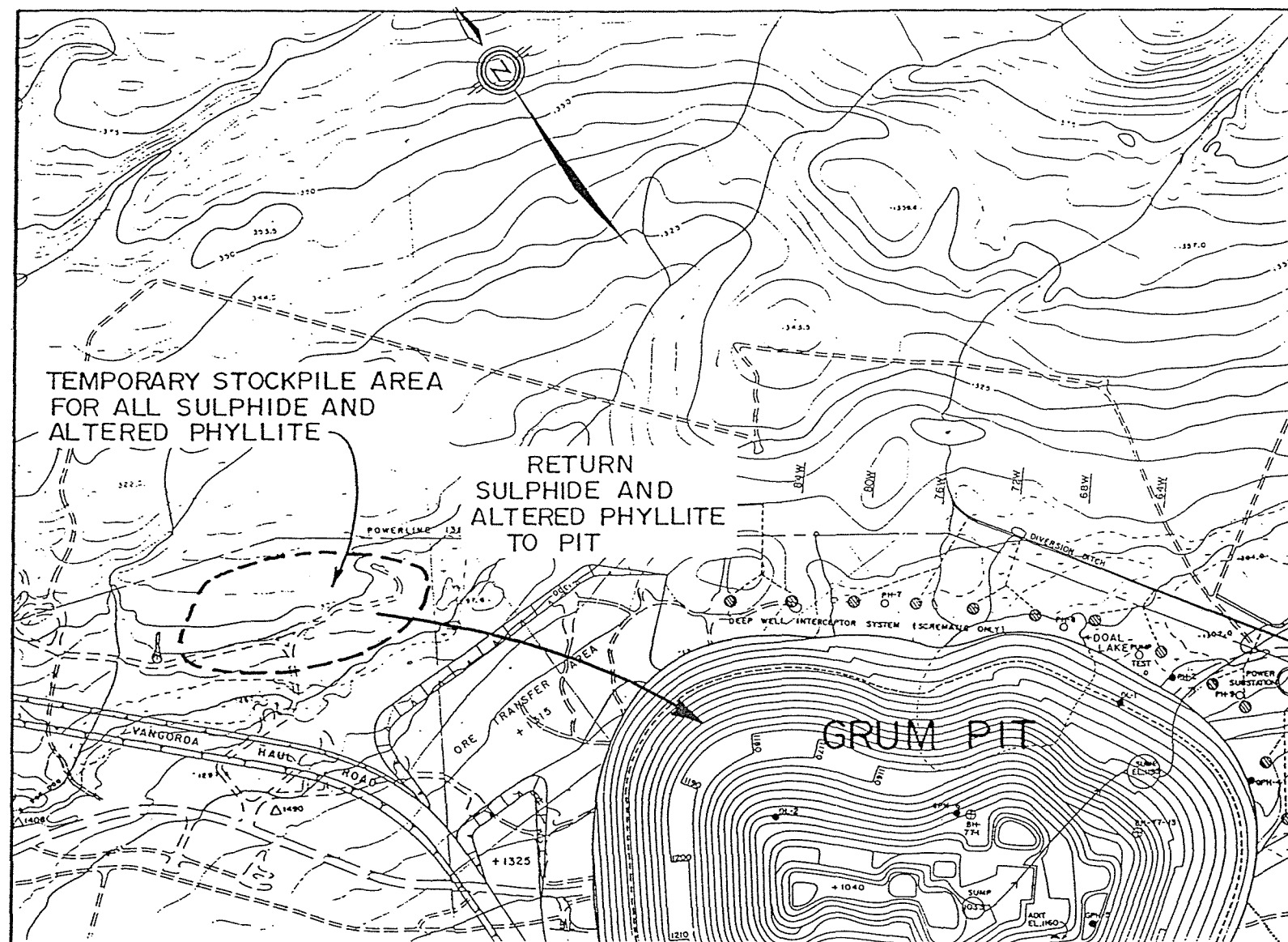
The purpose of this alternative is to store the potentially acid generating waste from the Grum pit under water. Sulphide and altered phyllite would be segregated from the other waste rock during operations and placed in a temporary stockpile, as shown on Figure 4.4. The remaining waste rock would be placed uncovered, in dumps, as in the previous alternatives. To limit AMD production from the temporary stockpile, the sulphide and altered phyllite would be blended with limestone or calcareous phyllite. At abandonment the sulphide and altered phyllite would be returned to the Grum Pit and covered with water. The stockpile area would be cleaned to remove all potentially acid generating material.

4.3.2 Water Quality Predictions based on Original Flow and Concentration Distributions

The model assumes that all sulphide and altered phyllite waste rock is temporarily stockpiled during operations. At the completion of mining, the above rock would be returned to the Grum pit and subsequently submerged by flooding the pit to 1265 metres. The remainder of the waste rock from the Grum pit would be placed in an uncovered dump of 135 hectares in area. Rock within this dump is considered to be acid consuming.

Water quality predictions for this alternative are shown in Table 4.2. The model predicts a mean monthly zinc concentration of 0.22 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The annual monthly concentration peaks are 1.00 and 0.49 mg/L in Vangorda Creek below the mine site and at Faro respectively. A reduction in zinc concentration of 6 percent is realized with this alternative.

A limitation of this alternative is that altered phyllite and other phyllites are not distinctly different and it will be difficult to effectively separate the waste rock types. Consequently the proportion of waste that will be returned to the pit will be larger than the insitu tonnage. This will reduce the risk of acid generation from the sulphide waste, but there is still a risk that loads of sulphide waste will go astray and contaminate the main dump. The overall main dump was given an effluent zinc concentration of 0.26 mg/L in the base case, to account for this phenomenon. In the base scenario the allowance for zinc loading from the sulphide cell was relatively high. For this scenario the load from the sulphide cell was reduced to zero and because of the large area of the Grum dump, and the likelihood that stray pockets of sulphide waste would be left within the dump, the assigned annual mean monthly zinc concentration for the main Grum dump was increased to 0.50 mg/L.



SCALE 1:10000

ALTERNATIVE 2.3

- Segregate sulphide and altered phyllite waste during operations;
- Blend sulphide and altered phyllite with limestone and place in temporary stockpile;
- Return sulphide and altered phyllite to Grum pit (under water).

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.3 PLAN		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		N.O. 4.4

TABLE 4.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.3

GRUM SULPHIDES AND ALTERED PHYLLITES RETURNED TO GRUM PIT

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	18.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	25.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	0.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.86	23.27	0.50	11.67	9.32
Grum Sulphide cell Infiltration	0.00	0.00	26.69	0.00	0.00
Grum Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.06
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.72
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	19.84
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.06
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	15.20
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.09
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	46.03
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.68
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.01
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				125.19	100.00

TABLE 4.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.45	4.45	5.94	7.29	49.13	68.03	41.03	34.42	27.67	22.27	7.29	7.29	23.27	279.28
Infiltration	Zn mg/l	0.20	0.20	0.20	0.98	0.59	0.78	0.39	0.39	0.39	0.20	0.20	0.20	0.50	
	Zn kg	0.87	0.87	1.17	7.15	28.92	53.36	16.09	13.50	10.85	4.37	1.43	1.43	11.67	140.03
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 4.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.3

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
Discharge	Zn mg/l	1.01	1.32	2.11	6.27	2.93	1.88	2.14	1.99	1.90	1.66	0.96	0.43	2.19	
Vangorda	Zn kg	10.13	11.99	21.12	109.86	372.83	272.86	180.72	143.37	109.90	66.45	15.50	5.70	110.04	1320.43
Mine Effluent	dam^3	32	29	36	49	417	483	281	239	191	134	52	46	166	1989
Discharge	Zn mg/l	0.04	0.05	0.05	0.18	0.10	0.13	0.07	0.07	0.08	0.05	0.04	0.05	0.09	
Grum	Zn kg	1.30	1.42	1.72	8.87	40.34	64.26	20.38	17.65	15.23	6.37	2.22	2.11	15.15	181.86
Mine Effluent	dam^3	42	38	46	67	544	628	366	311	249	174	68	59	216	2592
Discharge	Zn mg/l	0.27	0.35	0.50	1.78	0.76	0.54	0.55	0.52	0.50	0.42	0.26	0.13	0.58	
Vangorda & Grum	Zn kg	11.42	13.41	22.83	118.73	413.17	337.12	201.11	161.02	125.13	72.82	17.72	7.80	125.19	1502.29
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
Below Minesite	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6922
	Zn mg/l	0.12	0.16	0.23	1.00	0.28	0.19	0.20	0.20	0.19	0.16	0.09	0.05	0.22	
	Zn kg	11	13	23	119	413	337	201	161	125	73	18	8	125.19	1502.29
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.05	0.06	0.09	0.49	0.09	0.06	0.06	0.06	0.06	0.05	0.02	0.02	0.07	
	Zn kg	11	13	23	119	413	337	201	161	125	73	18	8	125.19	1502.29
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0002	0.0002	0.0004	0.0019	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.00	
	Zn kg	11	13	23	119	413	337	201	161	125	73	18	8	125.19	1502.29

4.4 Alternative 2.4

4.4.1 Description

Alternative 2.4 would require the mine to:

- Segregate sulphide waste;
- Place most of the sulphide waste (4.6 million tonnes) in a single sulphide cell; separate from the main dump;
- Construct till berms around cell and cover with 3 metres of till;
- Place remaining 1.7 million tonnes of sulphide in temporary stockpile and return to pit at abandonment.

This alternative offers the advantage of isolating the material of high acid generating potential from the remaining waste. Keeping this material totally separated assists operations in distinguishing the material from other wastes. The location of the dump has the advantage that it is closer to the mill in the event that this material is process at end of the mine life. The sulphide cell is shown in Figure 4.5. It would be constructed with till berms around its perimeter and with a three metre till cover as shown on Figure 4.6

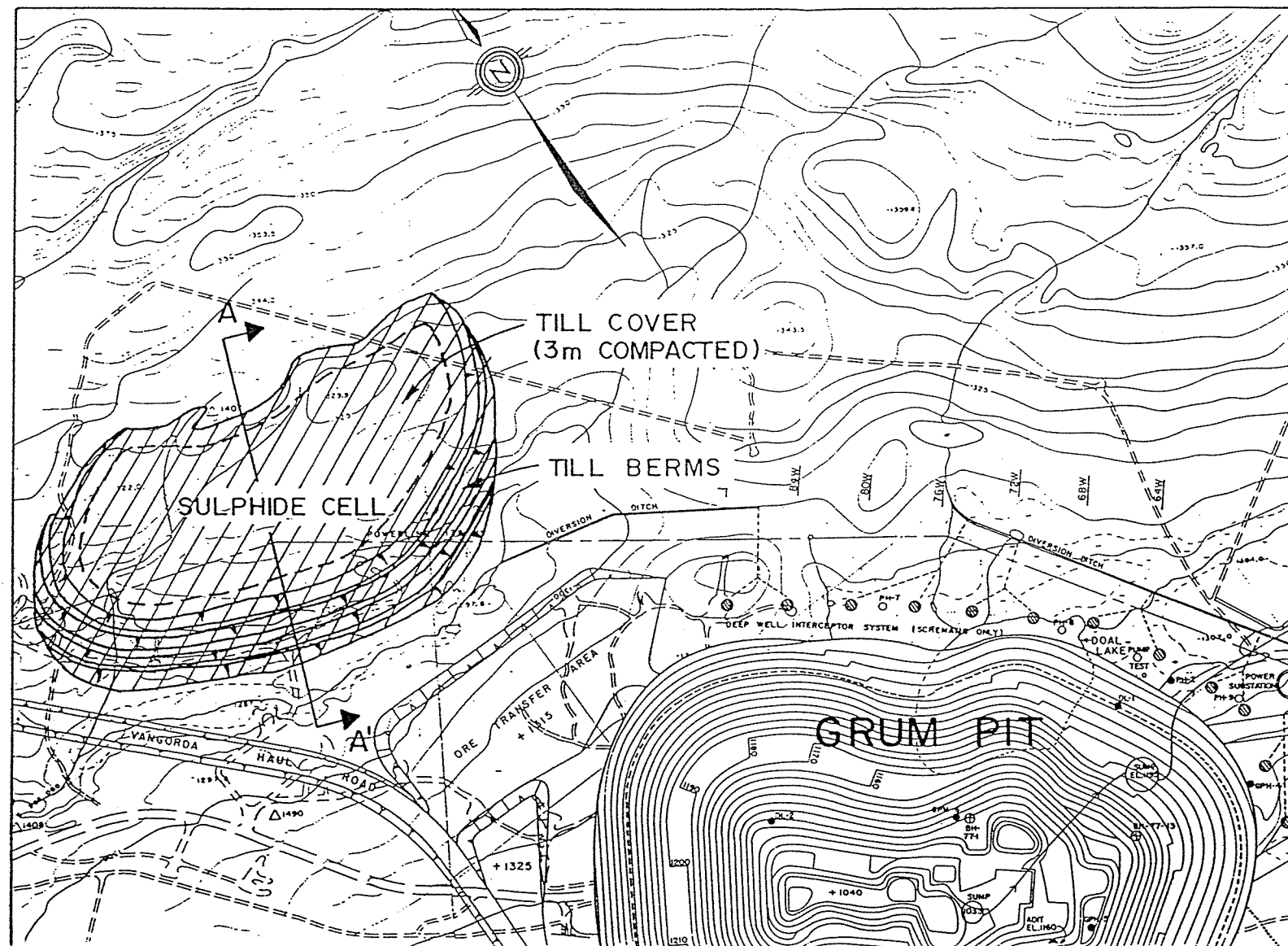
Construction quantity estimates for this option are presented below:

CONSTRUCTION ITEM	UNITS	QUANTITY
=====	=====	=====
Selective Placement of Sulphide Waste	l cu.m	2,908,240.40
Berm Construction		
Foundation Preparation	ha	59.00
Till Placement	cu.m	300,000.00
Sulphide Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Sulphide Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Internal Till Layers(1m)		
Till Haul	cu.m	104,000.00
Till Placement	cu.m	104,000.00
Replacement of Sul. Waste into Grum Pit	l cu.m	760,000.00
Erosion Protection of Till Cover	ha	5.20

4.4.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Alternative 2.4 is similar to the base case (Alternative 2.2) in that the sulphide and phyllite is segregated and abandoned in a till covered waste cell. This alternative differs in that the sulphide cell would be located north of the Grum pit and would thus drain into the western fork of Vangorda Creek. The zinc loading contribution from this sulphide cell would therefore not influence main fork Vangorda Creek water quality immediately downstream of the mine site. The zinc contributions from the cell would, though, combine with zinc contributions from the rest of the Vangorda/ Grum mine approximately two kilometres upstream of the Faro town site.

Water quality predictions for this alternative are shown in Table 4.3. The model predicts a mean monthly zinc concentration of 0.21 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The annual monthly concentration peaks are .97 and 0.52 mg/L in Vangorda Creek below the mine site and at Faro respectively. The main impact of this alternative is the reduction of zinc loading from 128 kg/mo. to 119 kg/mo. in Vangorda Creek immediately downstream of the mine site. However, the change in zinc concentration is negligible. Vangorda Creek at Faro has identical zinc concentrations and loadings as predicted in the base case (Alternative 2.2).

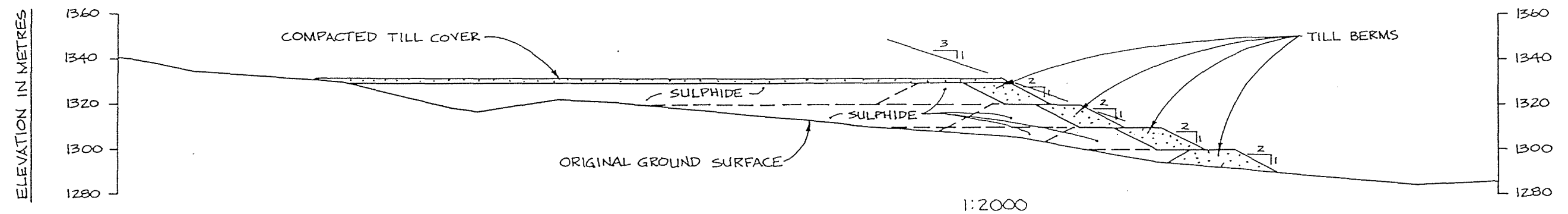


SCALE 1:10 000

ALTERNATIVE 2.4

- Segregate sulphide waste;
- Place most of the sulphide waste (4.6 million tonnes) in a single sulphide cell; separate from the main dump;
- Construct till berms around cell and cover with 3 metres of till;
- Place remaining 1.7 million tonnes of sulphide in temporary stockpile and return to pit at abandonment.

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.4 PLAN		PROJ. NO. 60609
		APPROVED
		N.O. 4.5
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		



SECTION A-A'

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
GRUM WASTE DUMP ALTERNATIVE 2.4 SECTION THROUGH SULPHIDE CELL		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		N.O. 4.6

TABLE 4.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.4

GRUM SULPHIDES AND ALTERED PHYLLITES NORTH OF GRUM PIT

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	-	18.0	ha
Vangorda Phyllite Cell Waste Dump Catchment Area	-	25.0	ha
Catchment of Vangorda Pit (incl. Pit)	-	148.0	ha
Mean Annual Precipitation	-	539.0	mm
Mean Annual Evaporation	-	377.0	mm
Upper Till Cover Thickness	-	2.00	m
Lower Till Cover Thickness	-	1.00	m
Upper Till Cover Hydraulic Conductivity	-	.0000014	cm/sec
Lower Till Cover Hydraulic Conductivity	-	.0000009	cm/sec
Foundation Soil Hydraulic Conductivity	-	.00000001	cm/sec
Waste Rock Hydraulic Conductivity	-	.006	cm/sec
Drainage layer Hydraulic Conductivity	-	.006	cm/sec
Vangorda Creek Catchment Area above Diversion	-	17.7	sq.km
Grum Waste Dumps Total Area (incl Sulphide Cell)	-	135.0	ha
Grum Sulphide Cell Area	-	6.0	ha
Catchment of Grum Pit (incl Pit Area)	-	295.0	ha
Catchment Area between Pits	-	250.3	ha

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	4.46
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	6.49
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.02
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.04
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.71
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	19.48
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.06
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	14.92
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.08
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	45.19
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.56
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.99
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				127.51	100.00

TABLE 4.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.4

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 4.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 2.4

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
	Zn mg/l	1.01	1.32	2.11	6.27	2.93	1.88	2.14	1.99	1.90	1.66	0.96	0.43	2.19	
	Zn kg	10.13	11.99	21.12	109.86	372.83	272.86	180.72	143.37	109.90	66.45	15.50	5.70	110.04	1320.43
Mine Effluent Discharge Grum	dam^3	31	29	36	49	415	480	279	237	190	133	52	45	165	1977
	Zn mg/l	0.03	0.03	0.03	0.11	0.06	0.08	0.04	0.05	0.05	0.03	0.03	0.03	0.06	
	Zn kg	0.85	0.97	1.12	5.20	25.51	36.89	12.13	10.72	9.67	4.12	1.49	1.37	9.17	110.04
Mine Effluent Discharge Vangorda & Grum	dam^3	41	38	46	66	542	625	364	310	248	173	68	59	215	2580
	Zn mg/l	0.27	0.34	0.49	1.73	0.73	0.50	0.53	0.50	0.48	0.41	0.25	0.12	0.55	
	Zn kg	10.98	12.96	22.24	115.06	398.34	309.75	192.85	154.10	119.56	70.58	16.99	7.07	119.21	1430.47
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.17	0.07	0.06	0.21	
	dam^3	95	86	99	118	1453	1766	980	818	663	468	198	166	576	6909
	Zn mg/l	0.12	0.15	0.22	0.97	0.27	0.18	0.20	0.19	0.18	0.15	0.09	0.04	0.21	
	Zn kg	11	13	22	115	398	310	193	154	120	71	17	7	119.21	1430.47
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	242	4636	6084	3163	2680	2198	1447	724	482	1865	22379
	Zn mg/l	0.05	0.06	0.10	0.52	0.09	0.05	0.06	0.06	0.06	0.05	0.03	0.02	0.07	
	Zn kg	12	14	24	125	423	332	204	164	128	77	19	8	127.51	1530.15
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0002	0.0002	0.0005	0.0020	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0004	
	Zn kg	12	14	24	125	423	332	204	164	128	77	19	8	127.51	1530.15

4.5 Summary and Discussion

Four alternative schemes were considered for the abandonment of the sulphide waste from the Grum pit. A summary of the predicted mean annual monthly and peak monthly zinc concentrations in Vangorda Creek at the mine site and at Faro for each of the alternatives, is presented in Table 4.4. The model predicts that Alternative 2.1 would generate an annual mean monthly zinc concentration in Vangorda Creek at Faro of about 0.12 mg/L with a peak monthly concentration of 0.75 mg/L. At these levels water treatment would likely be required. The zinc levels for Alternatives 2.2, 2.3 and 2.4 are very similar with peak monthly zinc concentrations at the Faro townsite in the order of 0.5 mg/L at Faro. The zinc loading contribution from the Grum sulphide waste represents about 7 percent of the total predicted zinc loading. The effect on the zinc loading from each of the alternative schemes compared to the base case component(Alt 2.2) is presented as follows:

<u>Alternative</u>	<u>Monthly Zinc Loading(Kg)</u>	<u>Loading Change (%)</u>
2.1	114	+700
2.2	14	0
2.3	12	-14
2.4	14	0

TABLE 4.4 : SUMMARY OF WATER QUALITY PREDICTIONS FROM GRUM WASTE DUMP

ALTERNATIVE	DUMP AREAS	VANGORDA PIT SEEPAGES A1/A2/A3	VANGORDA CRK. BELOW MINE		WATER QUALITY IN VANGORDA CREEK AT FARO (ZINC)					
			MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE * FROM ALT.1.3 (+/-)	CHANGE FROM ALT.1.3 (%)
GRUM WASTE DUMPS										
ALT. 2.1 – Unsegr., uncovered, Sulphide	141/0	1.25/0.50/2.25	0.40	1.53	228	668	0.12	0.75	100	79%
ALT. 2.2 – Till Covered Cell within Main Dump	18/26	1.25/0.50/2.25	0.22	1.05	128	423	0.07	0.52	0	0
ALT. 2.3 – Return All Sulphide to Pit	135/0	1.25/0.50/2.25	0.22	1.00	125	413	0.07	0.49	-3	-2%
ALT. 2.4 – Till Covered Cell Outside M/Dump	135/6	1.25/0.50/2.25	0.21	1.00	128	423	0.07	0.52	0	0

* Mean Monthly Zinc Loading



5.0 VANGORDA PIT

The final component considered in the overall abandonment plan for the Vangorda Plateau is Vangorda Pit. The original scheme presented in the IEE is referred to in this study as Alternative 3.1. The pit walls at the southeast end of Vangorda pit contain potentially acid generating rock. If left exposed, these slopes could contribute to the AMD problem at the site after abandonment and the drainage would have to be collected and treated. Several alternatives to this course of action have been considered in this study and are presented below.

5.1 Alternative 3.1 (Original Scheme)

5.1.1 Description

Alternative 3.1 for abandonment of the Vangorda Pit is described as follows:

- Pit flooded to Elevation 1122.5 m;
- No covers on pit walls;

Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00
Seepage Collection Ditch along Bench 1128		
Excavation	cu.m	2,000.00

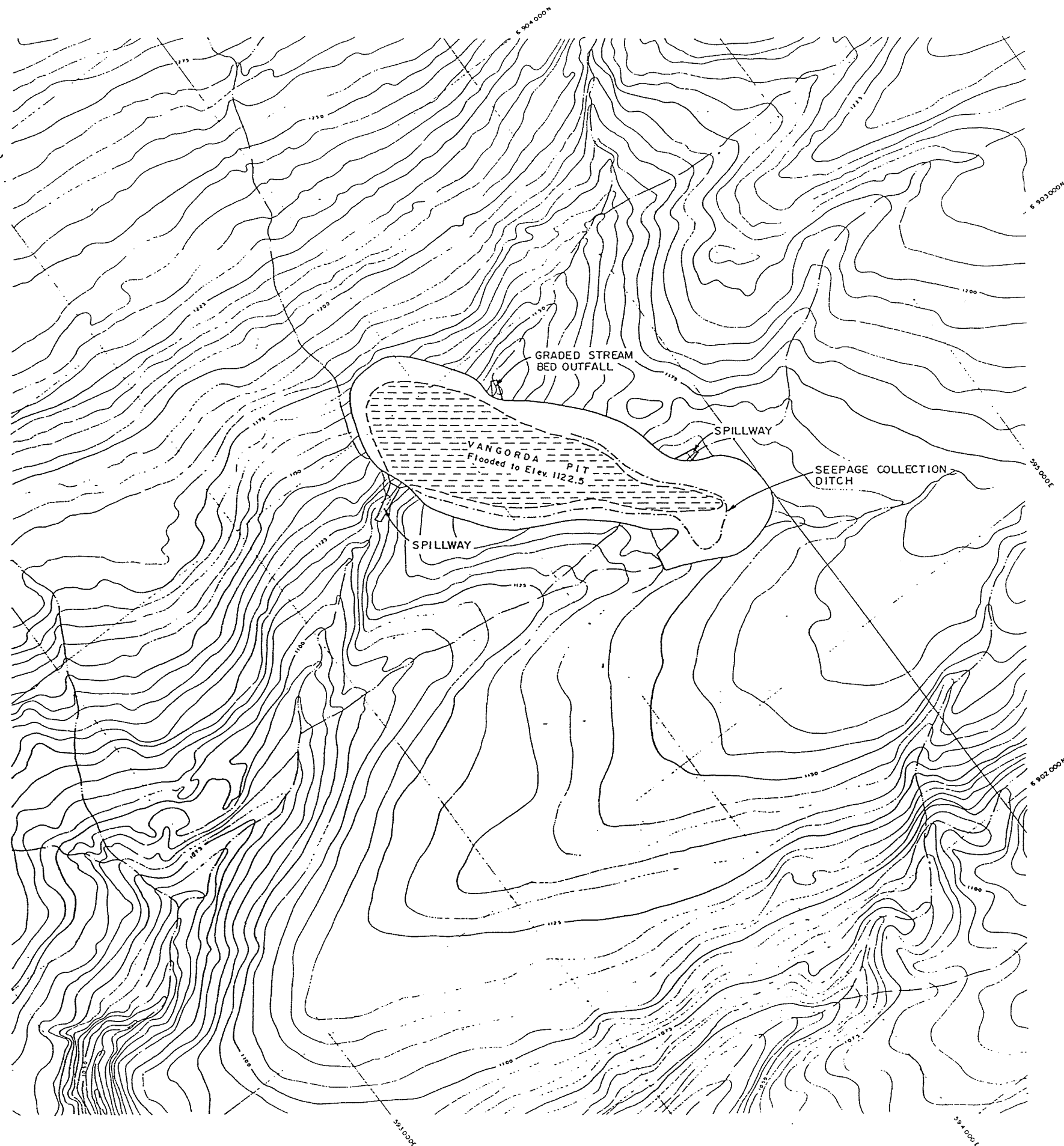
At the end of operations the pit would be allowed to flood to Elevation 1122.5, as shown in Figure 5.1, and the pit walls below this elevation would be submerged.

The pit walls above elevation 1122.5 metres however, would remain uncovered. A collection ditch would be constructed along the 1128 metre bench, as shown on Figure 5.1, to collect the drainage.

Other facilities include an inlet spillway, a graded stream outfall on the east side of the pit, and an outlet spillway at the north end.

5.1.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions are identical to those provided for Alternatives 1.3 and 2.2. Water predictions are presented in Table 3.4. The model predicts a mean monthly zinc concentration of 0.22 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The monthly concentration peaks are 1.05 and 0.52 mg/L in Vangorda Creek below the mine site and at Faro respectively.

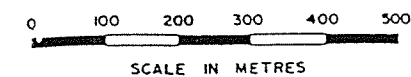


ALTERNATIVE 3.1

- Pit flooded to Elevation 1122.5 m;
- No covers on pit walls;
- Collect and treat drainage.

KEY

 WATER



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC 1989
VANGORDA PIT ALTERNATIVE 3.1 PLAN		PROJ NO 60609
		APPROVED
		NO 5.1
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

5.2 Alternative 3.2

5.2.1 Description

Alternative 3.2 would require the mine to:

- Flood Pit to elevation 1122.5 metres;
- Backfill east of Section 12 with rock to elevation 1122.5 metres;
- Cover pit walls east of Section 12 with till and vegetation.

Construction quantities for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Rock Backfill East of Section 12		
Rock Haul	cu.m	260,000.00
Rock Placement	cu.m	260,000.00
Till Cover on Vangorda Pit Walls		
Till Haul	cu.m	203,000.00
Till PLacement	cu.m	203,000.00
Clean Loose Sulphides from Pit Walls	sq.m	44,000.00
Erosion Protection of Till Cover	ha	5.20
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

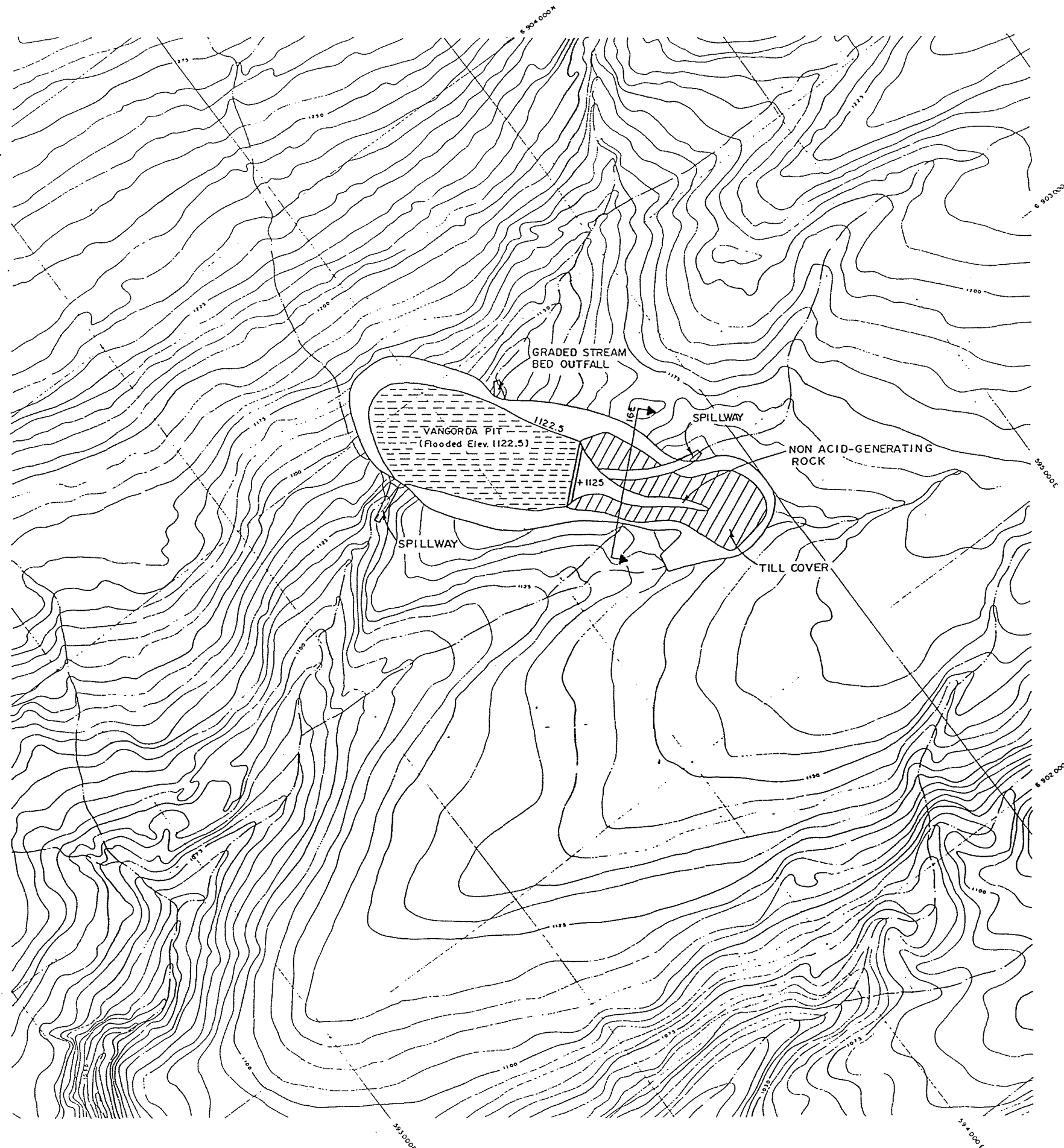
This alternative, which is shown on Figure 5.2, involves backfilling the pit with Vangorda waste rock east of Section 12 to elevation 1122.5 metres (the ultimate water level of the pit). A typical section through the pit is shown in Figure 5.3. A further 2.5 metre thick layer of non-acid generating waste rock would then be placed over this backfill to provide a working surface on which to place the till covers. Those portions of the pit wall in which potentially acid generating rock is exposed would then be covered with till placed at a 3:1 (horizontal to vertical) overall slope. The till covers would then

be vegetated to help prevent erosion. Loose sulphides would be scaled from the pit walls prior to placing the covers. Other facilities required would include an inlet spillway, an outlet spillway and graded streambed outfall. The purpose of this remediation is to prevent direct contact of precipitation and surface runoff with the pit wall sulphides. The till cover will also limit oxygen entry to the walls since the void ratio in intact rock is much smaller than in broken rock waste. There is also less likelihood for breathing in intact rock than in waste dumps.

5.2.2 Water Quality Predictions based on Original Flow and Concentration Distributions

The model for this alternative assumes that till covers would be placed on the Vangorda pit walls located in the southwestern and southeastern sections of the pit. It is estimated that wall till covers would reduce zinc concentrations in pit wall seeps by 80 percent with the predicted annual mean monthly zinc concentration for the entire Vangorda pit decreasing from 5.14 mg/L to 1.03 mg/L.

Water quality predictions for this alternative are shown in Table 5.1. The model predicts a mean monthly zinc concentration of 0.13 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations are 0.73 and 0.36 mg/L in Vangorda Creek below the mine site and at Faro respectively. The zinc concentrations in Vangorda Creek are 36 percent less than zinc concentrations predicted for the original scheme.



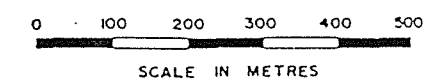
ALTERNATIVE 3.2

- Pit flooded to elevation 1122.5 metres;
- Backfill east of Section 12 with rock to elevation 1122.5 metres;
- Cover pit walls east of Section 12 with till and vegetation.

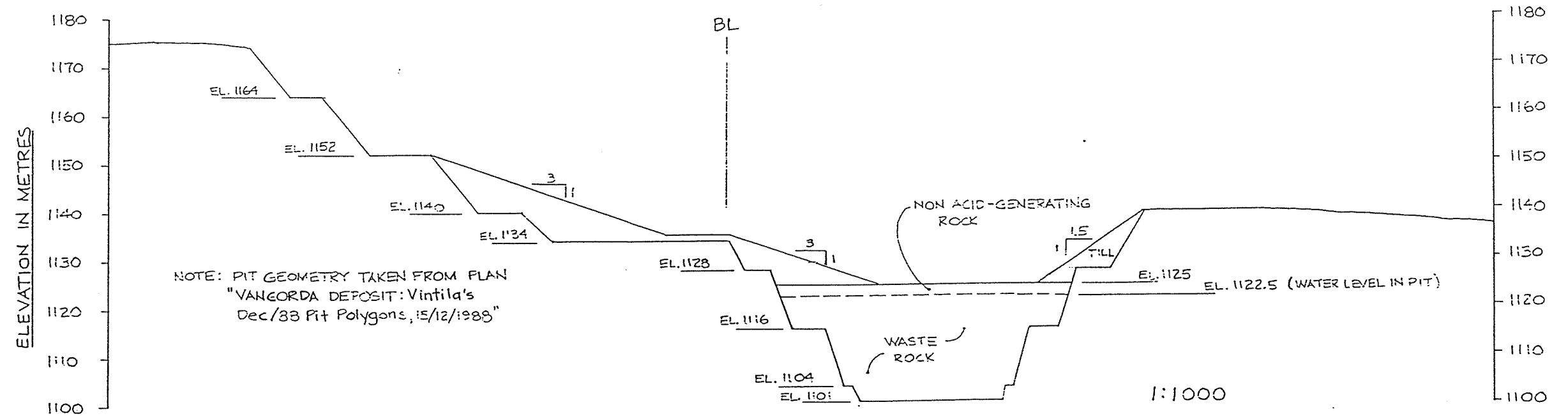
KEY

 WATER

 TILL COVER



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC 1989
VANGORDA PIT ALTERNATIVE 3.2 PLAN		PROJ NO 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO 5.2



SECTION 16E

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE	NOV. 89
VANGORDA PIT ALTERNATIVE 3.2 PIT SECTION		PROJ. NO.	60609
		APPROVED	
		NO.	5.3
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers			

TABLE 5.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.2

FLOOD VANGORDA PIT AND PLACE TILL COVERS ON WALLS

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	18.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	25.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	7.61
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	11.08
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.03
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.77
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.21
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	33.25
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.10
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	25.46
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.14
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	15.41
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	2.24
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.69
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				74.72	100.00

TABLE 5.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT										ALTERNATIVE 3.2 Feb-90						
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL	
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87	
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26		
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21	
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47	
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00	
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37	
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39	
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31	
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00	
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25	
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00	
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89	
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51	
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82	
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42	
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00	
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12	
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92	
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47	
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00	
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30	
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28	
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93	
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51	
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03		
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19	
Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94	
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06		
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07	

TABLE 5.1: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.2

Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
Discharge	Zn mg/l	0.43	0.74	1.26	4.06	1.44	0.99	0.99	0.98	0.95	1.06	0.69	0.27	1.14	
Vangorda	Zn kg	4.31	6.73	12.63	71.09	182.59	143.49	83.67	70.41	55.09	42.13	11.11	3.61	57.24	686.86
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	42	38	46	67	545	629	366	311	249	174	68	59	216	2595
Discharge	Zn mg/l	0.14	0.23	0.35	1.29	0.43	0.32	0.29	0.29	0.29	0.30	0.21	0.10	0.35	
Vangorda & Grum	Zn kg	5.79	8.64	15.85	86.52	233.11	202.82	106.93	90.91	73.03	53.01	14.33	5.66	74.72	896.59
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
Below Minesite	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6924
	Zn mg/l	0.06	0.10	0.16	0.73	0.16	0.11	0.11	0.11	0.11	0.11	0.07	0.03	0.13	
	Zn kg	6	9	16	87	233	203	107	91	73	53	14	6	74.72	896.59
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.02	0.04	0.07	0.36	0.05	0.03	0.03	0.03	0.03	0.04	0.02	0.01	0.04	
	Zn kg	6	9	16	87	233	203	107	91	73	53	14	6	74.72	896.59
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0003	0.0014	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Zn kg	6	9	16	87	233	203	107	91	73	53	14	6	74.72	896.59

5.3 Alternative 3.3

5.3.1 Description

This alternative is described as follows:

- Flood pit to elevation 1122.5 metres;
- Backfill east of Section 12 with rock to elevation 1122.5;
- Cover pit walls east of Section 12 with till and synthetic membrane.

Construction quantities for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Rock Backfill East of Section 12		
Rock Haul	cu.m	260,000.00
Rock Placement	cu.m	260,000.00
Till Cover on Vangorda Pit Walls		
Till Haul	cu.m	336,500.00
Till Placement	cu.m	336,500.00
Clean Loose Sulphides from Pit Walls	sq.m	44,000.00
Geomembrane Liner		
Supply & Place Sand Bedding	cu.m	22,500.00
Supply and Install 80mil HDPE membrane	sq.m	75,000.00
Haul/Place/Compact Till cover(1.0m)	cu.m	75,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

As discussed in Section 3.8, till covers alone have limited effectiveness at restricting water infiltration and oxygen diffusion. The addition of a synthetic membrane greatly increases the effectiveness of the cover.

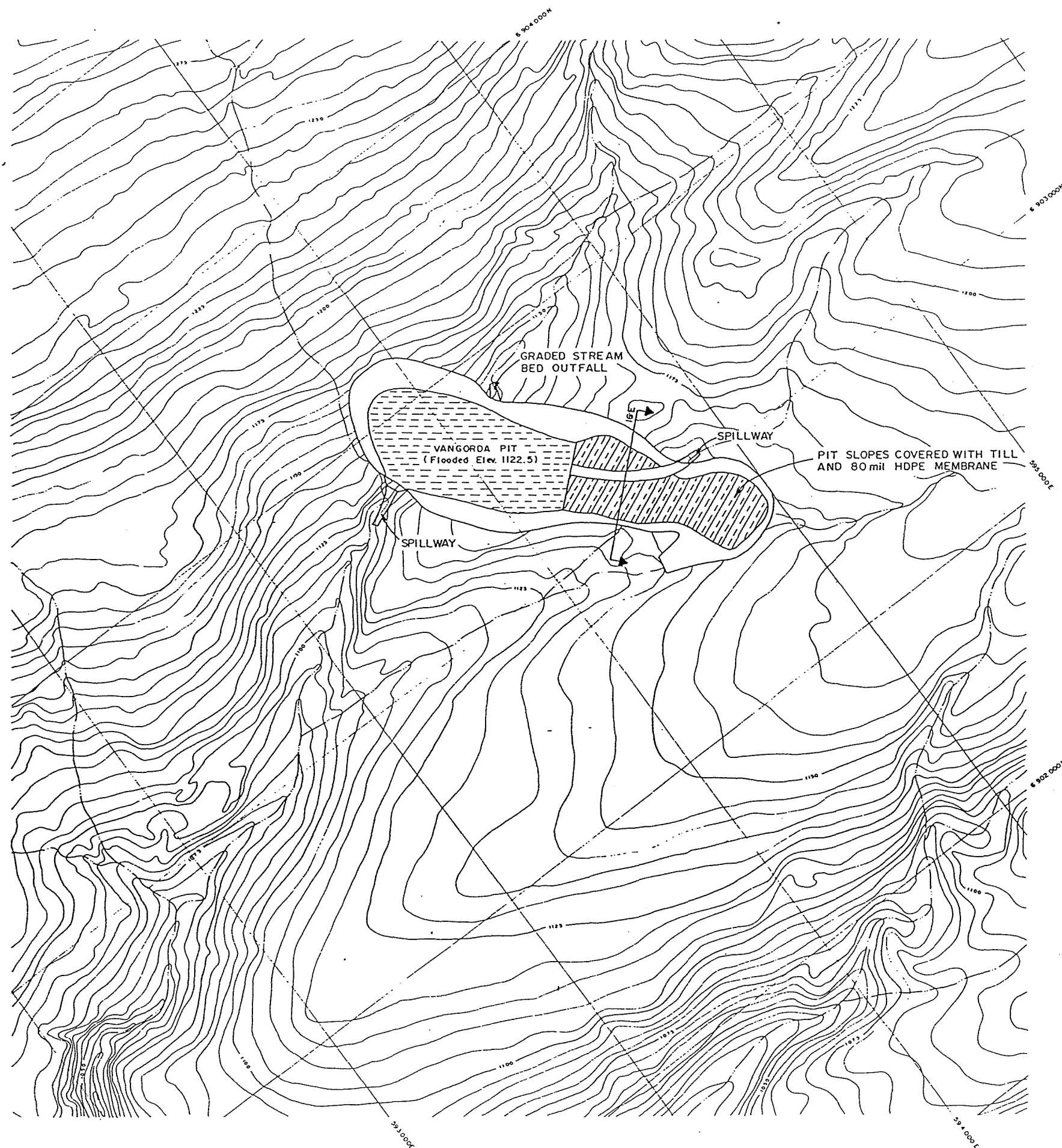
Alternative 3.3 is illustrated in Figures 5.4 and 5.5. As in Alternative 3.2, the pit would be allowed to flood to elevation 1122.5. East of Section 12, the pit would be backfilled with waste rock from Vangorda pit to the same elevation. A layer of non-acid generating rock would then be placed up to

elevation 1125 metres. Till would then be placed over those parts of the pit walls containing potentially acid generating material. Unlike Alternative 3.2, however, this till would have to be placed at 4:1 (horizontal to vertical) slopes to prevent the synthetic membrane from sliding. The 80 mil HDPE membrane would then be placed over the till. A 0.3 metre thick sand or gravel drainage layer would then be placed over the membrane. The drainage layer would then, in turn, be covered with another one metre thick layer of till for protection. As in Alternative 1.7 careful placement is required to avoid damaging the membrane.

5.3.2 Water Quality Predictions based on Original Flow and Concentration Distributions

The model assumes that geomembrane covers would reduce zinc concentrations from pit wall seeps by 95 percent. The mean monthly zinc concentration for the entire Vangorda pit would thus decrease from 5.15 mg/L to 0.26 mg/L.

Water quality predictions for this alternative are shown in Table 5.2. The model predicts a mean monthly zinc concentration of 0.11 mg/L in Vangorda Creek below the mine site and 0.03 mg/L at Faro. The annual mean monthly concentration peaks are 0.67 and 0.33 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 43 percent less than zinc concentrations predicted in the base case.

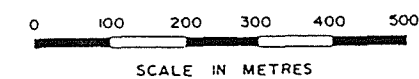


ALTERNATIVE 3.3

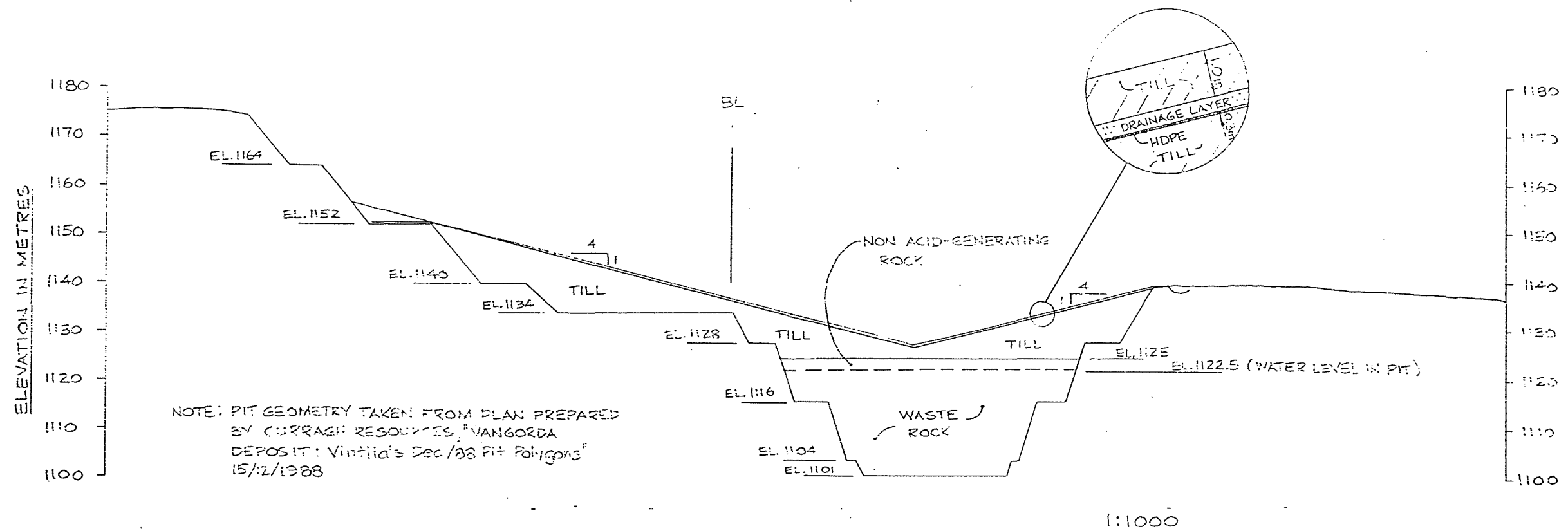
- Flood pit to elevation 1122.5 metres;
- Backfill east of Section 12 with rock to elevation 1122.5;
- Cover pit walls east of Section 12 with till and synthetic membrane.

KEY

-  WATER
-  HDPE MEMBRANE



CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC 1989
VANGORDA PIT ALTERNATIVE 3.3 PLAN		PROJ NO 60609
		APPROVED
		NO 5.4
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		



SECTION 16E

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE NOV. 89
VANGORDA PIT ALTERNATIVE 3.3 PIT SECTION		PROJ. NO. 60609
		APPROVED
		NO. 5.5
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

TABLE 5.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.3

FLOOD VANGORDA PIT AND PLACE TILL COVERS AND GEO-MEMBRANE ON PIT

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	18.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	25.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq. km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	8.76
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	12.77
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.04
Seepage into Grum Lake	12.06	31.69	0.04	1.32	2.04
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.39
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	38.30
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.12
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	29.33
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.16
Seepage into Vangorda Lake	4.27	11.21	0.26	2.88	4.44
Runoff into Vangorda Lake	11.48	30.16	0.01	0.45	0.69
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.94
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				64.86	100.00

TABLE 5.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.09	0.09	0.12	0.31	0.32	0.29	0.29	0.24	0.24	0.16	0.12	0.05	0.26	
	Zn kg	0.34	0.31	0.49	2.33	10.36	6.65	5.29	4.13	3.08	1.27	0.22	0.09	2.88	34.55

TABLE 5.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.3

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.05	0.05	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
	Zn kg	0.22	0.20	0.04	0.09	1.52	1.43	0.77	0.43	0.35	0.25	0.05	0.04	0.45	5.40
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
Discharge	Zn mg/l	0.34	0.65	1.10	3.64	1.15	0.82	0.77	0.79	0.77	0.94	0.64	0.24	0.94	
Vangorda	Zn kg	3.42	5.93	11.04	63.83	146.95	119.26	65.48	56.74	44.83	37.57	10.28	3.22	47.38	568.56
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	42	38	46	67	545	629	366	311	249	174	68	59	216	2595
Discharge	Zn mg/l	0.12	0.21	0.31	1.18	0.36	0.28	0.24	0.25	0.25	0.28	0.20	0.09	0.30	
Vangorda & Grum	Zn kg	4.90	7.84	14.26	79.26	197.47	178.58	88.74	77.24	62.77	48.45	13.50	5.27	64.86	778.28
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
Below Minesite	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6924
	Zn mg/l	0.05	0.09	0.14	0.67	0.14	0.10	0.09	0.09	0.09	0.10	0.07	0.03	0.11	
	Zn kg	5	8	14	79	197	179	89	77	63	48	14	5	64.86	778.28
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.02	0.03	0.06	0.33	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.03	
	Zn kg	5	8	14	79	197	179	89	77	63	48	14	5	64.86	778.28
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0003	0.0013	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	
	Zn kg	5	8	14	79	197	179	89	77	63	48	14	5	64.86	778.28

5.4 Alternative 3.4

5.4.1 Description

Alternative 3.4 involves flooding the pit to El. 1122.5 and covering potentially acid generating rock exposed on the pit walls above that elevation with polyethylene reinforced shotcrete with Silica Fume, as shown on Figures 5.6 and 5.7.

Scaling of the pit walls to remove loose rock and the installation of weep holes will be required prior to applying the shotcrete. The weep holes would prevent pore pressure build-up behind the shotcrete. Additional construction items associated with this alternative include the inlet spillway, outlet spillway, and graded streambed outfall shown in Figure 5.6.

Although shotcrete would initially be very effective at reducing water infiltration and oxygen diffusion into the pit walls, the shotcrete cover would deteriorate with time as the rock in the pit walls deteriorates, particularly due to frost action and slaking. Also, unlike till, shotcrete has no self-healing abilities to counteract this deterioration.

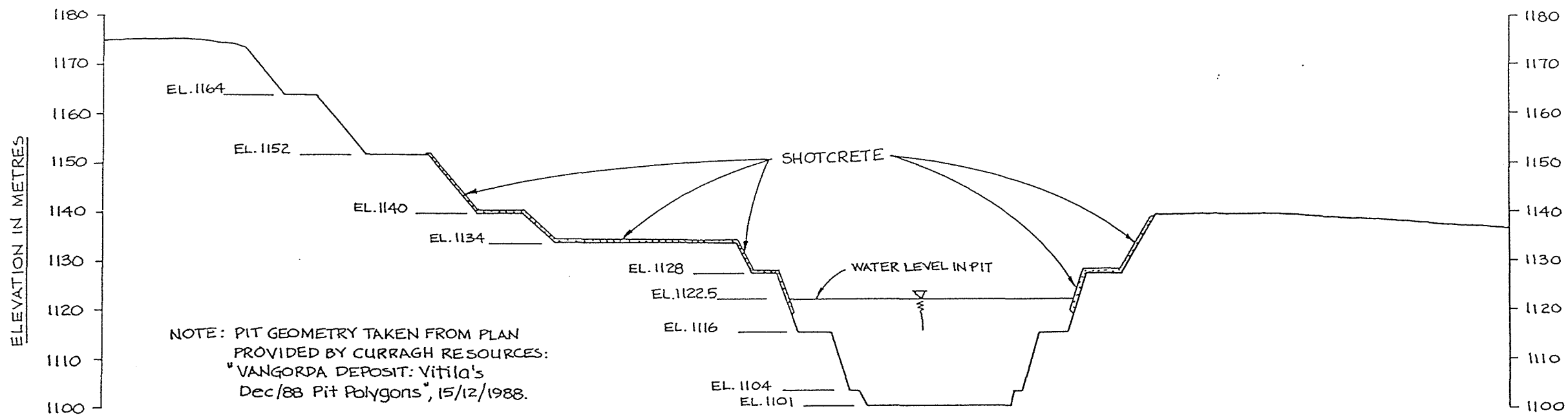
Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Shotcrete Exposed Sulphides on Pit walls		
Prepare Rock Surface	sq.m	44,000.00
Shotcrete Rock Surface	sq.m	44,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

5.4.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Shotcrete when freshly applied is considered to be as efficient as a till cover and is predicted to reduce zinc concentrations in pit wall seeps by 80 percent. The mean monthly zinc concentration for the entire Vangorda pit would thus decrease from 5.14 mg/L to 1.00 mg/L.

Water quality predictions for this alternative are similar to those for Alternative 3.2 shown in Table 5.1. The model predicts a mean monthly zinc concentration of 0.13 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations are 0.73 and 0.36 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 36 percent less than zinc concentrations predicted for the original scheme.



SECTION 16E

CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
VANGORDA PIT ALTERNATIVE 3.4 PIT SECTION		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO. 5.7

5.5 Alternative 3.5

5.5.1 Description

Alternative 3.5 uses an in-pit dam to raise the water level in the pit to cover the potentially acid generating rock exposed in the pit walls south of Section 12. The dam which has a crest elevation of 1140 metres would be located at Section 12, as shown in Figure 5.8 and would raise the water level east of Section 12 to elevation 1137.5 metres. Some sulphide-rich rock will remain exposed above El. 1137.5, especially along the northeast wall. West of Section 12 of the pit would be allowed to flood to El. 1122.5.

The construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Dam Construction At Section 12		
Foundation Preparation	ha	0.80
Till - Haul/ Place/ Compact	cu.m	287,700.00
Rockfill-Haul/place/	cu.m	673,500.00
Blanket Drains	cu.m	9,100.00
Piezometers	No.	10.00
Settlement Markers	No.	10.00
Emergency Spillway		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	2,000.00
Upstream Slope Protection(Riprap)	cu.m	4,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

The conceptual design for the embankment consists of a central till core with a rockfill shell. Further work would be required to determine the thickness of till core and the maximum stable slope angles for the shell. Non-acid generating rock would be imported for rockfill in the upstream shell above

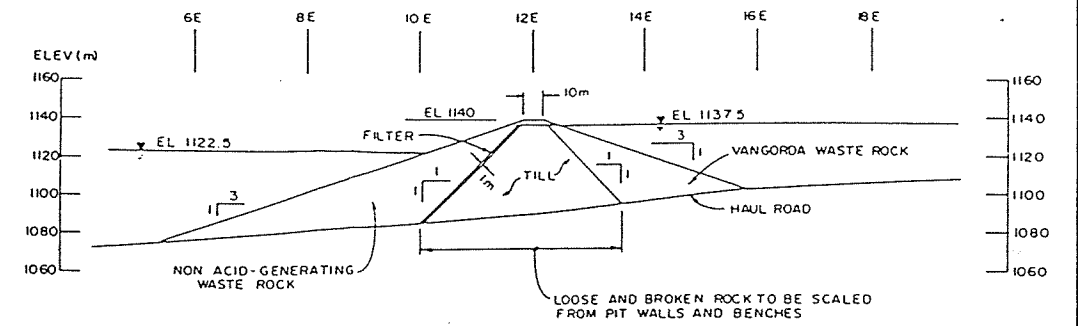
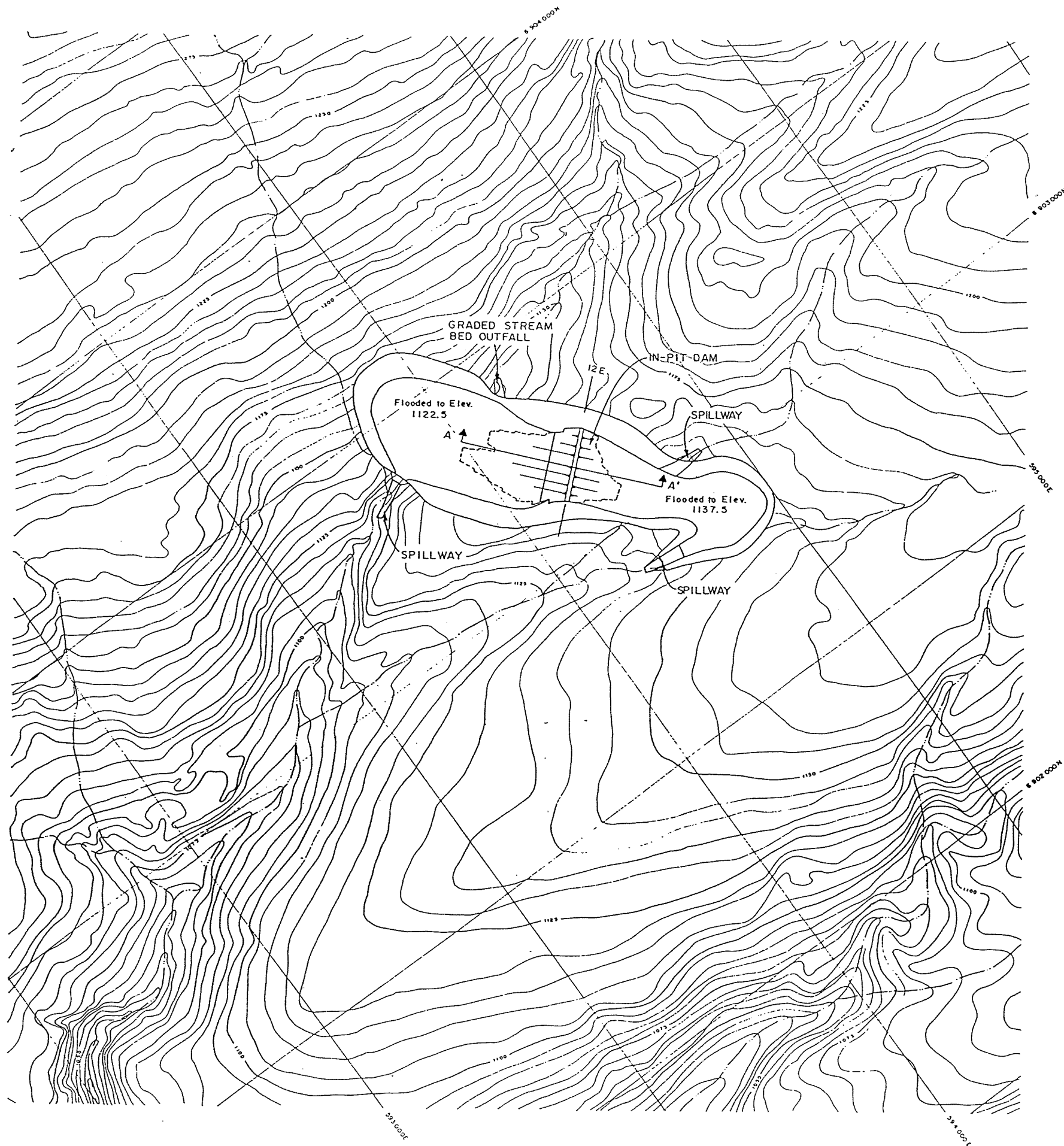
elevation 1137.5 metres and in the downstream shell above elevation 1122.5 metres. Waste rock from Vangorda pit could be used for the remainder of the rockfill, provided it is stored under water.

In addition to the dam, an inlet spillway, a graded streambed outfall, an outlet spillway at the northwest end of the pit, and an emergency spillway at the southwest end of the pit, would be required.

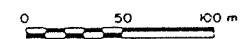
5.5.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Alternative 3.5 involves flooding the Vangorda pit to El. 1140 metres. A water cover to this elevation would submerge much of the wall sulphide otherwise left exposed in the base case (Alternative 2.2). Zinc concentrations are predicted to be reduced by 90 percent and the mean monthly zinc concentration for the entire Vangorda pit would decrease, from 5.14 mg/L to 0.51 mg/L.

Water quality predictions for this alternative are shown in Table 5.3. The model predicts a mean monthly zinc concentration of 0.12 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations are 0.69 and 0.34 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 41 percent less than zinc concentrations predicted in the base case.

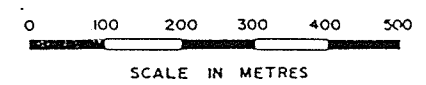


SECTION A-A'



ALTERNATIVE 3.5

- Construct in-pit dam at Section 12 with crest at Elevation 1140 m
- Flood pit (to Elevation 1122.5 west of Section 12, and Elevation 1137.5 east of Section 12).



CURRAGH RESOURCES INC.		VANGORDA PLATEAU DEVELOPMENT		DATE DEC 1989
VANGORDA PIT ALTERNATIVE 3.5 PLAN AND SECTION				PROJ NO 60609
				APPROVED
				NO
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers				5.8

TABLE 5.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.5

FLOOD VANGORDA PIT TO El. 1140 m.

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	18.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	25.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	250.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	8.24
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	12.01
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.04
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.92
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.31
Vangorda Sulphide Cell Infiltration.	0.33	0.87	28.60	24.84	36.03
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.08	0.11
Vangorda Phyllite Cell Infiltration.	0.46	1.21	15.77	19.02	27.59
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.11	0.15
Seepage into Vangorda Lake	4.27	11.21	0.51	5.76	8.35
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	2.42
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.83
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				68.96	100.00

TABLE 5.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.5

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT																
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL	
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87	
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26		
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21	
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47	
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00	
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37	
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39	
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31	
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00	
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25	
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00	
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89	
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51	
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82	
Vangorda Sulphide	dam^3	0.23	0.23	0.25	0.61	1.87	2.23	1.33	1.17	0.99	0.81	0.43	0.25	0.87	10.42	
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00	
	Zn kg	1.87	2.81	6.30	30.60	74.86	66.93	33.30	29.25	24.75	20.25	5.19	2.02	24.84	298.12	
Vangorda Sulphide	dam^3	0.42	0.38	0.42	1.80	5.79	9.00	4.86	4.02	3.27	2.33	1.02	0.84	2.85	34.16	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.09	0.17	0.36	0.10	0.08	0.07	0.02	0.01	0.01	0.08	0.92	
Vangorda Phyllite	dam^3	0.32	0.32	0.35	0.85	2.60	3.10	1.85	1.62	1.37	1.12	0.60	0.35	1.21	14.47	
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00	
	Zn kg	0.98	2.60	4.20	30.60	59.80	43.39	25.89	22.74	16.50	15.75	4.80	1.05	19.02	228.30	
Vangorda Phyllite	dam^3	0.59	0.53	0.59	2.50	8.05	12.50	6.75	5.58	4.54	3.23	1.42	1.17	3.95	47.44	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.01	0.01	0.01	0.12	0.24	0.50	0.13	0.11	0.09	0.03	0.01	0.01	0.11	1.28	
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93	
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51	
	Zn mg/l	0.17	0.17	0.25	0.63	0.63	0.58	0.58	0.48	0.47	0.33	0.25	0.09	0.51		
	Zn kg	0.68	0.62	0.97	4.67	20.71	13.30	10.58	8.26	6.15	2.55	0.44	0.17	5.76	69.09	

TABLE 5.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 3.5

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	18	127	145	85	72	58	40	16	13	50	603
Discharge	Zn mg/l	0.36	0.67	1.16	3.79	1.27	0.90	0.86	0.86	0.85	0.99	0.66	0.26	1.02	
Vangorda	Zn kg	3.63	6.11	11.66	66.43	161.88	130.20	73.09	62.15	48.94	39.58	10.67	3.44	51.48	617.77
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	42	38	46	67	545	629	366	311	249	174	68	59	216	2595
Discharge	Zn mg/l	0.12	0.21	0.33	1.22	0.39	0.30	0.26	0.27	0.27	0.29	0.20	0.09	0.32	
Vangorda & Grum	Zn kg	5.10	8.03	14.88	81.85	212.40	189.52	96.35	82.65	66.88	50.46	13.89	5.49	68.96	827.49
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.18	0.07	0.06	0.22	
Below Minesite	dam^3	95	86	99	119	1455	1769	982	820	664	469	198	166	577	6924
	Zn mg/l	0.05	0.09	0.15	0.69	0.15	0.11	0.10	0.10	0.10	0.11	0.07	0.03	0.12	
	Zn kg	5	8	15	82	212	190	96	83	67	50	14	5	68.96	827.49
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.02	0.03	0.06	0.34	0.05	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.04	
	Zn kg	5	8	15	82	212	190	96	83	67	50	14	5	68.96	827.49
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0003	0.0013	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	
	Zn kg	5	8	15	82	212	190	96	83	67	50	14	5	68.96	827.49

5.6 Alternative 3.6

5.6.1 Description

The final alternative considered involves removing the potentially acid generating materials from the pit walls and depositing this waste into the pit under water. The additional excavation required is shown in Figures 5.9 and 5.10. Two pit outlines are shown in these figures: one for removal of sulphides only and the other for removal of both sulphides and altered phyllites. However, to be effective both the sulphides and the altered phyllites would have to be removed. The total quantities of additional excavation required in bank cubic metres are given below:

Overburden	768,000 bcm
Sulphide	442,000 bcm
Phyllite	<u>479,000 bcm</u>
 TOTAL	 1,689,000 bcm

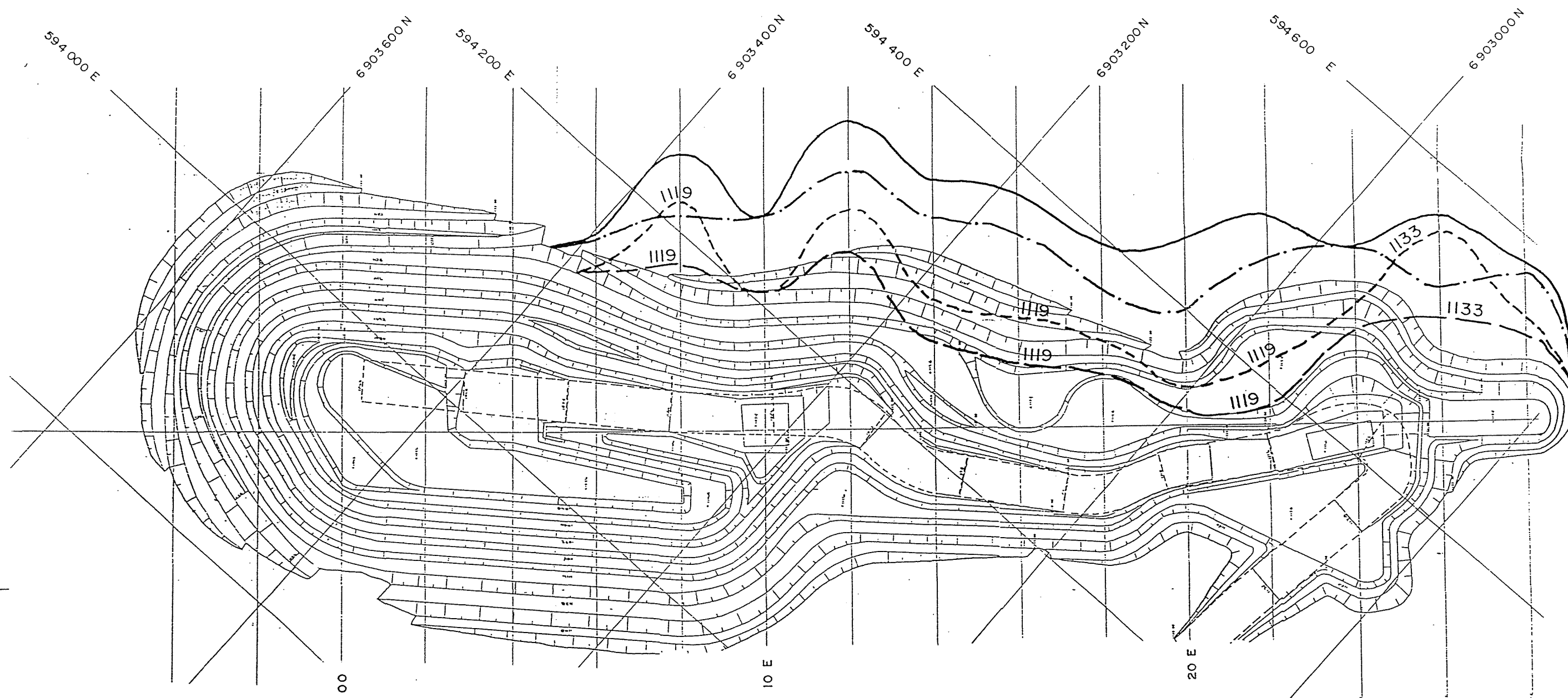
Construction Quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Excavate Sulphides & Alt. Phy. in Pit walls		
Excavation & Place in Pit	cu.m	921,000.00
Excavate Till Overburden		
Excavation of till	cu.m	768,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

5.6.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Alternative 3.6 investigates the effects of removing the exposed wall sulphides from the Vangorda pit walls. This alternative is considered to be as effective as applying till covers to the pit walls. It is considered that some acid generating wall rock will always remain regardless of removal effort, and therefore it is estimated that zinc concentrations would be reduced by 80 percent. The monthly zinc concentration for the entire Vangorda pit changes, from 5.14 mg/L to 1.03 mg/L.

Water quality predictions are shown in Table 5.2. The model predicts a mean monthly zinc concentration of 0.14 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The peak monthly concentrations are 0.74 and 0.36 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 36 percent less than zinc concentrations predicted in the base case.



LEGEND

1. ADDITIONAL EXCAVATION REQUIRED TO REMOVE SULPHIDE AND ALTERED PHYLLITE.

———— CREST OF PIT SLOPE

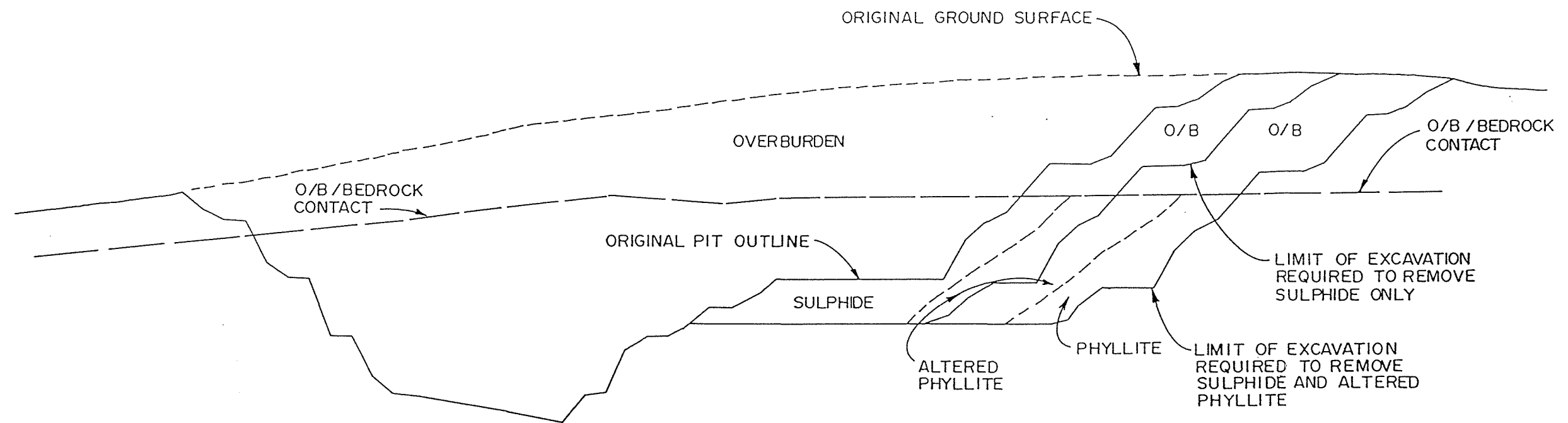
----- TOE OF PIT SLOPE

2. ADDITIONAL EXCAVATION REQUIRED TO REMOVE SULPHIDE ONLY.

..... CREST OF PIT SLOPE

----- TOE OF PIT SLOPE

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
VANGORDA PIT ALTERNATIVE 3.6 PLAN		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO. 5.9



CURRAGH RESOURCES INC.	VANGORDA PLATEAU DEVELOPMENT	DATE DEC. 1989
VANGORDA PIT ALTERNATIVE 3.6 SECTION SHOWING ADDITIONAL EXCAVATION REQUIRED		PROJ. NO. 60609
		APPROVED
		NO. 5.10
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

5.7 Summary and Discussion

A total of six different mitigative measures were considered for the abandonment of the Vangorda Pit. A summary of the predicted annual mean monthly and peak monthly concentrations for each alternative are shown in Table 5.4. Other than Alternative 3.1, the predicted annual mean monthly and peak monthly zinc concentration are very similar and represents, on average, a 31 percent improvement over Alternative 3.1. The change in zinc loading for each of the vangorda Pit alternatives compared to the base case (Alt 3.1) is presented as follows:

<u>Alternative</u>	<u>Monthly Zinc Loading(Kg)</u>	<u>Loading Change (%)</u>
3.1	66	-0
3.2	13	-80
3.3	3	-95
3.4	13	-80
3.5	7	-89
3.6	13	-80

TABLE 5.4 : SUMMARY OF WATER QUALITY PREDICTIONS FROM VVANGORDA PIT

ALTERNATIVE	DUMP AREAS	VANGORDA PIT SEEPAGES A1/A2/A3	VANGORDA CRK. BELOW MINE		WATER QUALITY IN VANGORDA CREEK AT FAPO (ZINC)					
			MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE * FROM ALT.1.3 (+/-)	CHANGE FROM ALT.1.3 (%)
VANGORDA PIT	(ha)	(l/s)								
ALT. 3.1 – Flood Pit, No Pit wall Covers	*	1.25/0.50/2.25	0.22	1.05	128	423	0.07	0.62	0	0%
ALT. 3.2 – Flood Pit, Pit Wall Covers	*	1.25/0.50/2.25	0.13	0.73	75	233	0.04	0.36	-53	-41%
ALT. 3.3 – Till cover, Geomembrane, Flood Pit	*	1.25/0.50/2.25	0.11	0.67	65	197	0.03	0.33	-63	-49%
ALT. 3.4 – Shotcrete Pit Walls	*	1.25/0.50/2.25	0.13	0.73	75	233	0.04	0.36	-53	-41%
ALT. 3.5 – In-pit Dam, Flood pit	*	1.25/0.50/2.25	0.12	0.69	69	212	0.04	0.34	-59	-46%
ALT. 3.6 – Remove Sulphides from Pit Walls	*	1.25/0.50/2.25	0.14	0.74	81	257	0.04	0.36	-47	-37%

* Mean Monthly Zinc Loading

6.0 ALTERNATIVE SCHEME COMBINATIONS

The previous sections present alternatives to each of the three major components of the original abandonment plan. Because it is unlikely that any of the component alternatives would be independently implemented, combinations of alternative components were developed. This section of the report discusses several selected alternatives.

The following combinations were selected

- Alternatives 1.3, 2.2 and 3.1*
- Alternatives 1.3, 2.2 and 3.2*
- Alternatives 1.4, 2.4 and 3.1.
- Alternatives 1.4, 2.4 and 3.5.
- Alternatives 1.5.1, 2.4 and 3.5.
- Alternatives 1.5.1, 2.4 and 3.2.
- Alternatives 1.5.1, 2.3 and 3.2.
- Alternatives 1.5, 2.4 and 3.2.
- Alternatives 1.5, 2.3 and 3.2.
- Alternatives 1.2, 2.1 and 3.1 w/treatment.

The alternatives marked with an asterisk are included in a summary table at the end of this section but are not discussed in detail because they have been included as component alternatives in previous sections.

6.1 Alternative 1.4/2.4/3.1

6.1.1 Description

This abandonment plan which includes the combination of Alternatives 1.4, 2.4 and 3.1 is described as follows:

- Segregate sulphide and phyllite waste from Vangorda Pit;
- Selectively place sulphide and phyllite in dump southwest of pit, above ravine;
- Construct till/rock berms around each waste type to form two cells;
- Place three metre till cover over both cells;
- Allow Vangorda pit to flood (to elevation 1122.5); No covers on pit walls;
- Separate till covered cell for Grum sulphide rock.

6.1.2 Water Quality Predictions based on Original Flow and Concentration Distributions

This combination would establish segregated Vangorda sulphide and phyllite waste cells which on abandonment would be covered with till. However, the ravine immediately south of the Vangorda pit would not be used for rock waste storage. Instead, this ravine would be reserved for a possible wetland development. The Vangorda pit, under this option, would be flooded to elevation 1122.5 metres. The northeastern and southwestern pit walls would not be covered with till, and predicted zinc concentrations in the wall seeps are assumed to be equivalent to operational wall seepage concentrations.

The Grum waste dumps would comprise an unsegregated main dump, and a till covered sulphide waste dump. The sulphide dump would be located northwest of the Grum pit. This dump, therefore, would be located in the watershed of the west fork of Vangorda Creek. The Grum pit would be flooded to elevation 1256 metres.

Water quality predictions are shown in Table 6.1. The model predicts a mean monthly zinc concentration of 0.20 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The monthly concentration peaks are 0.92 and 0.49 mg/L in Vangorda Creek below the mine site and at Faro respectively. The concentrations in Vangorda Creek at Faro are 4 percent less than zinc concentrations predicted in the base case.

Construction quantity estimates for this alternative are presented as follows:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Berms and Internal Layer		
Foundation Preparation	ha	56.30
Till Placement	cu.m	2,370,000.00
Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Rock Drain		
Supply & Install Blanket	cu.m	6,000.00
Supply & Install Finger Drains	cu.m	1,350.00
Supply & Install 60 mil HDPE	sq.m	350.00
Supply & Place Bedding	cu.m	120
Selective Placement of Waste	cu.m	4,296,500.00
Erosion Protection	ha	56.30
Selective Placement of Grum Sulphide Waste	lcu.m	2,908,240.40
Grum Sulphide Cell Berm Construction		
Foundation Preparation	ha	59.00
Till Placement	cu.m	300,000.00
Grum Sulphide Dump Cover(Lower 1m)		
Till Haul	cu.m	336,600.00
Till Placement and Compaction	cu.m	336,600.00
Grum Sulphide Dump Cover(Upper 2m)		
Till Haul	cu.m	683,400.00
Till Placement	cu.m	683,400.00
Internal Till Layers(1m)		
Till Haul	cu.m	104,000.00
Till Placement	cu.m	104,000.00
Replacement of Sul. Waste into Grum Pit	lcu.m	760,000.00
Erosion Protection of Till Cover	ha	5.20

TABLE 6.1: WATER QUALITY PREDICTIONS - COMBINATION 1.4, 2.4 and 3.1

COMBINATION 1.4/ 2.4/ 3.1

GRUM SULPHIDES AND ALTERED PHYLLITES NORTH OF GRUM PIT AND TILL Dec-89

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	12.4	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	27.6	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.0	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	253.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	4.67
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	6.80
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.02
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.09
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.74
Vangorda Sulphide Cell Infiltration.	0.23	0.60	28.60	17.11	14.06
Vangorda Sulphide Cell Runoff	0.75	1.96	0.03	0.05	0.04
Vangorda Phyllite Cell Infiltration.	0.51	1.33	15.77	21.00	17.25
Vangorda Phyllite Cell Runoff	1.66	4.36	0.03	0.12	0.10
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	47.33
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.87
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.03
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				121.75	100.00

TABLE 6.1: WATER QUALITY PREDICTIONS - COMBINATION 1.4, 2.4 and 3.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.16	0.16	0.17	0.42	1.29	1.54	0.92	0.81	0.68	0.56	0.30	0.17	0.60	7.18
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.29	1.94	4.34	21.08	51.57	46.11	22.94	20.15	17.05	13.95	3.57	1.39	17.11	205.37
Vangorda Sulphide	dam^3	0.29	0.26	0.29	1.24	3.99	6.20	3.35	2.77	2.25	1.60	0.70	0.58	1.96	23.53
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.06	0.12	0.25	0.07	0.06	0.05	0.02	0.01	0.01	0.05	0.63
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.94	2.87	3.42	2.04	1.79	1.52	1.24	0.66	0.39	1.33	15.98
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.08	2.87	4.64	33.78	66.01	47.90	28.59	25.11	18.22	17.38	5.30	1.16	21.00	252.04
Vangorda Phyllite	dam^3	0.65	0.59	0.65	2.76	8.88	13.80	7.45	6.16	5.02	3.57	1.57	1.29	4.36	52.37
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.55	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.41
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14	
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49

TABLE 6.1: WATER QUALITY PREDICTIONS - COMBINATION 1.4, 2.4 and 3.1

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT cont'd

SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Runoff into Vangorda lake	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from Area Between Pits	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent Discharge Vangorda	dam^3	10	9	10	17	126	143	84	71	57	39	16	13	50	596
	Zn mg/l	0.98	1.27	1.98	6.04	2.82	1.79	2.07	1.92	1.82	1.57	0.91	0.39	2.10	
	Zn kg	9.64	11.39	19.59	103.51	355.73	256.49	173.04	136.63	103.90	61.79	14.38	5.18	104.27	1251.27
Mine Effluent Discharge Grum	dam^3	31	29	36	49	415	480	279	237	190	133	52	45	165	1977
	Zn mg/l	0.03	0.03	0.03	0.11	0.06	0.08	0.04	0.05	0.05	0.03	0.03	0.03	0.06	
	Zn kg	0.85	0.97	1.12	5.20	25.51	36.89	12.13	10.72	9.67	4.12	1.49	1.37	9.17	110.04
Mine Effluent Discharge Vangorda & Grum	dam^3	41	38	45	66	541	623	363	309	247	173	68	58	214	2572
	Zn mg/l	0.25	0.33	0.46	1.65	0.70	0.47	0.51	0.48	0.46	0.38	0.23	0.11	0.53	
	Zn kg	10.49	12.36	20.71	108.71	381.23	293.38	185.17	147.35	113.57	65.91	15.87	6.55	113.44	1361.32
Vangorda creek Upstream	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek Below Minesite	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.17	0.07	0.06	0.21	
	dam^3	95	86	99	118	1452	1764	979	818	662	467	197	166	575	6902
	Zn mg/l	0.11	0.14	0.21	0.92	0.26	0.17	0.19	0.18	0.17	0.14	0.08	0.04	0.20	
	Zn kg	10	12	21	109	381	293	185	147	114	66	16	7	113.44	1361.32
Vangorda Creek at Faro	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
	dam^3	241	241	241	242	4636	6084	3163	2680	2198	1447	724	482	1865	22379
	Zn mg/l	0.05	0.06	0.09	0.49	0.09	0.05	0.06	0.06	0.06	0.05	0.02	0.01	0.07	
	Zn kg	11	13	23	119	406	316	196	157	122	73	18	7	121.75	1461.00
Pelly River At Faro	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0002	0.0002	0.0004	0.0019	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0004	
	Zn kg	11	13	23	119	406	316	196	157	122	73	18	7	121.75	1461.00

6.2 Alternative 1.4/2.4/3.2

6.2.1 Description

The abandonment plan combining Alternatives 1.4, 2.4 and 3.2 is summarised as follows:

- Segregate sulphide and phyllite waste from Vangorda Pit;
- Selectively place sulphide and phyllite in dump southwest of pit, above ravine;
- Construct till/rock berms around each waste type to form two cells;
- Place three metre till cover over both cells;
- Place Till covers on Vangorda pit walls and flood to elevation 1122.5;
- Separate till covered cell for Grum sulphide rock.

6.2.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions for this combination are presented on Table 6.2. The model predicts an annual mean monthly zinc concentration of 0.11 mg/L in Vangorda Creek below the mine site and 0.04 mg/L at Faro. The monthly concentration peaks are 0.59 and 0.33 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 52 percent less than zinc concentrations predicted in the base case.

TABLE 6.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4/2.4/3.2

GRUM SULPHIDES AND ALTERED PHYLLITES NORTH OF GRUM PIT
SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER
ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	12.4	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	27.6	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area(incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	253.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	8.24
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	12.01
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.04
Seepage into Grum Lake	12.06	31.69	0.04	1.32	1.92
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.31
Vangorda Sulphide Cell Infiltration.	0.23	0.60	28.60	17.11	24.82
Vangorda Sulphide Cell Runoff	0.75	1.96	0.03	0.05	0.08
Vangorda Phyllite Cell Infiltration.	0.51	1.33	15.77	21.00	30.46
Vangorda Phyllite Cell Runoff	1.66	4.36	0.03	0.12	0.17
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	16.70
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	2.43
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	1.83
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				68.95	100.00

TABLE 6.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4/2.4/3.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
Feb-90															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.16	0.16	0.17	0.42	1.29	1.54	0.92	0.81	0.68	0.56	0.30	0.17	0.60	7.18
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	1.29	1.94	4.34	21.08	51.57	46.11	22.94	20.15	17.05	13.95	3.57	1.39	17.11	205.37
Vangorda Sulphide	dam^3	0.29	0.26	0.29	1.24	3.99	6.20	3.35	2.77	2.25	1.60	0.70	0.58	1.96	23.53
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.06	0.12	0.25	0.07	0.06	0.05	0.02	0.01	0.01	0.05	0.63
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.94	2.87	3.42	2.04	1.79	1.52	1.24	0.66	0.39	1.33	15.98
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.08	2.87	4.64	33.78	66.01	47.90	28.59	25.11	18.22	17.38	5.30	1.16	21.00	252.04
Vangorda Phyllite	dam^3	0.65	0.59	0.65	2.76	8.88	13.80	7.45	6.16	5.02	3.57	1.57	1.29	4.36	52.37
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.55	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.41
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03	
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19
Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07

TABLE 6.2: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.4/2.4/3.2

Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	17	126	143	84	71	57	39	16	13	50	596
Discharge	Zn mg/l	0.39	0.68	1.12	3.78	1.31	0.89	0.91	0.89	0.86	0.95	0.63	0.23	1.04	
Vangorda	Zn kg	3.83	6.13	11.11	64.74	165.49	127.12	75.98	63.66	49.10	37.46	9.99	3.09	51.48	617.71
Mine Effluent	dam^3	31	29	36	49	415	480	279	237	190	133	52	45	165	1977
Discharge	Zn mg/l	0.03	0.03	0.03	0.11	0.06	0.08	0.04	0.05	0.05	0.03	0.03	0.03	0.06	
Grum	Zn kg	0.85	0.97	1.12	5.20	25.51	36.89	12.13	10.72	9.67	4.12	1.49	1.37	9.17	110.04
Mine Effluent	dam^3	41	38	45	66	541	623	363	309	247	173	68	58	214	2572
Discharge	Zn mg/l	0.11	0.19	0.27	1.06	0.35	0.26	0.24	0.24	0.24	0.24	0.17	0.08	0.28	
Vangorda & Grum	Zn kg	4.68	7.10	12.23	69.94	191.00	164.02	88.11	74.39	58.77	41.58	11.48	4.46	60.65	727.75
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.37	0.31	0.25	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	95	86	99	118	1452	1764	979	818	662	467	197	166	575	6902
	Zn mg/l	0.05	0.08	0.12	0.59	0.13	0.09	0.09	0.09	0.09	0.09	0.06	0.03	0.11	
	Zn kg	5	7	12	70	191	164	88	74	59	42	11	4	60.65	727.75
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	242	4636	6084	3163	2680	2198	1447	724	482	1865	22379
	Zn mg/l	0.02	0.03	0.06	0.33	0.05	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.04	
	Zn kg	5	8	14	80	216	186	99	84	67	48	13	5	68.95	827.43
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0003	0.0013	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.00	
	Zn kg	5	8	14	80	216	186	99	84	67	48	13	5	68.95	827.43

6.3 Alternative 1.5.1/2.2/3.5

6.3.1 Description

The abandonment plan combining Alternatives 1.5.1, 2.2 and 3.5 is summarized as follows:

- Place all Vangorda waste, unsegregated, in temporary stockpile during operations; Blend with limestone or calcareous phyllite;
- Construct in-pit dam at Section 12 with crest at El.1140;
- Return all Vangorda waste rock to pit;
- Allow pit to flood, providing water cover for waste rock.

Construction quantity estimates for this combination alternative are presented below:

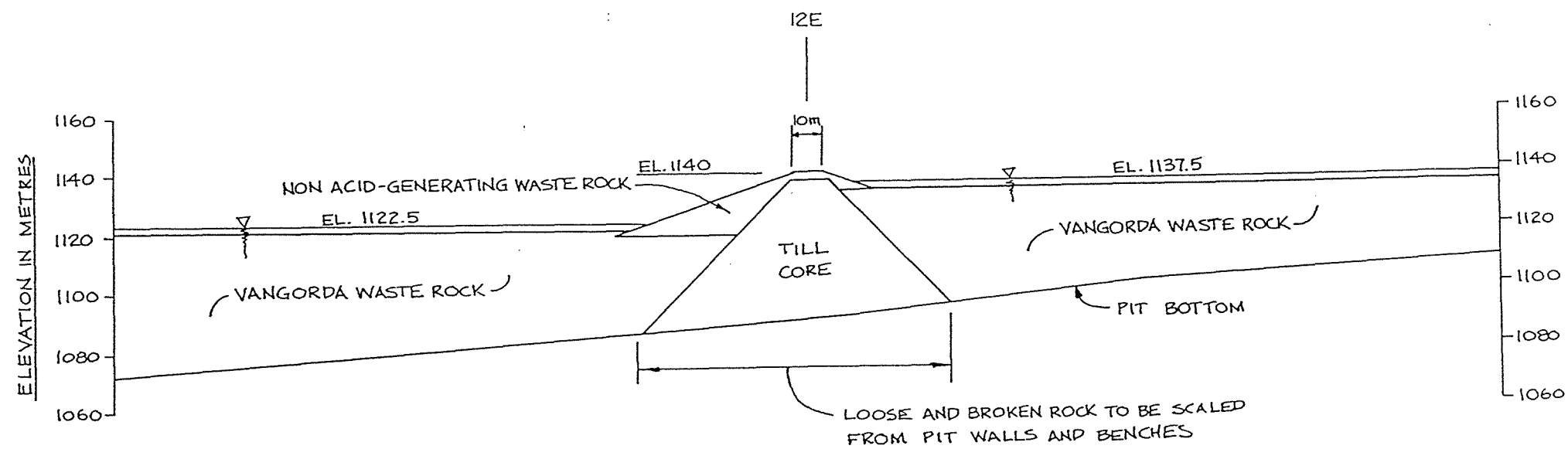
CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Waste	cu.m	4,296,500.00
Replacement of All Waste into Vangorda Pit	cu.m	4,360,947.50
Clean up Stockpile Area	ha	43.00
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Dam Construction At Section 12		
Foundation Preparation	ha	0.80
Till - Haul/Place/ Compact	cu.m	287,700.00
Rockfill-Haul/place/	cu.m	172,000.00
Blanket Drains	cu.m	9,100.00
Piezometers	No.	10.00
Settlement Markers	No.	10.00
Emergency Spillway		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	2,000.00
Upstream Slope Protection(Riprap)	cu.m	4,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

Figure 6.1 shows a longitudinal section through Vangorda Pit illustrating this abandonment plan. Waste rock would be placed up to El 1121.5 on the downstream side of the dam, and up to El. 1136.5 on the upstream side. One metre of water cover would be maintained over the waste rock on both sides. Raising the water level east of Section 12 also provides a water cover for most of the potentially acid generating rock exposed on the pit walls.

6.3.2 Water Quality Predictions based on Original Flow and Concentration Distributions

This combination, would have all Vangorda waste rock removed to the Vangorda pit at the completion of mining. Vangorda pit east of Section 12 would then be flooded to elevation 1140 metres. This water level would effectively minimize acid generation from the pit wall rocks, and negate acid generating potential of waste rock returned to the pit. The Grum pit would also be flooded to the 1256 metre level, while Grum waste dumps would consist of a till covered sulphide cell and an unsegregated, uncovered main rock dump for low acid generating and acid consuming waste rock.

Water quality predictions are shown in Table 6.3. The model predicts a mean monthly zinc concentration of 0.04 mg/L in Vangorda Creek below the mine site and 0.01 mg/L at Faro. The monthly concentration peaks are 0.18 and 0.08 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 80 percent less than zinc concentrations predicted in the base case and are close to the existing natural load of Vangorda creek. This would result in a two-fold increase from existing metal loading in the creek.



1:2000

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
COMBINATION 1.5.1/2.4/3.5 VANGORDA PIT SECTION THROUGH IN-PIT DAM		PROJ. NO. 60609
		APPROVED
		NO. 6.1
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

TABLE 6.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.5

VANGORDA SULPHIDE AND PHYLLITE WASTE RETURNED TO VANGORDA PIT AND

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.3	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	293.2	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	22.82
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	33.25
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.10
Seepage into Grum Lake	12.06	31.69	0.04	1.32	5.32
Runoff into Grum Lake	22.88	60.13	0.02	0.90	3.62
Vangorda Sulphide Cell Infiltration.	0.00	0.00	26.69	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	0.51	5.76	23.12
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	6.71
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	5.06
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				24.91	100.00

TABLE 6.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.5

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.17	0.17	0.25	0.63	0.63	0.58	0.58	0.48	0.47	0.33	0.25	0.09	0.51	
	Zn kg	0.68	0.62	0.97	4.67	20.71	13.30	10.58	8.26	6.15	2.55	0.44	0.17	5.76	69.09

TABLE 6.3: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.5

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	8	8	8	12	109	118	70	60	48	32	13	11	41	496
Discharge	Zn mg/l	0.09	0.09	0.14	0.43	0.25	0.16	0.20	0.17	0.16	0.11	0.05	0.03	0.18	
Vangorda	Zn kg	0.77	0.70	1.15	5.01	26.80	19.02	13.67	9.96	7.54	3.53	0.66	0.35	7.43	89.16
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	40	37	44	61	527	602	351	299	239	167	65	56	207	2488
Discharge	Zn mg/l	0.06	0.07	0.10	0.33	0.15	0.13	0.11	0.10	0.11	0.09	0.06	0.04	0.12	
Vangorda & Grum	Zn kg	2.25	2.61	4.37	20.44	77.32	78.34	36.93	30.46	25.47	14.41	3.88	2.40	24.91	298.88
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.03	0.03	0.04	0.04	0.54	0.65	0.36	0.30	0.24	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	94	85	98	113	1437	1743	967	808	654	461	195	163	568	6818
	Zn mg/l	0.02	0.03	0.04	0.18	0.05	0.04	0.04	0.04	0.04	0.03	0.02	0.01	0.04	
	Zn kg	2	3	4	20	77	78	37	30	25	14	4	2	24.91	298.88
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.01	0.01	0.02	0.08	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	
	Zn kg	2	3	4	20	77	78	37	30	25	14	4	2	24.91	298.88
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0000	0.0000	0.0001	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	
	Zn kg	2	3	4	20	77	78	37	30	25	14	4	2	24.91	298.88

6.4 Alternative 1.5.1/2.2/3.2

6.4.1 Description

This alternative abandonment plan combines component alternatives 1.5.1, 2.4 and 3.2 and is summarized as follows:

- Place all Vangorda waste, unsegregated, in temporary stockpile during operations; Blend with limestone or calcareous phyllite;
- Return all waste to Vangorda pit at abandonment and allow pit to flood;
- Cover pit walls east of Section 12 with till and vegetation;
- Dispose of Grum waste as per Alternative 2.2.

As not all of the Vangorda waste will be accommodated in the pit below El. 1122.5, some of the waste will have to be placed above water. West of Section 12, all waste will be placed under water below El.1122.5. The remaining waste rock will be placed east of Section 12 and completely covered with 3 metres of till as shown on Figure 6.2. Therefore, the quantity of till required for covering this waste rock and the pit walls is greater than that given for Alternative 3.2 alone.

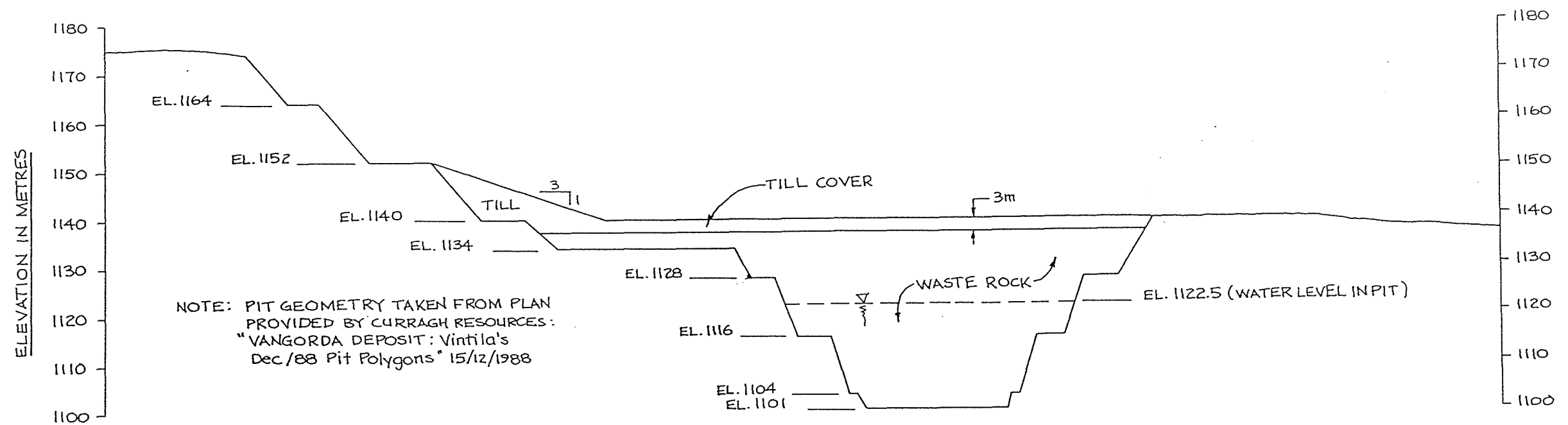
Construction quantities estimated for this option are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Waste	cu.m	4,296,500.00
Replacement of All Waste into Vangorda Pit	lcu.m	4,360,947.50
Clean up Stockpile Area	ha	43.00
Outlet Spillway at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection (Riprap)	cu.m	4,000.00
Till Cover on Vangorda Pit Walls		
Till Haul	cu.m	175,200.00
Till Placement	cu.m	175,200.00
Clean Loose Sulphides from Pit Walls	sq.m	44,000.00
Erosion Protection of Till Cover	ha	5.20
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection (riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

6.4.2 Water Quality Predictions based on Original Flow and Concentration Distributions

It is estimated that the combination of pit flooding and placement of till covers on the wall and over the rock would reduce zinc concentrations from the pit by 80 percent. The Grum pit would also be flooded to El. 1256, while Grum waste dumps would consist of a till covered sulphide cell and an unsegregated, uncovered main rock dump for low acid generating and acid consuming waste rock.

Water quality predictions are shown in Table 6.4. The model predicts an annual mean monthly zinc concentration of 0.05 mg/L in Vangorda Creek below the mine site and 0.02 mg/L at Faro. The monthly concentration peaks are 0.22 and 0.10 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 76 percent less than zinc concentrations predicted in the original scheme and are close to existing natural loadings.



SECTION 16E

CURRAGH RESOURCES INC. VANGORDA PLATEAU DEVELOPMENT		DATE DEC. 1989
COMBINATION 1.5.1/2.4/3.2 SECTION THROUGH VANGORDA PIT		PROJ. NO. 60609
		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO. 6.2

TABLE 6.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.2

FLOOD VANGORDA PIT, RETURN ALL VANGORDA WASTE TO PIT, AND PLACE

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.3	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	293.2	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	18.54
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	27.01
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.08
Seepage into Grum Lake	12.06	31.69	0.04	1.32	4.32
Runoff into Grum Lake	22.88	60.13	0.02	0.90	2.94
Vangorda Sulphide Cell Infiltration.	0.00	0.00	26.69	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	37.55
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	5.45
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	4.11
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				30.66	100.00

TABLE 6.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03	
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19

TABLE 6.4: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.2/3.2

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	8	8	8	12	109	118	70	60	48	32	13	11	41	496
Discharge	Zn mg/l	0.17	0.17	0.25	0.82	0.44	0.27	0.35	0.30	0.29	0.19	0.09	0.05	0.32	
Vangorda	Zn kg	1.45	1.31	2.12	9.68	47.52	32.31	24.24	18.22	13.69	6.08	1.10	0.52	13.19	158.25
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	40	37	44	61	527	602	351	299	239	167	65	56	207	2488
Discharge	Zn mg/l	0.07	0.09	0.12	0.41	0.19	0.15	0.14	0.13	0.13	0.10	0.07	0.05	0.15	
Vangorda & Grum	Zn kg	2.93	3.22	5.34	25.11	98.04	91.64	47.50	38.73	31.62	16.96	4.32	2.57	30.66	367.98
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.03	0.03	0.04	0.04	0.54	0.65	0.36	0.30	0.24	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	94	85	98	113	1437	1743	967	808	654	461	195	163	568	6818
	Zn mg/l	0.03	0.04	0.05	0.22	0.07	0.05	0.05	0.05	0.05	0.04	0.02	0.02	0.05	
	Zn kg	3	3	5	25	98	92	48	39	32	17	4	3	30.66	367.98
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.01	0.01	0.02	0.10	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	
	Zn kg	3	3	5	25	98	92	48	39	32	17	4	3	30.66	367.98
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0000	0.0001	0.0001	0.0004	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.00	
	Zn kg	3	3	5	25	98	92	48	39	32	17	4	3	30.66	367.98

6.5 Alternative 1.5.1/2.3/3.2

6.5.1 Description

This alternative abandonment plan combines component alternatives 1.5.1, 2.3 and 3.2 and is summarized as follows:

- Place all Vangorda waste, unsegregated, in temporary stockpile during operations; Blend with limestone or calcareous phyllite;
- Return all waste to Vangorda pit at abandonment and allow pit to flood;
- Cover pit walls east of Section 12 with till and vegetation;
- Return Grum Altered Phyllite and Sulphide into Grum Pit.

6.5.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions are shown in Table 6.5. The model predicts an annual mean monthly zinc concentration of 0.05 mg/L in Vangorda Creek below the mine site and 0.02 mg/L at Faro. The monthly concentration peaks are 0.16 and 0.08 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 78 percent less than zinc concentrations predicted in the original scheme.

TABLE 6.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.3/3.2

FLOOD VANGORDA PIT AND PLACE TILL COVERS ON WALLS
 SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Feb-90

Vangorda Sulphide Cell Waste Dump Area	=	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	0.0	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	0.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	293.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.86	23.27	0.50	11.67	41.17
Grum Sulphide cell Infiltration	0.00	0.00	ERR	0.00	0.00
Grum Sulphide Cell Runoff	0.00	0.00	ERR	0.00	0.00
Seepage into Grum Lake	12.06	31.69	0.04	1.32	4.67
Runoff into Grum Lake	22.88	60.13	0.02	0.90	3.18
Vangorda Sulphide Cell Infiltration.	0.00	0.00	ERR	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	ERR	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	ERR	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	ERR	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	40.63
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	5.90
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	4.44
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				28.34	100.00

TABLE 6.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.3/3.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT																
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL	
Grum Waste Dumps		4.45	4.45	5.94	7.29	49.13	68.03	41.03	34.42	27.67	22.27	7.29	7.29	23.27	279.28	
Infiltration	Zn mg/l	0.20	0.20	0.20	0.98	0.59	0.78	0.39	0.39	0.39	0.20	0.20	0.20	0.50		
	Zn kg	0.87	0.87	1.17	7.15	28.92	53.36	16.09	13.50	10.85	4.37	1.43	1.43	11.67	140.03	
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Infiltration	Zn mg/l	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.00	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	ERR		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00	
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25	
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00	
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89	
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51	
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82	
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Infiltration	Zn mg/l	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.00	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	ERR		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Infiltration	Zn mg/l	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.00	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	ERR		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93	
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51	
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03		
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19	
Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94	
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06		
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07	

TABLE 6.5: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5.1/2.3/3.2

PAGE 3 OF 3

Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	8	8	8	12	109	118	70	60	48	32	13	11	41	496
Discharge	Zn mg/l	0.17	0.17	0.25	0.82	0.44	0.27	0.35	0.30	0.29	0.19	0.09	0.05	0.32	
Vangorda	Zn kg	1.45	1.31	2.12	9.68	47.52	32.31	24.24	18.22	13.69	6.08	1.10	0.52	13.19	158.25
Mine Effluent	dam^3	32	29	36	49	417	483	281	239	191	134	52	46	166	1989
Discharge	Zn mg/l	0.04	0.05	0.05	0.18	0.10	0.13	0.07	0.07	0.08	0.05	0.04	0.05	0.09	
Grum	Zn kg	1.30	1.42	1.72	8.87	40.34	64.26	20.38	17.65	15.23	6.37	2.22	2.11	15.15	181.86
Mine Effluent	dam^3	40	37	44	61	526	601	351	299	239	167	65	56	207	2486
Discharge	Zn mg/l	0.07	0.07	0.09	0.30	0.17	0.16	0.13	0.12	0.12	0.07	0.05	0.05	0.14	
Vangorda & Grum	Zn kg	2.75	2.74	3.84	18.55	87.85	96.57	44.62	35.87	28.92	12.44	3.32	2.63	28.34	340.11
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.03	0.03	0.04	0.04	0.54	0.65	0.36	0.30	0.24	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	94	85	98	113	1437	1742	967	808	654	461	194	163	568	6815
	Zn mg/l	0.03	0.03	0.04	0.16	0.06	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.05	
	Zn kg	3	3	4	19	88	97	45	36	29	12	3	3	28.34	340.11
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.01	0.01	0.02	0.08	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.02	
	Zn kg	3	3	4	19	88	97	45	36	29	12	3	3	28.34	340.11
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0000	0.0000	0.0001	0.0003	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.00	
	Zn kg	3	3	4	19	88	97	45	36	29	12	3	3	28.34	340.11

6.6 Alternative 1.5/2.2/3.2

6.6.1 Description

This alternative abandonment plan combines Alternatives 1.5, 2.2 and 3.2 and is summarized as follows:

- Segregate sulphide and phyllite waste from Vangorda Pit;
- Construct till/rock berms around perimeter, place phyllite waste in cell on ridge southwest of pit, and cover with 3 metres of till;
- Blend Vangorda sulphides with limestone or calcareous phyllite and place in temporary stockpile;
- Return Vangorda sulphides to pit below elevation 1122.5 at abandonment, and allow pit to flood;
- Backfill east of Section 12 with rock to El. 1122.5 and cover pit walls with till and vegetation;
- Dispose of Grum waste as per Alternative 2.2.

6.6.2 Water Quality Predictions based on Original Flow and Concentration Distributions

This combination, involves the replacement Vangorda sulphide waste rock to the Vangorda pit at the completion of mining. The phyllite rock would be placed in a waste cell and covered with till. Till would be placed on the northeastern and southwestern Vangorda pit walls. The Vangorda pit would then be flooded to elevation 1122.5 metres. Submersion of sulphide waste should effectively negate the acid generating potential of the sulphide waste rock. The combination of pit flooding and placement of till covers is predicted to reduce pit wall concentrations by 80 percent. The Grum pit would also be flooded to El.1256, while Grum waste dumps would consist of a till covered sulphide cell and an unsegregated, uncovered main rock dump for potentially low acid-generating and acid consuming waste rock.

Water quality predictions are shown in Table 6.6. The model predicts an annual mean monthly zinc concentration of 0.09 mg/L in Vangorda Creek below the mine site and 0.03 mg/L at Faro. The monthly concentration peaks are 0.51 and 0.25 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 59 percent less than zinc concentrations predicted in the base case.

Construction quantity estimates for this alternative are presented below:

CONSTRUCTION ITEM =====	UNITS =====	QUANTITY =====
Selective Placement of Waste	cu.m	4,296,500.00
Replacement of All Waste into Vangorda Pit	cu.m	4,360,947.50
Clean up Stockpile Area	ha	43.00
Outlet Spillway Construction at North End of Pit		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	4,000.00
Dam Construction At Section 12		
Foundation Preparation	ha	0.80
Till - Haul/Place/ Compact	cu.m	287,700.00
Rockfill-Haul/place/	cu.m	172,000.00
Blanket Drains	cu.m	9,100.00
Piezometers	No.	10.00
Settlement Markers	No.	10.00
Emergency Spillway		
Excavation	cu.m	4,000.00
Erosion Protection(Riprap)	cu.m	2,000.00
Upstream Slope Protection(Riprap)	cu.m	4,000.00
Inlet Spillway at Northeast Wall		
Excavation	cu.m	12,000.00
Erosion Protection(riprap)	cu.m	9,000.00
Graded Streambed Outfall		
Excavation	cu.m	1,200.00

TABLE 6.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.2/3.2

FLOOD VANGORDA PIT, VANGORDA SULPHIDE RETURNED TO PIT, TILL COVE

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	28.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	294.7	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	6.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	265.2	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam ³)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.46	22.24	0.26	5.68	10.91
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	15.90
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.03	0.05
Seepage into Grum Lake	12.06	31.69	0.04	1.32	2.54
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.73
Vangorda Sulphide Cell Infiltration.	0.00	0.00	26.69	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.51	1.35	15.77	21.31	40.90
Vangorda Phyllite Cell Runoff	1.68	4.43	0.03	0.12	0.23
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	22.11
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	3.21
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	2.42
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				52.09	100.00

TABLE 6.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.2/3.2

PAGE 2 OF 3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.26	4.26	5.68	6.97	46.95	65.01	39.21	32.89	26.44	21.28	6.97	6.97	22.24	266.87
Infiltration	Zn mg/l	0.10	0.10	0.10	0.50	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.10	0.26	
	Zn kg	0.43	0.43	0.57	3.48	14.09	26.00	7.84	6.58	5.29	2.13	0.70	0.70	5.68	68.21
Grum Sulphide Cell	dam^3	0.08	0.08	0.08	0.20	0.62	0.74	0.44	0.39	0.33	0.27	0.14	0.08	0.29	3.47
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.60	0.00
	Zn kg	0.62	0.94	2.10	10.20	24.95	22.31	11.10	9.75	8.25	6.75	1.73	0.67	8.28	99.37
Grum Sulphide Cell	dam^3	0.14	0.13	0.14	0.60	1.93	3.00	1.62	1.34	1.09	0.78	0.34	0.28	0.95	11.39
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.03	0.06	0.12	0.03	0.03	0.02	0.01	0.00	0.00	0.03	0.31
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	26.69	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.95	2.91	3.47	2.07	1.82	1.54	1.26	0.67	0.39	1.35	16.21
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.09	2.91	4.70	34.27	66.97	48.60	29.00	25.47	18.48	17.64	5.37	1.18	21.31	255.69
Vangorda Phyllite	dam^3	0.66	0.59	0.66	2.80	9.01	14.00	7.56	6.25	5.09	3.62	1.59	1.31	4.43	53.13
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.56	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.43
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03	
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19

TABLE 6.6: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.2/3.2

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02	0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18	1.67	20.07
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	9	9	9	16	121	136	79	68	54	37	15	12	47	566
Discharge	Zn mg/l	0.27	0.49	0.72	2.84	0.95	0.60	0.67	0.65	0.59	0.64	0.44	0.14	0.73	
Vangorda	Zn kg	2.55	4.23	6.83	44.09	114.76	81.47	53.40	43.82	32.27	23.75	6.49	1.71	34.61	415.38
Mine Effluent	dam^3	32	29	36	50	418	484	281	239	192	134	52	46	166	1992
Discharge	Zn mg/l	0.05	0.07	0.09	0.31	0.12	0.12	0.08	0.09	0.09	0.08	0.06	0.04	0.11	
Grum	Zn kg	1.48	1.91	3.22	15.43	50.52	59.32	23.26	20.50	17.94	10.88	3.22	2.05	17.48	209.72
Mine Effluent	dam^3	41	38	45	65	538	620	361	307	246	172	67	58	213	2557
Discharge	Zn mg/l	0.10	0.16	0.22	0.91	0.31	0.23	0.21	0.21	0.20	0.20	0.14	0.06	0.24	
Vangorda & Grum	Zn kg	4.03	6.14	10.05	59.52	165.28	140.79	76.66	64.32	50.21	34.63	9.71	3.76	52.09	625.10
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	95	86	99	117	1449	1760	977	816	661	466	197	165	574	6887
	Zn mg/l	0.04	0.07	0.10	0.51	0.11	0.08	0.08	0.08	0.08	0.07	0.05	0.02	0.09	
	Zn kg	4	6	10	60	165	141	77	64	50	35	10	4	52.09	625.10
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.02	0.03	0.04	0.25	0.04	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.03	
	Zn kg	4	6	10	60	165	141	77	64	50	35	10	4	52.09	625.10
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0001	0.0001	0.0002	0.0010	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.00	
	Zn kg	4	6	10	60	165	141	77	64	50	35	10	4	52.09	625.10

6.7 Alternative 1.5/2.3/3.2

6.7.1 Description

This alternative abandonment plan combines Alternatives 1.5, 2.3 and 3.2 and is summarized as follows:

- Segregate sulphide and phyllite waste from Vangorda Pit;
- Construct till/rock berms around perimeter, place phyllite waste in cell on ridge southwest of pit, and cover with 3 metres of till;
- Blend Vangorda sulphides with limestone or calcareous phyllite and place in temporary stockpile;
- Return Vangorda sulphides to pit below elevation 1122.5 at abandonment, and allow pit to flood;
- Backfill east of Section 12 with rock to El. 1122.5 and cover pit walls with till and vegetation;
- Return Grum Altered Phyllite and Sulphide waste to Grum Pit.

6.7.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions are shown in Table 6.7. The model predicts an annual mean monthly zinc concentration of 0.09 mg/L in Vangorda Creek below the mine site and 0.03 mg/L at Faro. The monthly concentration peaks are 0.45 and 0.22 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 61 percent less than zinc concentrations predicted in the base case.

TABLE 6.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.3/3.2

PAGE 1 OF 3

FLOOD VANGORDA PIT AND PLACE TILL COVERS ON WALLS

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	0.0	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	28.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	0.0	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	0.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	265.3	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.86	23.27	0.50	11.67	23.45
Grum Sulphide cell Infiltration	0.00	0.00	ERR	0.00	0.00
Grum Sulphide Cell Runoff	0.00	0.00	ERR	0.00	0.00
Seepage into Grum Lake	12.06	31.69	0.04	1.32	2.66
Runoff into Grum Lake	22.88	60.13	0.02	0.90	1.81
Vangorda Sulphide Cell Infiltration.	0.00	0.00	ERR	0.00	0.00
Vangorda Sulphide Cell Runoff	0.00	0.00	ERR	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.51	1.35	15.77	21.31	42.81
Vangorda Phyllite Cell Runoff	1.68	4.43	0.03	0.12	0.24
Seepage into Vangorda Lake	4.27	11.21	1.03	11.52	23.14
Runoff into Vangorda Lake	11.48	30.16	0.06	1.67	3.36
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	2.53
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				49.77	100.00

TABLE 6.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.3/3.2

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT															
Feb-90															
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL
Grum Waste Dumps		4.45	4.45	5.94	7.29	49.13	68.03	41.03	34.42	27.67	22.27	7.29	7.29	23.27	279.28
Infiltration	Zn mg/l	0.20	0.20	0.20	0.98	0.59	0.78	0.39	0.39	0.39	0.20	0.20	0.20	0.50	
	Zn kg	0.87	0.87	1.17	7.15	28.92	53.36	16.09	13.50	10.85	4.37	1.43	1.43	11.67	140.03
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration	Zn mg/l	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	ERR	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Infiltration	Zn mg/l	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.00
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	ERR	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vangorda Phyllite	dam^3	0.36	0.36	0.39	0.95	2.91	3.47	2.07	1.82	1.54	1.26	0.67	0.39	1.35	16.21
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	15.77	0.00
	Zn kg	1.09	2.91	4.70	34.27	66.97	48.60	29.00	25.47	18.48	17.64	5.37	1.18	21.31	255.69
Vangorda Phyllite	dam^3	0.66	0.59	0.66	2.80	9.01	14.00	7.56	6.25	5.09	3.62	1.59	1.31	4.43	53.13
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03	
	Zn kg	0.01	0.01	0.01	0.14	0.27	0.56	0.15	0.12	0.10	0.04	0.02	0.01	0.12	1.43
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51
	Zn mg/l	0.35	0.35	0.49	1.26	1.26	1.16	1.16	0.96	0.95	0.65	0.50	0.19	1.03	
	Zn kg	1.36	1.23	1.94	9.34	41.43	26.59	21.15	16.52	12.30	5.09	0.88	0.34	11.52	138.19

TABLE 6.7: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.5/2.3/3.2

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95		30.16	361.94
Vangorda lake	Zn mg/l	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.04	0.04	0.04	0.02	0.02		0.06	
	Zn kg	0.09	0.08	0.18	0.35	6.09	5.72	3.09	1.70	1.39	0.99	0.22	0.18		1.67	20.07
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62		19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05		50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02		0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30		1.26	15.12
Mine Effluent	dam^3	9	9	9	16	121	136	79	68	54	37	15	12		47	566
Discharge	Zn mg/l	0.27	0.49	0.72	2.84	0.95	0.60	0.67	0.65	0.59	0.64	0.44	0.14		0.73	
Vangorda	Zn kg	2.55	4.23	6.83	44.09	114.76	81.47	53.40	43.82	32.27	23.75	6.49	1.71		34.61	415.38
Mine Effluent	dam^3	32	29	36	49	417	483	281	239	191	134	52	46		166	1989
Discharge	Zn mg/l	0.04	0.05	0.05	0.18	0.10	0.13	0.07	0.07	0.08	0.05	0.04	0.05		0.09	
Grum	Zn kg	1.30	1.42	1.72	8.87	40.34	64.26	20.38	17.65	15.23	6.37	2.22	2.11		15.15	181.86
Mine Effluent	dam^3	41	38	45	65	538	619	361	307	246	172	67	58		213	2555
Discharge	Zn mg/l	0.09	0.15	0.19	0.82	0.29	0.24	0.20	0.20	0.19	0.18	0.13	0.07		0.23	
Vangorda & Grum	Zn kg	3.85	5.65	8.55	52.96	155.10	145.73	73.78	61.47	47.50	30.11	8.71	3.82		49.77	597.23
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04		0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05		20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107		361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0		0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06		0.21	
Below Minesite	dam^3	95	86	99	116	1449	1759	977	816	660	466	197	165		574	6885
	Zn mg/l	0.04	0.07	0.09	0.45	0.11	0.08	0.08	0.08	0.07	0.06	0.04	0.02		0.09	
	Zn kg	4	6	9	53	155	146	74	61	48	30	9	4		49.77	597.23
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18		0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482		1864	22365
	Zn mg/l	0.02	0.02	0.04	0.22	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01		0.03	
	Zn kg	4	6	9	53	155	146	74	61	48	30	9	4		49.77	597.23
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00		194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458		519699	6236387
	Zn mg/l	0.0001	0.0001	0.0002	0.0009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000		0.00	
	Zn kg	4	6	9	53	155	146	74	61	48	30	9	4		49.77	597.23

6.8 Alternative 1.2/2.1/3.1 with treatment

6.8.1 Description

This alternative abandonment plan combines Alternatives 1.2, 2.1 and 3.1 with collection and treatment and is summarized as follows:

- Non-segregation of sulphide and phyllite waste from Vangorda Pit;
- No Construction of till covers over the waste rock ;
- No till cover for the pit walls ;
- Altered Phyllite and Sulphide waste randomly mixed with Grum waste.

6.8.2 Water Quality Predictions based on Original Flow and Concentration Distributions

Water quality predictions are shown in Table 6.8. The model predicts an annual mean monthly zinc concentration of 0.23 mg/L in Vangorda Creek below the mine site and 0.07 mg/L at Faro. The monthly concentration peaks are 0.54 and 0.26 mg/L in Vangorda Creek below the mine site and at Faro respectively. These concentrations in Vangorda Creek are 4 percent above the zinc concentrations predicted in the base case.

TABLE 6.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2/2.1/3.1

PAGE 1 OF 3

VANGORDA UNSEGREGATED DUMP EAST OF CREEK AND SOUTH OF PIT - NO T

SUMMARY OF PARAMETERS USED IN THE PREDICTION OF WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT

Vangorda Sulphide Cell Waste Dump Area	=	37.1	ha	(Original dump area = 20.8)
Vangorda Phyllite Cell Waste Dump Catchment Area	=	0.0	ha	(Original dump area = 22.5)
Catchment of Vangorda Pit (incl. Pit)	=	148.0	ha	
Mean Annual Precipitation	=	539.0	mm	
Mean Annual Evaporation	=	337.1	mm	
Upper Till Cover Thickness	=	2.00	m	
Lower Till Cover Thickness	=	1.00	m	
Upper Till Cover Hydraulic Conductivity	=	.0000014	cm/sec	
Lower Till Cover Hydraulic Conductivity	=	.0000009	cm/sec	
Foundation Soil Hydraulic Conductivity	=	.00000001	cm/sec	
Waste Rock Hydraulic Conductivity	=	.006	cm/sec	
Drainage layer Hydraulic Conductivity.	=	.006	cm/sec	
Vangorda Creek Catchment Area above Diversion	=	17.7	sq.km	
Grum Waste Dumps Total Area (incl Sulphide Cell)	=	135.0	ha	
Grum Sulphide Cell Area	=	0.0	ha	
Catchment of Grum Pit (incl Pit Area)	=	295.0	ha	
Catchment Area between Pits	=	256.1	ha	

SUMMARY OF POTENTIAL CONTAMINANT SOURCES AND LOADINGS BELOW MINESITE AFTER ABANDONMENT

	MEAN MONTHLY DISCHARGE (L/s)	MEAN MONTHLY DISCHARGE (dam^3)	MEAN MONTHLY ZINC LEVELS (mg/L)	MEAN MONTHLY LOADINGS (kg)	PERCENT OF TOTAL LOADINGS (%)
Grum Waste Dump Infiltration	8.86	23.27	4.92	114.40	31.04
Grum Sulphide cell Infiltration	0.00	0.00	28.89	0.00	0.00
Grum Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Grum Lake	12.06	31.69	0.04	1.32	0.36
Runoff into Grum Lake	22.88	60.13	0.02	0.90	0.24
Vangorda Sulphide Cell Infiltration.	2.43	6.39	28.89	184.66	50.11
Vangorda Sulphide Cell Runoff	0.00	0.00	0.03	0.00	0.00
Vangorda Phyllite Cell Infiltration.	0.00	0.00	14.85	0.00	0.00
Vangorda Phyllite Cell Runoff	0.00	0.00	0.03	0.00	0.00
Seepage into Vangorda Lake	4.27	11.21	5.14	57.62	15.64
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	2.27
Runoff From area Between Lakes	19.29	50.68	0.02	1.26	0.34
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				368.53	100.00

TABLE 6.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2/2.1/3.1

PAGE 2 OF 3

PREDICTED WATER QUALITY IN VANGORDA CREEK AFTER ABANDONMENT																
SOURCE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	TOTAL	
Grum Waste Dumps		4.45	4.45	5.94	7.29	49.13	68.03	41.03	34.42	27.67	22.27	7.29	7.29	23.27	279.28	
Infiltration	Zn mg/l	1.93	1.93	1.93	9.61	5.77	7.69	3.84	3.85	3.85	1.93	1.92	1.92	4.92		
	Zn kg	8.57	8.57	11.43	70.09	283.50	523.16	157.78	132.35	106.40	42.87	14.03	14.03	114.40	1372.80	
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Grum Sulphide Cell	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage into	l/s	4.00	4.00	5.00	10.00	33.00	25.00	19.00	18.00	14.00	8.00	2.00	2.00	12.00	144.00	
Grum Lake	dam^3	10.71	9.68	13.39	25.92	88.39	64.80	50.89	48.21	36.29	21.43	5.18	5.36	31.69	380.25	
	Zn mg/l	0.02	0.03	0.02	0.05	0.06	0.05	0.02	0.03	0.06	0.02	0.02	0.02	0.04	0.00	
	Zn kg	0.21	0.29	0.27	1.30	5.30	3.24	1.02	1.45	2.18	0.43	0.10	0.11	1.32	15.89	
Grum Lake Runoff	dam^3	8.94	8.05	8.94	8.64	151.76	190.05	102.65	84.81	69.11	49.11	21.59	17.85	60.13	721.51	
	Zn mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	
	Zn kg	0.13	0.12	0.13	0.13	2.28	2.85	1.54	1.27	1.04	0.74	0.32	0.27	0.90	10.82	
Vangorda Sulphide	dam^3	1.52	1.52	1.56	4.39	14.28	17.11	10.04	8.66	7.25	5.84	2.97	1.56	6.39	76.71	
Cell Infiltration	Zn mg/l	8.00	12.01	25.00	50.00	39.99	29.99	25.00	25.00	25.00	25.00	12.01	8.00	28.89	0.00	
	Zn kg	12.20	18.30	39.03	219.37	571.05	512.93	250.99	216.59	181.26	145.94	35.71	12.50	184.66	2215.88	
Vangorda Sulphide	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Infiltration	Zn mg/l	3.00	8.00	12.00	36.00	23.00	14.00	14.00	14.00	12.00	14.00	8.00	3.00	14.85	0.00	
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vangorda Phyllite	dam^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cell Runoff	Zn mg/l	0.01	0.01	0.01	0.05	0.03	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.03		
	Zn kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Seepage into	l/s	1.47	1.47	1.47	2.87	12.24	8.86	6.82	6.44	5.02	2.91	0.68	0.68	4.24	50.93	
Vangorda lake	dam^3	3.93	3.55	3.93	7.43	32.79	22.97	18.27	17.25	13.00	7.80	1.76	1.82	11.21	134.51	
	Zn mg/l	1.74	1.74	2.47	6.29	6.32	5.79	5.79	4.79	4.73	3.26	2.50	0.94	5.14		
	Zn kg	6.82	6.17	9.71	46.72	207.30	133.08	105.85	82.68	61.55	25.47	4.41	1.72	57.62	691.49	

TABLE 6.8: WATER QUALITY PREDICTIONS - ALTERNATIVE 1.2/2.1/3.1

Runoff into	dam^3	4.48	4.04	4.48	4.34	76.13	95.34	51.49	42.54	34.67	24.64	10.83	8.95	30.16	361.94
Vangorda lake	Zn mg/l	0.10	0.10	0.20	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.28	
	Zn kg	0.45	0.40	0.90	1.73	30.45	28.60	15.45	8.51	6.93	4.93	1.08	0.90	8.36	100.33
Runoff from	l/s	2.81	2.81	2.81	2.81	47.77	61.81	32.31	26.69	22.48	15.45	7.02	5.62	19.20	230.39
Area Between Pits	dam^3	7.53	6.80	7.53	7.28	127.95	160.21	86.54	71.49	58.27	41.38	18.20	15.05	50.68	608.22
	Zn mg/l	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn kg	0.08	0.14	0.15	0.29	3.84	4.81	1.73	1.43	1.17	0.83	0.36	0.30	1.26	15.12
Mine Effluent	dam^3	10	9	10	16	123	135	80	68	55	38	16	12	48	573
Discharge	Zn mg/l	1.96	2.73	4.98	16.58	6.57	4.98	4.66	4.50	4.55	4.61	2.65	1.22	5.25	
Vangorda	Zn kg	19.47	24.88	49.64	267.82	808.81	674.62	372.29	307.78	249.75	176.34	41.21	15.11	250.64	3007.70
Mine Effluent	dam^3	32	29	36	49	417	483	281	239	191	134	52	46	166	1989
Discharge	Zn mg/l	0.28	0.31	0.33	1.46	0.71	1.11	0.58	0.57	0.58	0.33	0.28	0.32	0.71	
Grum	Zn kg	9.00	9.12	11.99	71.80	294.92	534.06	162.07	136.50	110.78	44.87	14.82	14.71	117.89	1414.63
Mine Effluent	dam^3	42	38	46	65	540	619	361	307	246	172	68	58	214	2562
Discharge	Zn mg/l	0.68	0.89	1.35	5.20	2.04	1.95	1.48	1.45	1.46	1.28	0.83	0.52	1.73	
Vangorda & Grum	Zn kg	28.47	34.00	61.63	339.63	1103.73	1208.68	534.35	444.27	360.53	221.21	56.03	29.82	368.53	4422.33
Treated Mine	dam^3	37	34	41	59	486	557	325	277	222	155	61	52	192	2306
Effluent Water	Zn mg/l	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
(90% of Volume)	Zn kg	18.71	17.14	20.60	29.38	243.19	278.33	162.42	138.32	110.82	77.61	30.52	26.05	96.09	1153.09
Untreated Mine	dam^3	4	4	5	7	54	62	36	31	25	17	7	6	21	256
Effluent Water	Zn mg/l	0.68	0.89	1.35	5.20	2.04	1.95	1.48	1.45	1.46	1.28	0.83	0.52	1.73	
(10% of Volume)	Zn kg	2.85	3.40	6.16	33.96	110.37	120.87	53.44	44.43	36.05	22.12	5.60	2.98	36.85	442.23
Vangorda creek	cu.m/sec	0.02	0.02	0.02	0.02	0.34	0.44	0.23	0.19	0.16	0.11	0.05	0.04	0.14	
Upstream	mm	3.03	2.73	3.03	2.93	51.45	64.43	34.80	28.75	23.43	16.65	7.32	6.05	20.38	244.60
	dam^3	54	48	54	52	911	1140	616	509	415	295	130	107	361	4330
	Zn mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Zn kg	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Vangorda Creek	cu.m/sec	0.04	0.03	0.04	0.04	0.54	0.66	0.36	0.30	0.25	0.17	0.07	0.06	0.21	
Below Minesite	dam^3	95	86	99	117	1451	1759	977	816	661	467	197	165	574	6892
	Zn mg/l	0.23	0.24	0.27	0.54	0.24	0.23	0.22	0.22	0.22	0.21	0.18	0.18	0.23	
	Zn kg	22	21	27	63	354	399	216	183	147	100	36	29	132.94	1595.32
Vangorda Creek	cu.m/sec	0.09	0.09	0.09	0.09	1.73	2.27	1.18	1.00	0.82	0.54	0.27	0.18	0.70	
at Faro	dam^3	241	241	241	241	4634	6080	3161	2678	2196	1446	723	482	1864	22365
	Zn mg/l	0.09	0.09	0.11	0.26	0.08	0.07	0.07	0.07	0.07	0.07	0.05	0.06	0.07	
	Zn kg	22	21	27	63	354	399	216	183	147	100	36	29	132.94	1595.32
Pelly River	cu.m/sec	26.00	21.80	19.50	23.10	412.00	715.00	387.00	250.00	209.00	157.00	69.00	39.00	194.03	2328.40
At Faro	dam^3	69638	58389	52229	61871	1103501	1915056	1036541	669600	559786	420509	184810	104458	519699	6236387
	Zn mg/l	0.0003	0.0004	0.0005	0.0010	0.0003	0.0002	0.0002	0.0003	0.0003	0.0002	0.0002	0.0003	0.0003	
	Zn kg	22	21	27	63	354	399	216	183	147	100	36	29	132.94	1595.32

6.9 Summary and Discussion

The first stage of this study involved a review of a number of alternative mitigative measures for the Vangorda Dump, the Grum Dump and the Vangorda Pit. Using the original scheme as a base case, alternative mitigative measures were applied to each of the three main components and the water quality for each scheme was predicted using the original mass-loading model. The second stage involved combining selected alternatives from each component and evaluating the resultant impact on water quality. A summary of the results of the analysis is presented in Table 6.9. Plots of the predicted total mean monthly zinc concentration distribution in Vangorda Creek at Faro townsite for each of the combination alternatives including background levels have been prepared and are presented on Figures 6.3 and 6.4. Included on these graphs are estimated mean monthly toxic limits for fish habitat in Vangorda Creek prepared by P. A. Harder & Associates and the fresh water zinc limits for aquatic life as recommended by the Canadian Council of Resource and Environment Ministers (CCREM). The mean monthly toxic level for the month of April has been adjusted from the value presented in the Harder report "Impact Assessment of Fish Resources in Vangorda Creek" December 1989, to be more representative of condition for early April.

With the exception of the peak flush in April, the results indicate that alternatives which include total or partial return of the Vangorda waste to the pit combined with either till or water covers, would produce zinc levels in Vangorda creek at Faro which are generally within the CCREM guidelines and below the mean toxic limits for fish habitat developed by P. A. Harder and Associates

Based on the results of the preceding analyses, SRK recommends that an approach to the abandonment of the Vangorda mine site might be to provide a plan that has the flexibility to accommodate several of the alternatives considered in this study. The prediction of the water quality impact on Vangorda Creek is dependent on many factors of which there is still a high degree of uncertainty. The abandonment plan could therefore be completed in stages with each subsequent stage selected on the basis of results of a regular monitoring program. The monitoring program should include not only water quality but also temperature and oxygen content in the dumps.

The initial stages of the recommended abandonment plan could include Alternative 1.4 and 2.2 which involve constructing the rock/till berms for the Vangorda dumps during the till stripping phase of the development. As waste rock is deposited behind the berms, results from the monitoring program of seeps from waste rock and the pit walls would enable selection of the subsequent stages. Based on the results of the analysis in this report alternatives that might be most effective would include the return of the Vangorda sulphide rock to the pit combined with either pit wall covers or water covered behind an in-pit dam. This mitigation would minimize the impact on Vangorda Creek at Faro, however the predicted residual impact on Vangorda Creek at the minesite would still exceeds the CCREM guidelines and impact by the mine on the fish habitat in the upper reaches would remain. The risk of runaway AMD, however would be avoided.

**TABLE 6.9 : SUMMARY OF WATER QUALITY PREDICTIONS FOR ALTERNATIVE SCHEME COMBINATIONS
ASSUMING ORIGINAL CONCENTRATION AND FLOW DISTRIBUTIONS BASED ON ORIGINAL
MEAN ANNUAL CONCENTRATIONS**

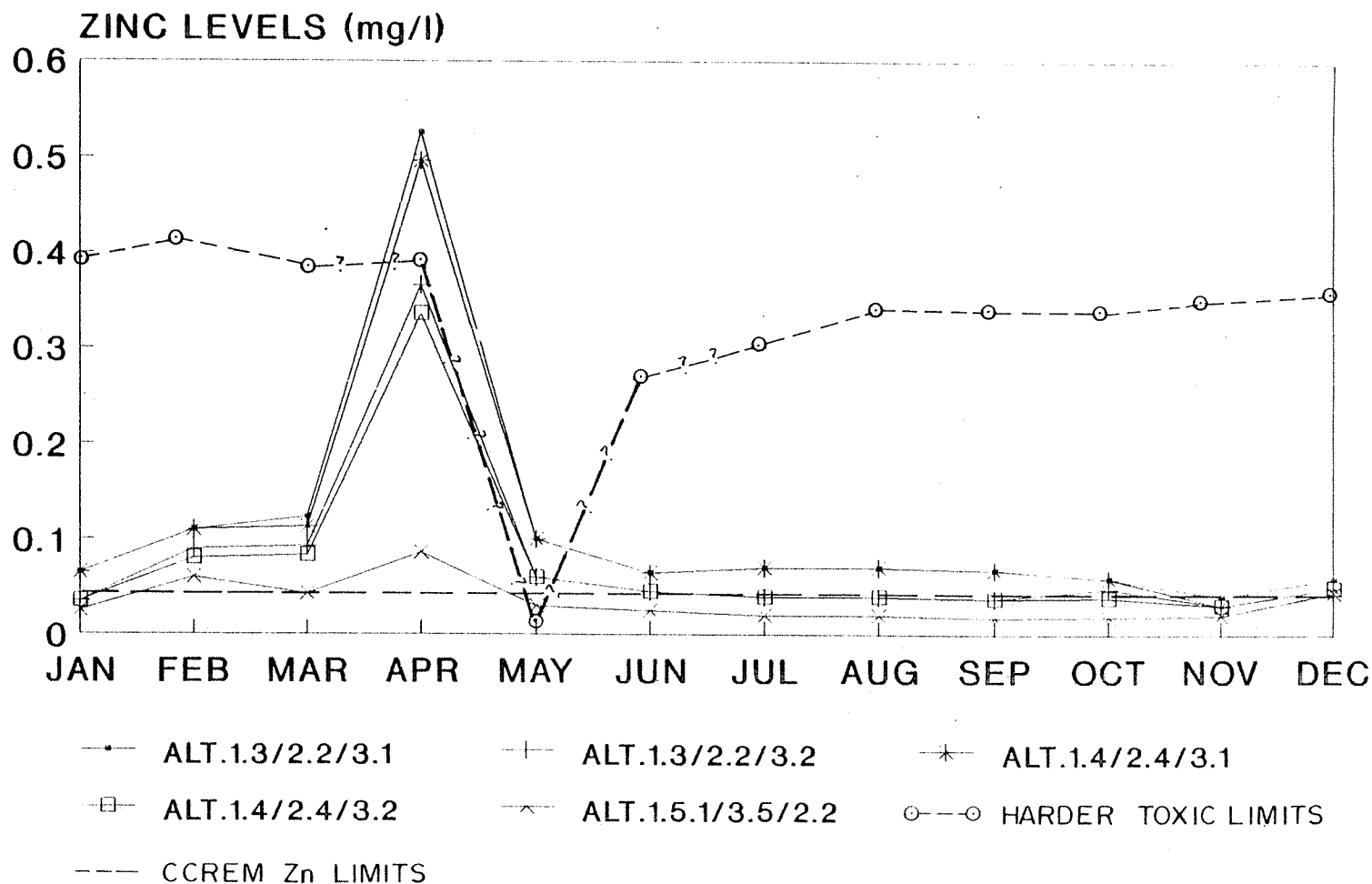
ALTERNATIVE COMBINATION SCHEMES	VANGORDA PIT SEEPAGES A1/A2/A3 L/s	VANGORDA CRK. BELOW MINE		VANGORDA CRK AT FARO (Zinc)					
		MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE* FROM BASE CAS (+/-)	CHANGE FROM BASE CASE (%)
ALT. 1.3/2.2/3.1**	1.25/0.50/2.25	0.22	1.05	128	423	0.07	0.52	0	0%
ALT. 1.3/2.2/3.2	1.25/0.50/2.25	0.13	0.73	75	233	0.04	0.36	-53	-41%
ALT. 1.4/2.4/3.1	1.25/0.50/2.25	0.20	0.92	122	406	0.07	0.49	-6	-5%
ALT. 1.4/2.4/3.2	1.25/0.50/2.25	0.11	0.59	61	216	0.04	0.33	-67	-52%
ALT. 1.5.1/2.2/3.5	1.25/0.50/2.25	0.04	0.18	25	78	0.01	0.08	-103	-80%
ALT. 1.5.1/2.2/3.2	1.25/0.50/2.25	0.05	0.22	31	98	0.02	0.10	-97	-76%
ALT. 1.5.1/2.3/3.2	1.25/0.50/2.25	0.05	0.16	28	88	0.02	0.08	-100	-78%
ALT. 1.5/2.2/3.2	1.25/0.50/2.25	0.09	0.51	52	165	0.03	0.25	-76	-59%
ALT. 1.5/2.3/3.2	1.25/0.50/2.25	0.09	0.45	50	155	0.03	0.22	-78	-61%
ALT. 1.2/2.1/3.1 ***	1.25/0.50/2.25	0.23	0.54	133	399	0.07	0.26	5	4%

* Mean Monthly Zinc Loading

** Base Case

*** With Water Treatment

MEAN MONTHLY ZN CONCENTRATION AT FARO ALTERNATIVE COMBINATIONS



Note: To bring harder toxic limits into closer relationship to flow timing used for water quality model the following adjustments have been made: 1) Harders estimated toxic level for March has been applied to April 2) April has been applied to May, other months are unchanged.

FIGURE 6.3

MEAN MONTHLY ZN CONCENTRATION AT FARO ALTERNATIVE COMBINATIONS

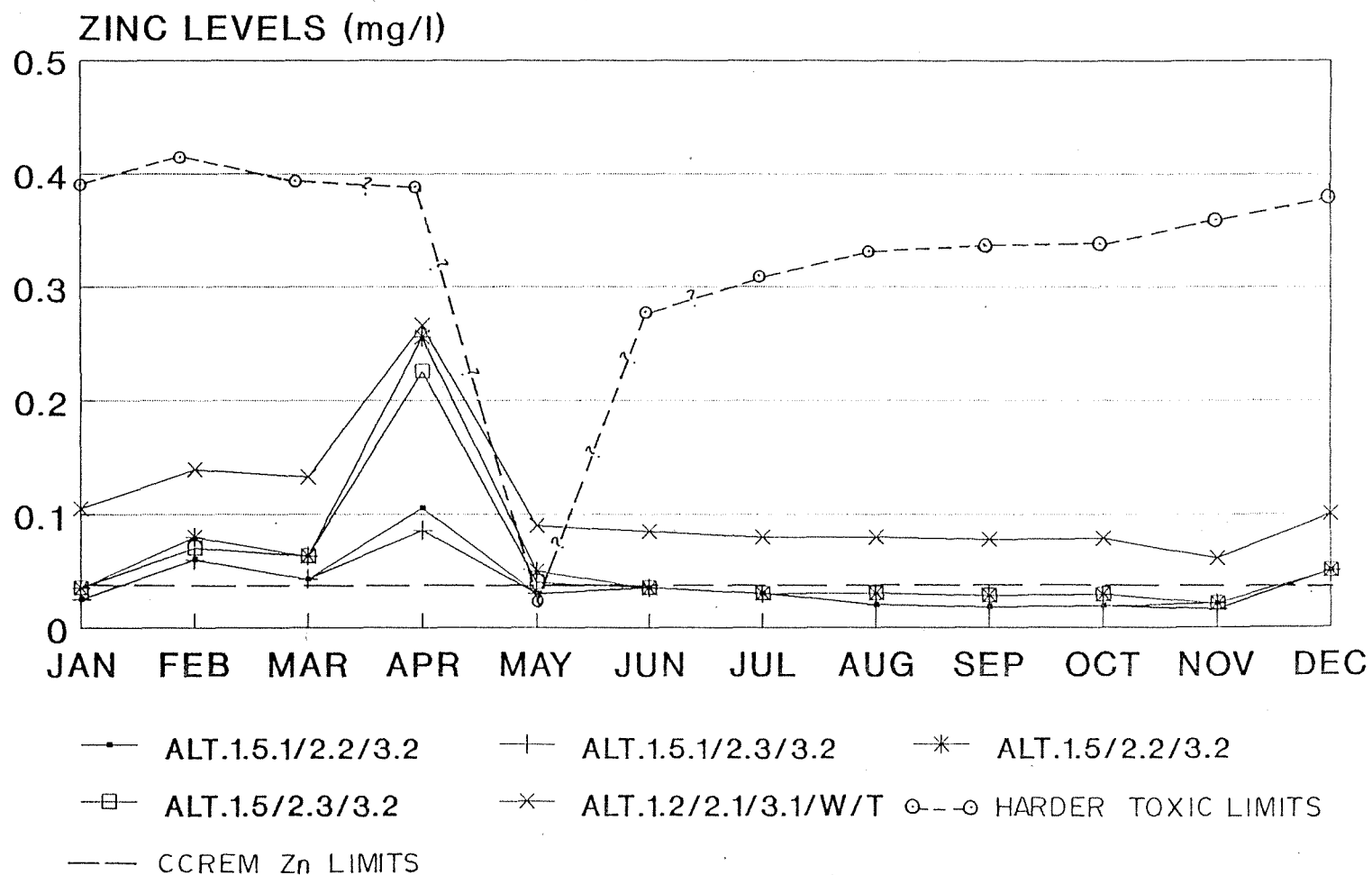


FIGURE 6.4



7.0 WATER QUALITY PREDICTION ALTERNATIVES

7.1 General

The water quality prediction model developed for the original scheme (Alternative 1.3, 2.2 and 3.1) and which is presented in the IEE, was based on preliminary seep survey data from Faro minesite and from Humidity Cell test data. The original model was also used as the basis for the comparative analysis completed in the preceding sections. This section discusses firstly the assumptions that were used in the original model including the flow and metal concentration distributions selected, and secondly, presents a discussion on the sensitivity of the model to variations in these parameters. As part of the sensitivity analysis, derived average and worst case conditions were applied to the base case and the predicted water quality in Vangorda creek for each condition was computed. In addition, predicted water quality in Vangorda Creek was computed for each of the alternative combinations discussed in Section 6.0 based on the worst case AMMC's and the original distribution.

7.2 Original Model

7.2.1 Metal Concentrations

The soluble zinc levels predicted for each month of the year from the major AMD contributors were developed in the model as a percentage of the annual mean monthly concentration (AMMC). The AMMC is defined as the total annual metal loading in kilograms divided by the total annual discharge in decametres (1000 cu.metres). The percentage value selected for each month was based on known distributions derived from preliminary Faro seep data.

The AMMC of zinc used in the model were also derived from the preliminary seep survey data and water quality data from Faro. A summary of the AMMC used in various Vangorda/ Grum model components for the original scheme are shown in Table 7.1. The loadings and flows from the Vangorda Cells, however, differ from the original model because of the adjustments made to the cell surface areas.

Seepage from the main Grum dumps was assigned an AMMC of 0.26 mg/L. Acid-Base accounting results indicate that this material should be acid consuming to weakly acid generating. At Faro, similar unsegregated dumps have seepages which vary in zinc concentration from 0.01 to 1.6 mg/L.

Seepage from both the Grum and Vangorda sulphide dumps were assigned an AMMC value of 28.6 mg/L based on results of the Sulphide waste Humidity Cell tests that are shown in Figure 7.1. This concentration is approximately 35 percent greater than the seepage from the Faro main dump (X23) which has an AMMC of 21.2 mg/L.

Seepage from the Phyllite dump at Vangorda was assigned an AMMC of 15.7 mg/L. Based on acid-base accounting results, phyllite waste is considered to have lower acid generating potential than sulphide waste. The assigned AMMC is approximately 25 percent less than the X23 dump seep at

TABLE 7.1
Summary of Potential Contaminant Sources and Loadings
Below Minesite After Abandonment

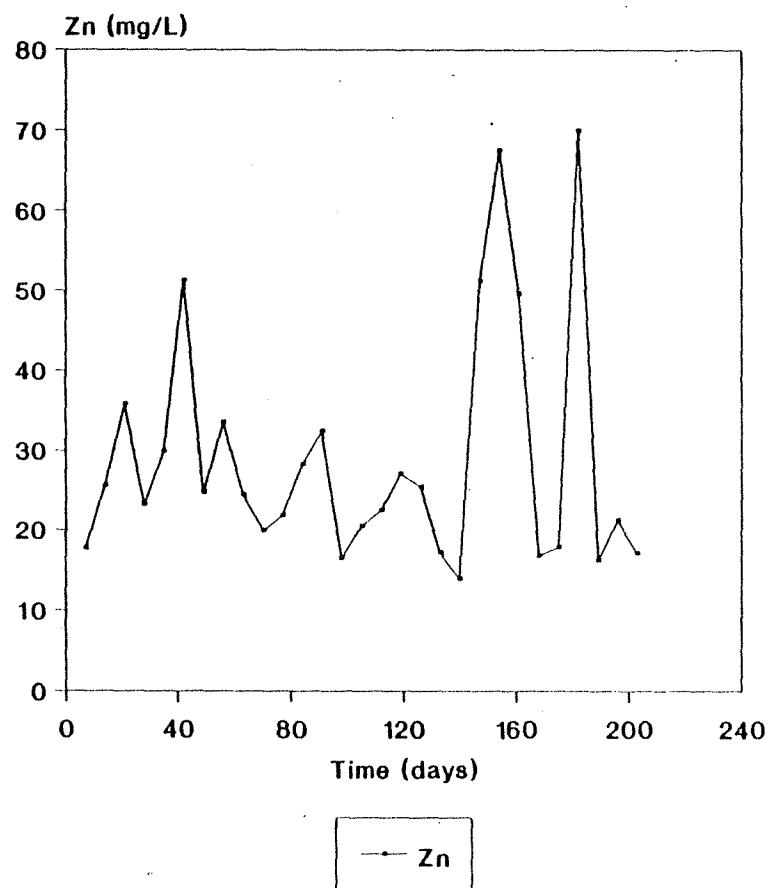
	Mean Monthly Discharge	Mean Monthly Discharge	Mean Monthly Zinc Levels	Mean Monthly Loadings	Percent of Total Loadings
	(l/s)	(dam^3)	(mg/l)	(kg)	(%)
Grum Waste Dump Infiltration	8.46	22.23	0.26	75.80	4.54
Grum Sulphide cell Infiltration	0.11	0.29	28.60	8.28	6.48
Grum Sulphide Cell Runoff	0.36	0.95	0.03	0.02	0.02
Seepage into Grum Lake	12.05	31.66	0.04	1.35	1.05
Runoff into Grum Lake	22.88	60.12	0.02	0.90	0.71
Vangorda Sulphide Cell Infiltration	0.33	0.87	28.60	24.84	19.45
Vangorda Sulphide Cell Runoff	1.08	2.85	0.03	0.07	0.06
Vangorda Phyllite Cell Infiltration	0.46	1.21	15.72	18.97	14.85
Vangorda Phyllite Cell Runoff	1.50	3.95	0.03	0.10	0.08
Seepage into Vangorda Lake	4.27	11.21	5.15*	57.75	45.22
Runoff into Vangorda Lake	11.48	30.16	0.28	8.36	6.55
Runoff from area Between Lakes	19.29	50.68	0.02	1.26	0.99
Vangorda Creek	137.29	360.79	0.00	0.00	0.00
				127.71	100.00
*Average of three Zones within the pit					

Faro and was estimated from the early Stages of the inoculated Humidity cell tests for the Phyllite waste as shown on Figure 7.2.

Zinc concentrations assigned to Vangorda and Grum pit walls are largely based on Faro pit seepage data. Preliminary results indicated that the AMMC for the Faro pit is approximately 10 mg/L. During operations at Vangorda, 10 mg/L was assigned to all seepages originating from pit walls. At abandonment, however, the physical configurations of the pits will change, and so the zinc concentrations were adjusted as outlined below.

Seepage from Grum pit walls after abandonment will be restricted to elevations above EL.1256 metres, as the lower walls will be covered by water. The wall rock above the flood level is predominantly non-acid generating to acid consuming rock on till and therefore an estimated AMMC of 0.04 mg/L was assigned to the Grum Pit wall seepage.

HUMIDITY CELL TEST
SULPHIDE COMPOSITE



HUMIDITY CELL TEST
SULPHIDE COMPOSITE II (Inoculated)

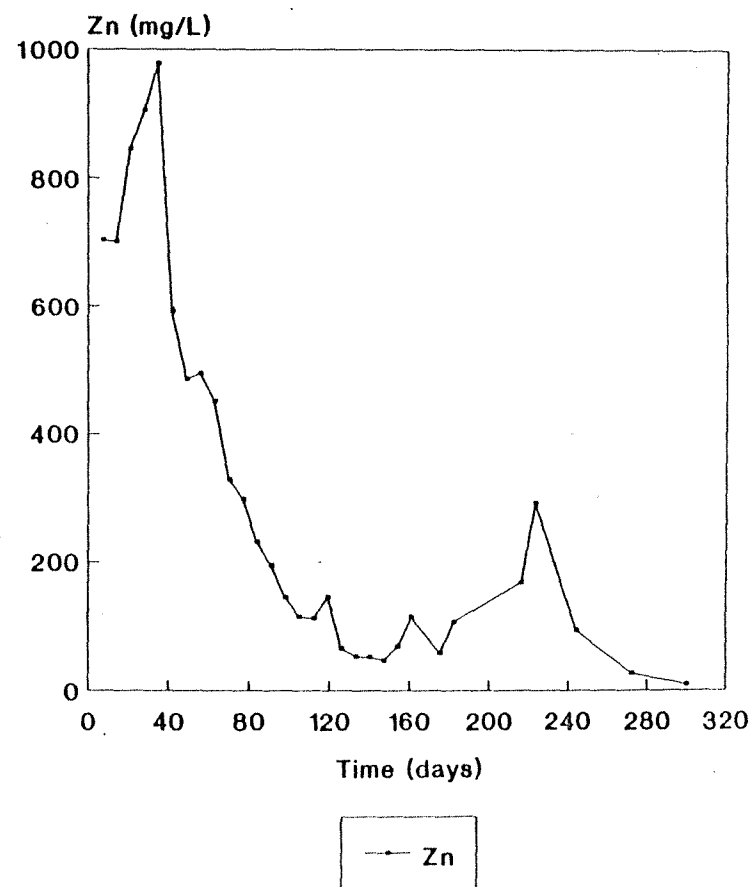
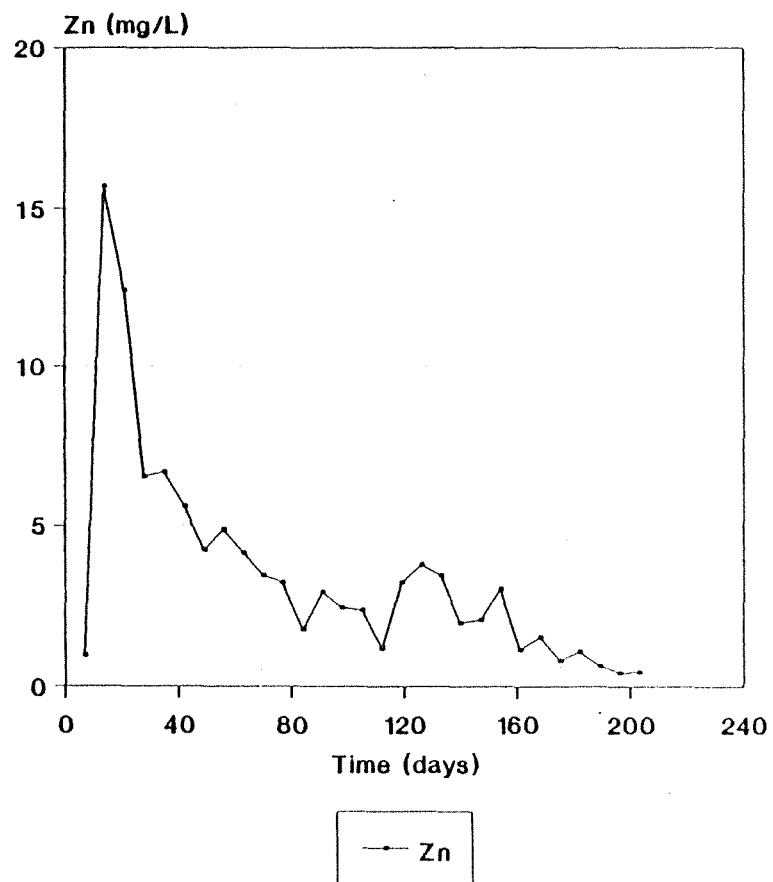


FIGURE 7.1

HUMIDITY CELL TEST
PHYLLITE COMPOSITE



HUMIDITY CELL TEST
PHYLLITE COMPOSITE II (Inoculated)

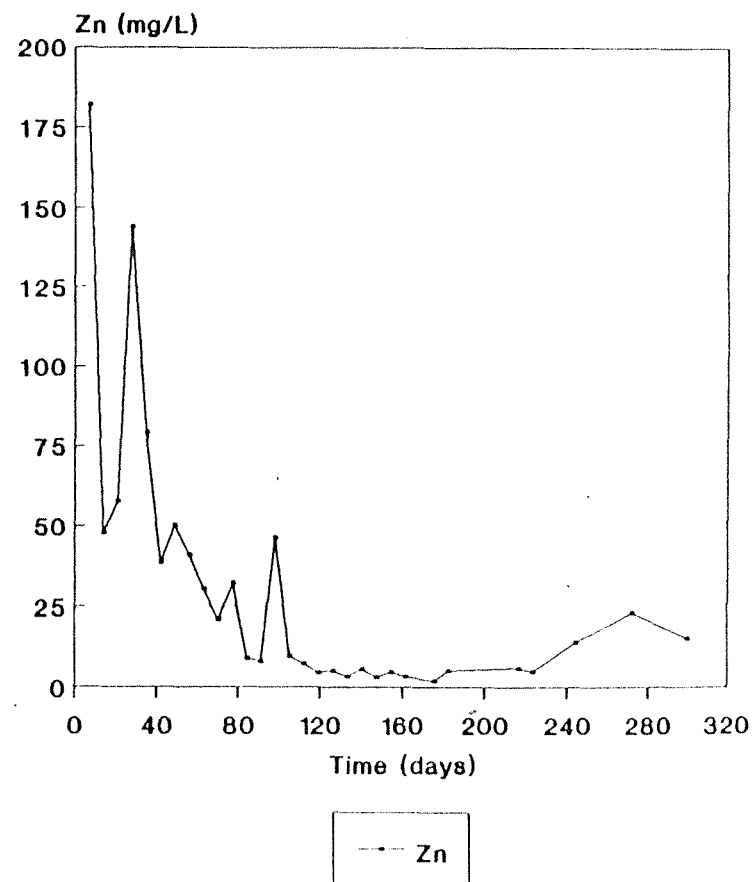


FIGURE 7.2

At abandonment, the Vangorda pit will also be flooded. The water level in this pit will be at El. 1122.5 metres. Unlike Grum, significant sulphide materials will remain in the pit walls above this flood level, especially in the northeastern (Area 1) and southwestern walls (Area 2). To model more effectively the different physical and chemical configuration within the pit, the latter was divided into three respective sections : Area 1 encompasses the northeast face of the pit between Section 10E and 26E and north of long section 00; Area 2 encompasses the southern face of the pit between section 12E and 26E and south of long section 00; and Area 3 is located west of section 10E. The majority of the wall sulphides are submerged in Area 3 and hence a decommissioning seepage for this zone was assigned an AMMC of approximately 2 mg/L. Pit flooding, however, will not cover the wall sulphides in areas 2 and 3, therefore an AMMC of 10 mg/L was maintained for seeps from these walls after abandonment.

During operations the runoff component into the pit was considered to be significant because of the contact with exposed sulphide ore at the base of the pit. At decommissioning, runoff would only make contact with isolated exposed sulphide pockets on the pit wall surface and the contribution would be much less. Consequently an AMMC for the runoff into Vangorda pit was assigned a value of about 0.3 mg/L. However, the runoff into Grum Pit which would not be exposed to any acid generating rock was assigned a minimum AMMC value of 0.02mg/L. A similar value was used for the runoff from area between the lakes. Runoff from the till covered dumps were assigned an AMMC of 0.03 mg/L.

7.2.2 Metal Concentration Distributions

Faro seepage and water quality data indicates that metal concentrations vary significantly throughout the year. The initial Vangorda/Grum water quality prediction model considers this variation by incorporating a variable monthly concentration and a variable monthly flow. Based on very preliminary Faro seep and water quality monitoring data, a profile was selected with a concentration peak in April reflecting the flushing of accumulated soluble metal salts by dump snow melt. This assumption has been examined in light of more extensive subsequent Faro seep data and it is discussed later in this section. The assumed monthly zinc concentration distribution for the sulphide cell and the pit walls is presented as a percentage of the AMMC, as shown on Figure 7.3.

Zinc concentrations from pit wall seepages were assumed to decline gradually from the April peak over the summer and fall months. Concentrations from waste dump seepages were assumed to decline rapidly from the April peak to a relatively constant summer level. This rapid decline was based on the assumption that in a dump interior the rate of generation of soluble acid salts would not change dramatically during the year but the flux of water would be higher in the summer resulting in lower concentrations after the initial early spring flush. The higher spring concentration peak for the dumps results from the initial flush of stored acid products as compared to smaller flushing peak associated with the pit walls which reflects the smaller number of pathways in the intact rock. Winter levels for both pit and dump seeps are at minimums.

ZINC CONCENTRATION DISTRIBUTION

Original Model

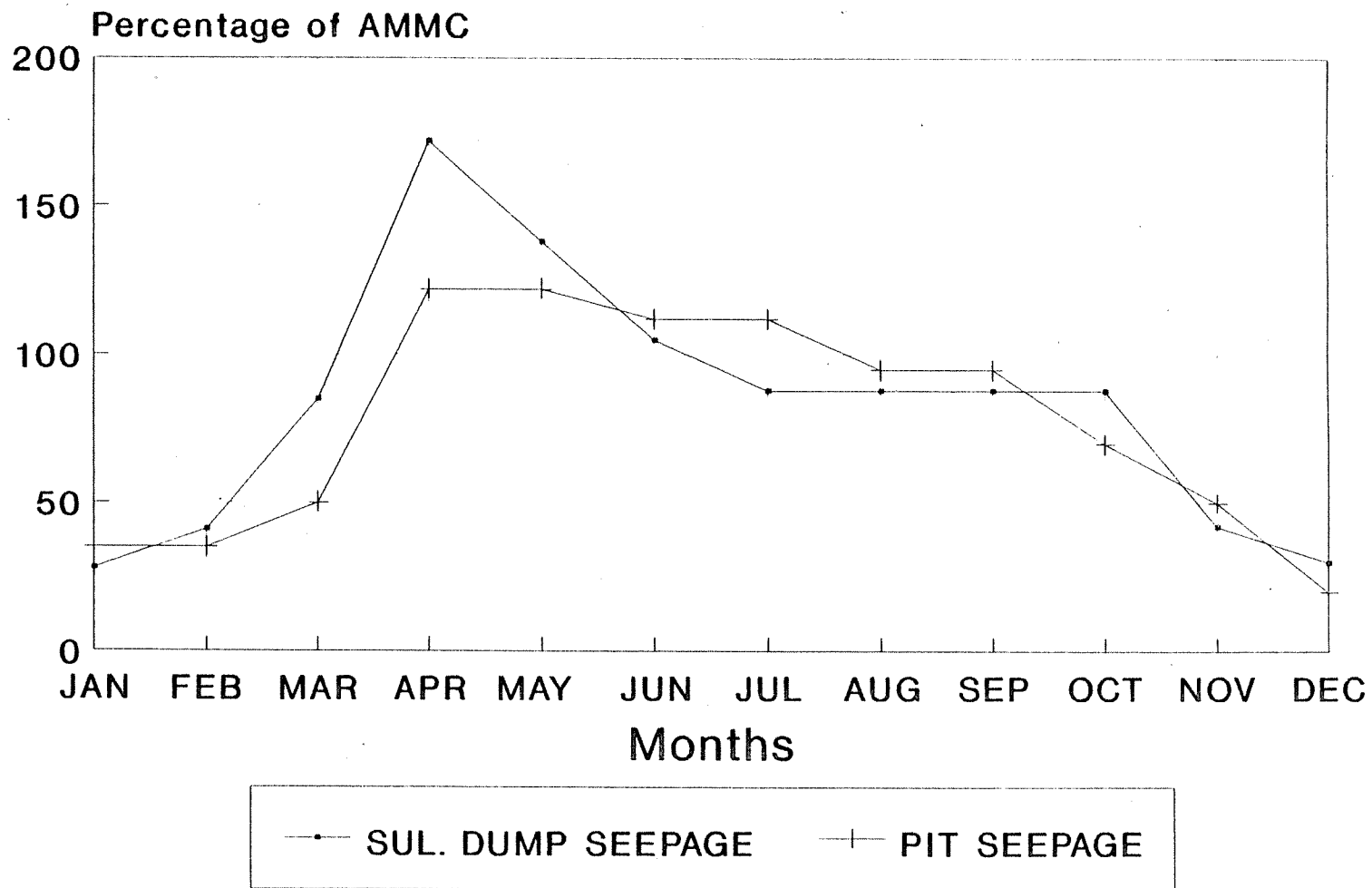


FIGURE 7.3

7.2.3 Dump and Pit Wall Flow Estimates

Precipitation data from the Faro town site, the Faro mine site, and the Vangorda plateau was used as input into the "Hydrologic Evaluation of Land Fill Performance (HELP Version II) computer model which is discussed in Section 7.2.4. The HELP model was used to develop estimates of the infiltration runoff and evapotranspiration rates for the Vangorda and Grum dumps. With a layered till cover consisting of a moderately compacted upper till layer (2 metres) and a lower normally compacted layer (1 metre), the mean annual infiltration, evaporation and runoff were estimated by the model to be 10, 55, and 35 percent of the total annual precipitation respectively. The hydraulic conductivity of the upper and lower layers used in the model were 1.4×10^{-6} cm/sec. and 1.0×10^{-6} cm/sec respectively. It was found that the HELP model is insensitive to the runoff coefficient(CN) entered into the model but was sensitive to the hydraulic conductivity of the layer till cover. Variations in the hydraulic conductivity and the impact on the resultant seepage flow from the dump are discussed later in section 7.2.4.

For the Grum dump, the HELP model assumes an uncovered dump with zero runoff. The resultant mean annual infiltration and evaporation were computed by the model to 37 and 63 percent of the total annual precipitation respectively.

The monthly distribution for runoff from the dump and other areas is based on the Vangorda catchment unit discharge distribution. For example the runoff from the Vangorda Sulphide cell from the month of July was calculated as the product of the estimated mean annual runoff(HELP) and the ratio of the unit discharge for July (13 l/s/km^2) divided by the mean annual unit discharge (7.67 l/s/km^2). Similar calculations were used in estimating the mean monthly distribution for infiltration from the dumps. However the ratios were adjusted for certain months to reflect recorded seepage flows for dumps at Faro. The assumed flow distribution from the Vangorda/ Grum waste dumps is shown on Figure 7.4.

Seepage flow predictions for the pit walls of both Vangorda and Grum pits were calculated in the post abandonment model assuming the formation of lakes in both pits. Grum pit wall seepage was estimated to be 12 L/s while the three pit wall areas at Vangorda were estimated at 1.25, 0.50, and 2.5 L/s for areas 1, 2, and 3 respectively. Wall seepage was calculated using the Simple Well formula and by comparing the results with seepage recorded in the Faro pit. This same procedure was used to calculate operational wall seepage rates. The application of the Well formula to Vangorda pit and assumptions used are presented in Table 7.2. The annual pit wall seepage distribution was determined from rainfall data and Faro seepage flow records and is also shown in Figure 7.4.

SEEPAGE FLOW DISTRIBUTION

Original Model

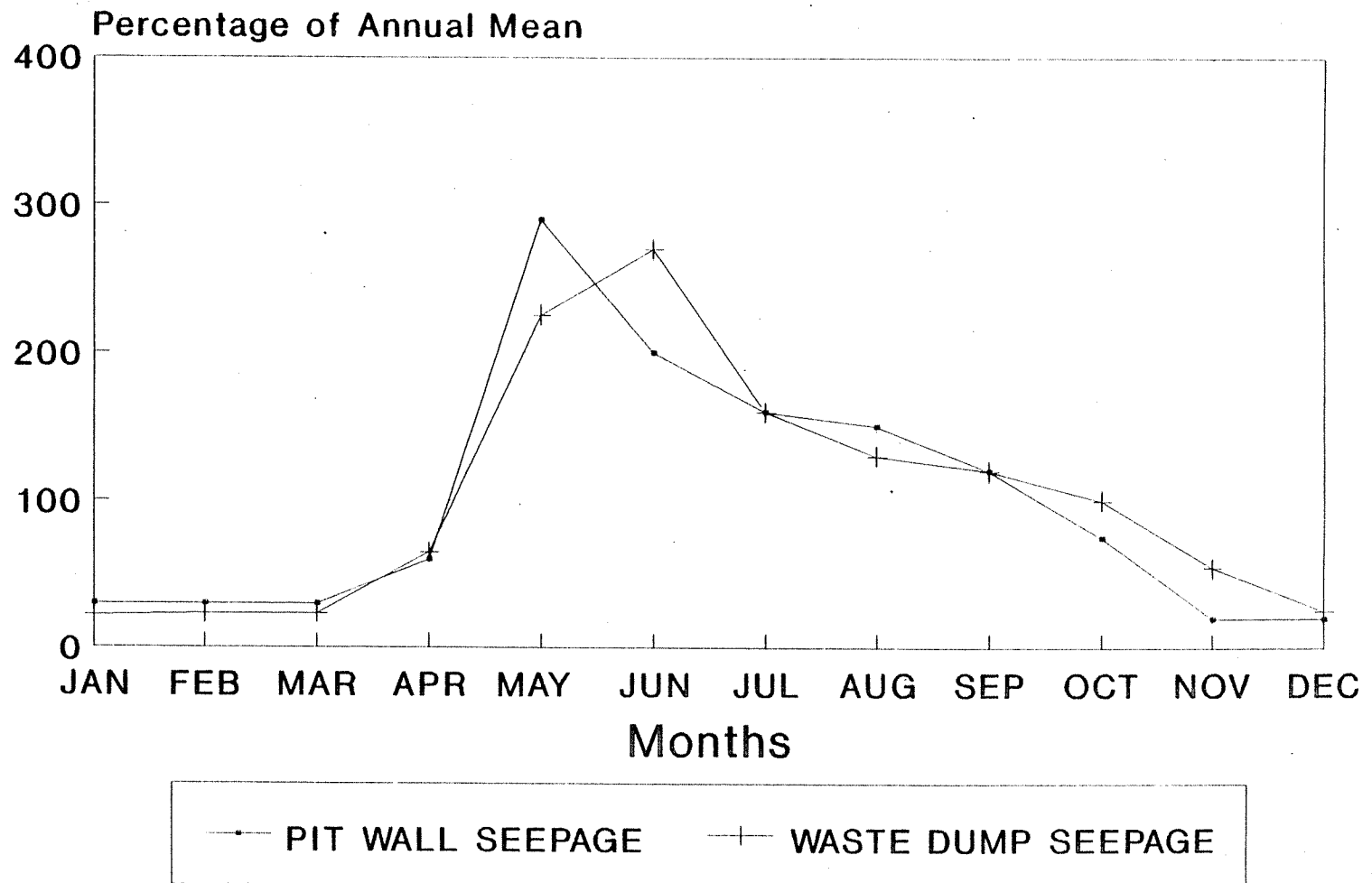
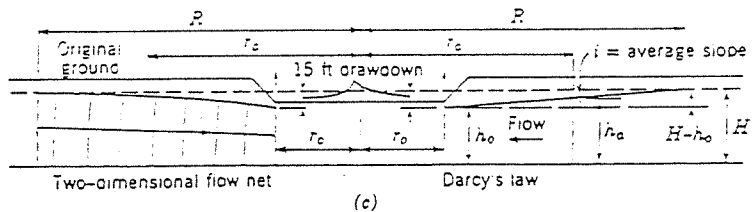
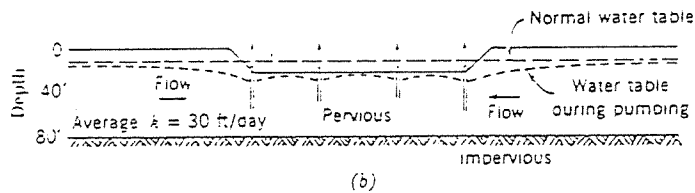


FIGURE 7.4

TABLE 7.2
Vangorda Pit Wall Seepage as Derived from the
Simplified Well Formula

Well Formula: $Q = \frac{\pi K (H^2 - h_o^2)}{2.3 \log_{10} (R/r_o)}$

Area	$H^2 - h_o^2$	R/h_o	K (cm/s)	Flow	Adjusted Flow
Area 1	$60^2 - 33^2$	5	5×10^{-5}	2.45	1.25
Area 2	$40^2 - 33^2$	3	5×10^{-5}	0.73	0.50
Area 3	$80^2 - 70^2$	3	5×10^{-5}	2.15	2.50



Assumptions:

$K = 5 \times 10^{-5} \text{ cm/s}$

Typical conductivity for moderately fractured metamorphic rock

$R/h_o = 3 \text{ or } 5$

R = Radius of drawdown influence

R/h_o = Radius of pit bottom

$R/r_o = 3$ is typical

$R/r_o = 5$ is conservative

7.2.4 Precipitation, Runoff, Infiltration and Percolation Estimates (Help Model)

Estimates for the rates of infiltration and evapotranspiration were developed by using the Hydrologic Evaluation of Land Fill Performance (HELP Version II) computer model.

The Hydrologic Evaluation of Landfill Performance (HELP) program was developed to assist landfill designers and regulators by providing a tool to allow rapid, economical screening of alternative designs. Specifically, the program may be used to estimate the magnitudes of various components of the water budget, including the volume of leachate produced and the thickness of water saturated soil (head) above barrier layers. The results may be used to compare the leachate production potential of alternative designs, select and size appropriate drainage and collection systems, and size leachate treatment facilities.

The model uses climatologic, soil and design data to produce daily estimates of water movement across, into, through, and out of landfills. To accomplish this, daily precipitation is partitioned into surface storage (snow), runoff, infiltration, surface evaporation, evapotranspiration, percolation, stored soil moisture, and subsurface lateral drainage to maintain a water budget. Surface runoff and subsurface lateral inflow are not considered.

As noted above, the HELP program models a number of hydrologic processes. Runoff is computed using the Soil Conservation Service Runoff Curve Number method. When the program is run for a closed landfill using the default soil data option, a default runoff curve number is selected automatically. However, the program gives the user an opportunity to override the default value. When soil data are entered manually, and when an open landfill is being modelled, the user must estimate an appropriate runoff curve number. A complete discussion of the curve number technique is available from the Soil Conservation Service.

Factors such as surface slope and roughness are not considered directly in estimating runoff, and hence infiltration. However, they may be taken into account in the manual selection of a curve number. This approach to runoff estimation is made possible by considering only daily precipitation totals, and not intensity, duration and distribution of individual rainfall events (storms).

Percolation and vertical water routing are modelled using Darcy's Law for saturated flow with modifications for unsaturated condition. Lateral drainage is computed analytically from a linearized Boussinesq equation corrected to agree with numerical solutions of the non-linearized form for the range of design specifications used in hazardous waste landfills. Evapotranspiration is estimated by a modified Penman method adjusted for limiting soil moisture conditions.

Although the HELP model was developed primarily for agricultural purposes, it was considered that the model would provide a reasonable first approximation of the water balance and flow mechanisms within the dump. The model provides for climatological input for conditions similar to those expected at the Vangorda minesite. The climatological parameters used in the model include precipitation,

temperature, solar radiation, leaf area indices and evaporative depth. A synthetic weather generator was incorporated into Version 2 of the HELP model to compute daily values of temperature and solar radiation. The solar radiation used in the evapotranspiration computation was generated synthetically from data compiled for Fairbanks, Alaska. The maximum leaf area index was given a value of zero for bareground conditions and the evaporative zone depth assumed was about 50mm. Daily precipitation and mean monthly temperatures developed for the minesite were also used in the model to complement the synthetically generated data.

The soil and design data input includes initial soil water, number and types of layers, runoff curve number, saturated hydraulic conductivity, wilting point, field capacity and porosity. The model was run for two conditions; during operations and post abandonment. During operations the model assumes three layers; a vertical percolation layer (wasterock), a lateral drainage layer (drains) and a barrier soil liner (insitu till). For the post abandonment case, the model used 5 layers; a two metre vertical layer (loosely compacted till), one metre barrier liner (compacted till), a vertical percolation layer (waste rock), a lateral drainage layer (drains) and a barrier soil liner (insitu till). A summary of the soil parameters used in the model for each layer is shown below:

Layer	Soil Type	Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Sat Hyd. Conductivity (cm/sec)	Initial Soil Water (Vol/Vol)
Vertical Percolation	Waste	.453	.19	.08	6×10^{-3}	.19
Vertical Percolation	Loosely compacted Till	.4640	.311	.18	1.4×10^{-6}	.31
Lateral Drainage	Sand and Gravel	.453	.19	.08	6×10^{-3}	.24
Barrier Soil	In-situ Till	.40	.36	.29	1×10^{-8}	.40
Barrier Soil	Compacted Till	.42	.35	.27	1×10^{-6}	.42

As previously discussed the mean annual runoff and evapotranspiration for the till covers based on the above parameters were computed by the model to be 35 and 55 percent of the mean annual total precipitation respectively. From uncovered waste dumps the evapotranspiration would be about 63 percent. The model predicts that the mean annual infiltration and percolation for till covered dumps

would be about 10 and 1 percent respectively of the mean annual precipitation. For uncovered dumps the mean annual infiltration and percolation was computed to be 37 and 1 percent of the mean annual precipitation respectively.

It was found that the infiltration and runoff computed by the model were sensitive to the hydraulic conductivity of the soils. A relatively low permeability (1.4×10^{-6} cm/sec.) was selected for the upper till in an attempt to better represent anticipated runoff conditions. It was found that by increasing the hydraulic conductivity from 10^{-6} to 10^{-5} cm/sec the infiltration and/or seepage from the dump increased from 10 to 22 percent of the mean annual precipitation with runoff reducing from 35 to 11 percent. These results indicate that compaction and contouring of the final surface of the till cover would be necessary to encourage runoff and reduce infiltration.

Similarly a low hydraulic conductivity (10^{-8} cm/sec) was used in the model for the lower barrier soil to represent an impervious barrier below the dump in order to maximise the total seepage loss. It is likely in practice that the insitu till would contain some sandy zones which would result in a hydraulic conductivity of about 10^{-7} cm/sec and that percolation from the dump would be in the order of 6 percent of the mean annual precipitation. In contrast to the cover the percolation estimates for the model were not found to be sensitive to the permeability of the lower barrier soil layer.

7.3 Water Quality Prediction Alternatives

In response to comments by the Review Committee on the water quality analyses in the July 1989 IEE, SRK has reviewed the Water/Mass/Balance model with respect to the sensitivity of components within the model to changes in metal concentrations and flow rates. It was discussed in the review comments that the predicted zinc levels in pit wall seeps are underestimated and values representing individual seeps recorded at the Faro Pit should be used in the model. An analysis of the most recent seep survey data from Faro indicates that there are one or two seeps which at certain times of the year were recorded to have zinc concentrations in the order of 300 mg/L. However the flow from these seeps is very low and thus the loading contribution to the system is minimal. SRK feels that these individual seeps are not representative of the overall seepage quality at Faro and using these values in the model would result in unrealistic predictions. The model divides the Vangorda Pit Wall into three distinct zones and assigns mean monthly concentrations and mean monthly flows to each zone. To assign individual seep values to mean monthly concentrations for each zone within the pit would be misrepresentative. In the following section, SRK, in assessing the sensitivity of the model to input changes, compares ten different conditions including those from the original model. The input data changes concentrate on seepage flow rates from the Vangorda Pit Walls and zinc concentrations from each of the main components.

Given the nature of the model and the degree of uncertainty of some of the input data, SRK feels that to refine the prediction model further, at this time, to include fluctuations about the monthly mean zinc concentrations and seepage flows, would be misleading.

7.3.1 Variations in Annual Mean Monthly Concentrations

The mean monthly zinc concentrations used in the model are derived as a percentage of the estimated annual mean monthly concentration (AMMC). The AMMC used in the original model were developed from the early seep data collected from the Faro mine. To evaluate the sensitivity of the model to changes in the AMMC, an alternative set of AMMC's were developed based on more recent seep survey data from Faro (1987 and 1988 Seep Surveys - Faro Pit and Rock Waste Dumps - SRK (B.C.) June 1989). Data from the upper wall areas at the Faro pit and the Zone II pit were used to develop the alternative AMMC for the northeast and southwest wall of the Vangorda Pit. A summary of data used is presented as follows:

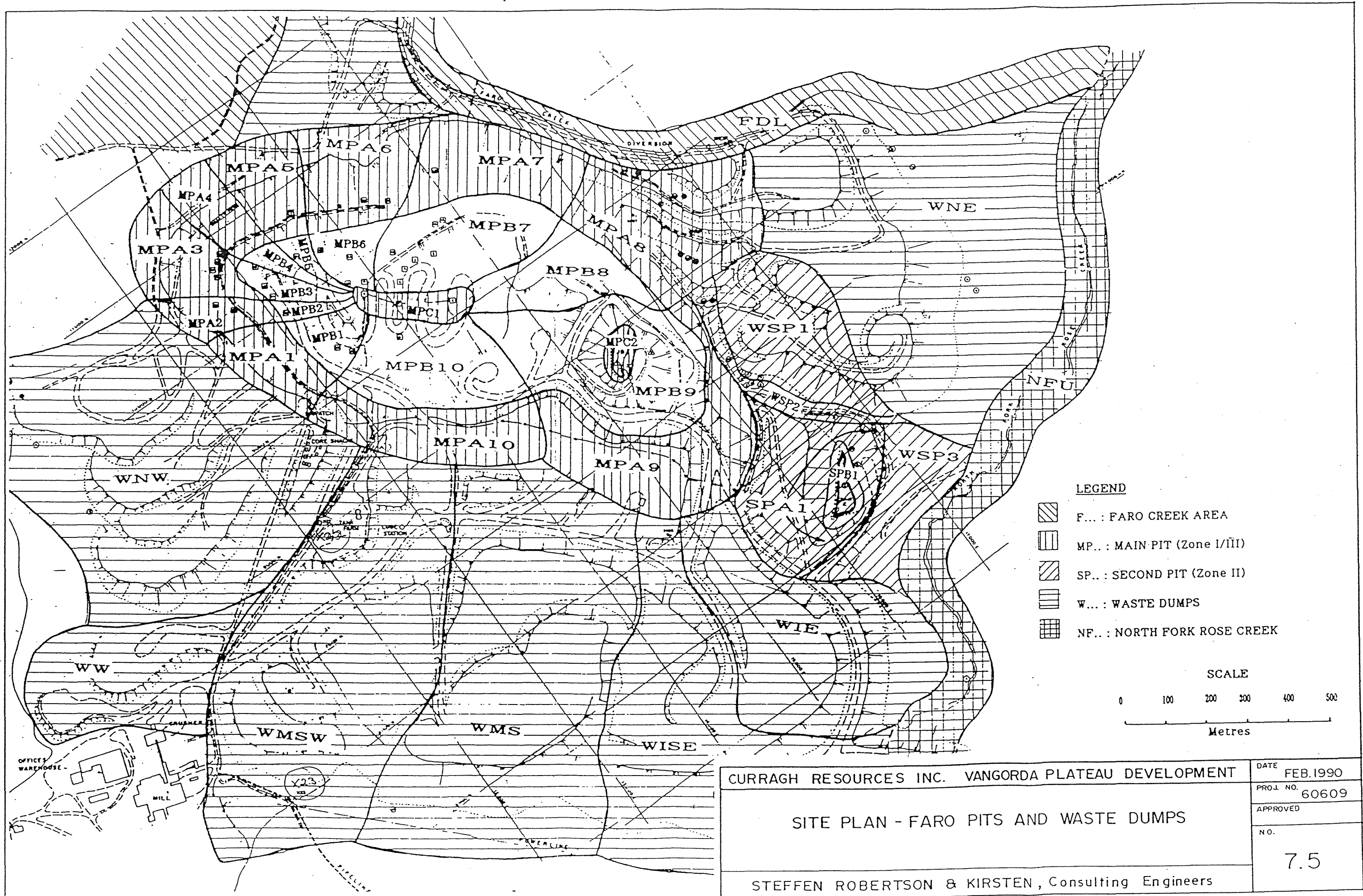
Zone	Flow dam ³ /yr	Load kg/yr	Zinc Conc. mg/L
MPA2	1.3	202.2	156.6
MPA3	22.4	8.0	0.4
MPA4	0.9	0.3	0.3
MPA6	534.8	7417.3	13.9
MPA8	110.9	421.3	3.8
Zone II (Seep #31)	<u>1.4</u>	<u>164.6</u>	<u>120.4</u>
Total	671.7	8213.7	12.2

A plan of the pit and dumps at Faro and the various zones referenced is shown in Figure 7.5

The north wall of Vangorda pit contains relatively few exposed sulphide-rich areas and no seep data from similar wall types at Faro are available. Consequently the AMMC for this area of the pit was assumed to be about 2 mg/L. The annual mean monthly zinc concentration from seeps at Zone MPA4 were used as the basis for the Grum pit AMMC.

Five waste dump areas from the Faro minesite were reviewed in developing the AMMC for the waste dumps at Vangorda and Grum. A summary showing the annual mean monthly zinc concentration from each area is presented below:

Zone Code	Mean Monthly Concentration, mg/L	Description
FCO	4.2	Old Faro Creek Channel
WSP2	4.0	South Zone 2 Waste Dump
WMSW	21.09	South West Main Dump (X23)
WNW	0.81	North West Dump
WNE	0.17	East Dump



The annual mean monthly zinc concentration in the seepage from the old Faro Creek valley south of pit (X23) was used as the basis for the AMMC in the sulphide cells at Vangorda. Similarly the AMMC for the phyllite cell at Vangorda was based on the water quality recorded at Zone FCO at the old Faro Creek channel north of the pit. The estimated AMMC for the Grum waste dump was based on the average of the mean monthly zinc levels from the northwest and east dumps.

A second alternative set of AMMC's was also developed to represent a worst case scenario. The Faro average AMMC's for the pit wall seepage at the NE and SW walls were arbitrarily doubled to represent a worst case condition. The Grum pit walls and the N wall of the Vangorda pit were not increased for the worst case because it is anticipated that these areas are low risk and would not likely exceed the assigned values for the average Faro case. The AMMC for the Vangorda and Grum sulphide cell was increased by a factor of 5 from the value determined for the Faro average case to represent a worst case condition. This concentration is in the same order of magnitude as the zinc levels recorded in the inoculated Humidity cell for the sulphide rock as shown on Figure 7.1. Similarly the inoculated cell for the phyllite rock indicated that after 300 days, the zinc levels were about 12 mg/L. Although this value is lower than the assumed AMMC for the Phyllite dump in the original case which was based on early results of the Humidity cell tests, it was considered as a worst case condition based on the latest results. A summary of the three sets of AMMC's used in the model are presented in Table 7.3.

TABLE 7.3
Annual Mean Monthly Concentration (AMMC) Alternative

AREA	ORIGINAL (O) (mg/L)	FARO AVERAGE (FA) (mg/L)	ESTIMATED WORST (W) (mg/L)
NE WALL VANGORDA PIT	10.2	12.2	24.2
SW WALL VANGORDA PIT	10.2	12.2	24.2
N WALL VANGORDA PIT	1.6	2.0	2.0
SULPHIDE DUMP VANGORDA	29.0	21.0	100.0
PHYLLITE DUMP VANGORDA	15.7	4.0	12.0
SULPHIDE DUMP GRUM	29.0	21.0	100.0
UNSEGREGATED DUMP GRUM	0.3	0.5	3.0
GRUM PIT	0.04	0.4	0.4

7.3.2 Variations in Monthly Metal Concentration Distributions

Four alternative monthly metal concentration distributions, which have been investigated. These include:

- The Original (O) dump and pit wall distributions (Figure 7.3). The waste dump distribution shown was based on Humidity Cell data and Faro water quality data and was used as a basis for the sulphide cells, the phyllite cell, and the unsegregated waste dumps. The pit wall seep concentration distribution shown was derived from preliminary Faro seep survey data.
- The Faro dump and pit wall distributions (F) (Figures 7.6 and 7.7). These distributions are based on the more complete Faro seep survey data. The concentration distribution for waste dumps is of interest in that concentration variability throughout the year is small. The concentration distribution for pit wall seeps differs from the original in that the spring peak is more pronounced, and the possibility of a late summer to early fall secondary peak is indicated.
- The Sulphide (S) distribution (Figure 7.3). This distribution differs from the original distribution in that both dumps and pit walls are assigned the same concentration distribution for their seeps.
- The Uniform (U) distribution which represents a constant concentration (AMMC) applied for each month of the year.

ZINC CONCENTRATION DISTRIBUTION

Faro Pit Wall Seeps

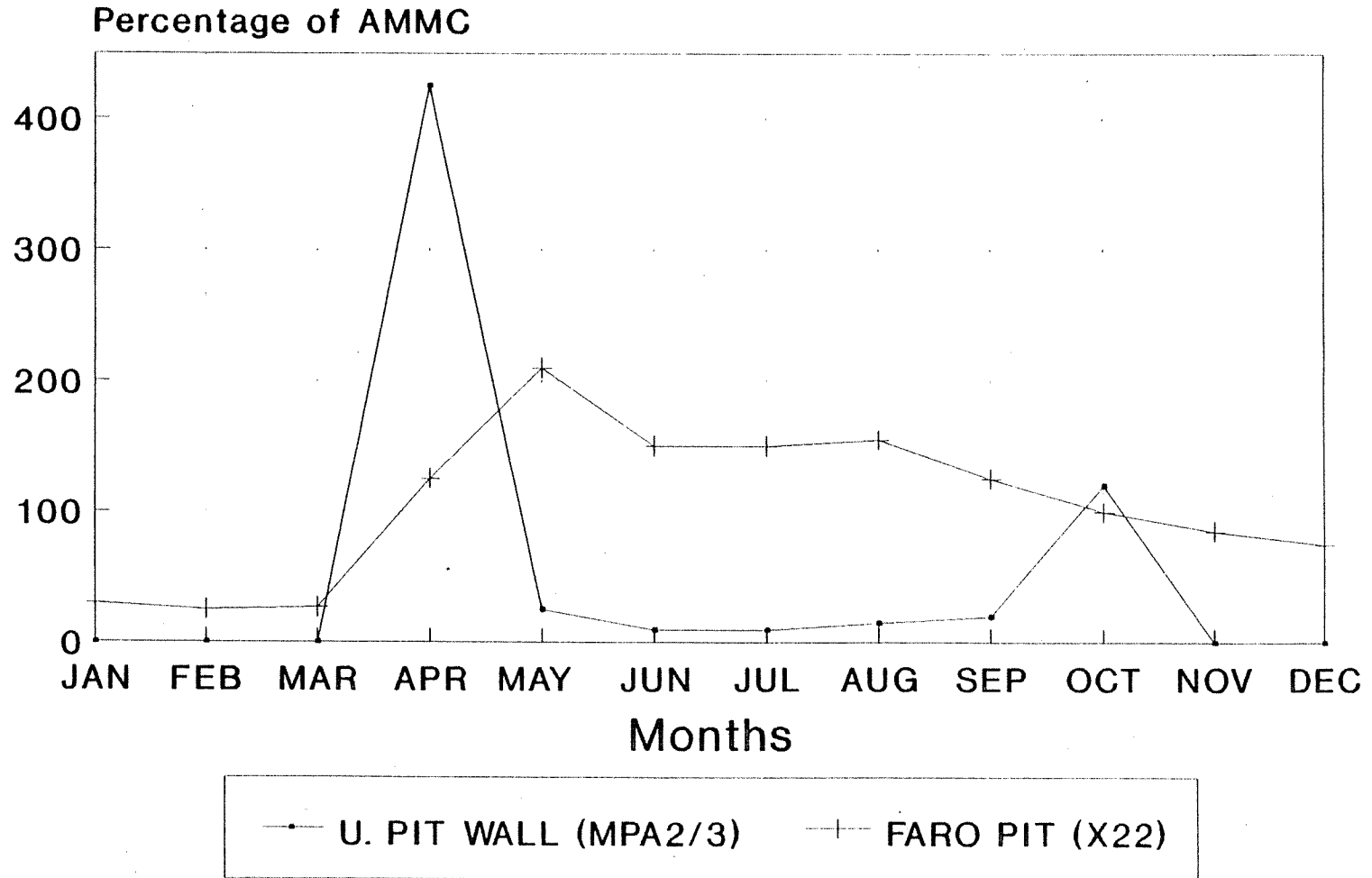


FIGURE 7.6

ZINC CONCENTRATION DISTRIBUTION

Faro Dump Seeps

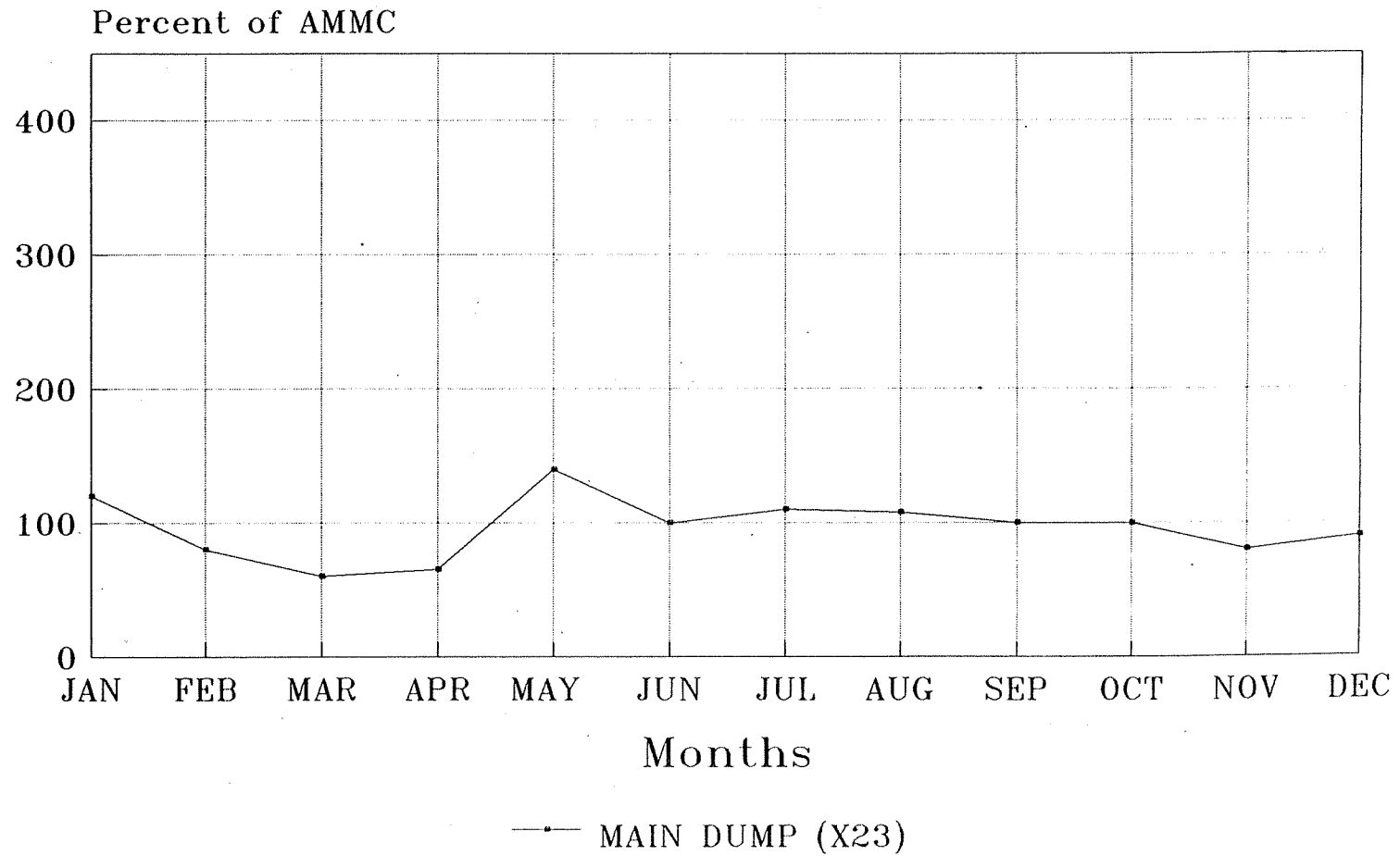


FIGURE 7.7

7.3.3 Pit Flow Variations

The annual mean monthly pit wall seepage used in the original model was based on the Simple Well formula assuming a hydraulic conductivity through the rock of 5×10^{-4} cm/sec. The ratio of the radius of drawdown influence (R) to pit radius (r) was assumed to be 3. To evaluate the sensitivity of the model to seepage flow rates, the assumed hydraulic conductivity was increased to 10^{-4} cm/sec. The resultant annual mean monthly seepage rates for the three areas of the Vangorda pit were calculated as follows:

<u>Area</u>	<u>Flow</u>
1	2.45 L/S
2	0.67 L/S
3	4.50 L/S

7.4 Summary and Discussion

Using different combinations of the above, the resultant water quality in Vangorda Creek below the minesite and at Faro were developed using the original scheme (Alternatives 1.3, 2.2 and 3.1) as a base. The revised surface areas of both the phyllite and sulphide cells, of 25 and 18 hectares respectively, were used. Five alternative conditions were analyzed assuming the same pit wall seepage flows and distributions as the original model, but including variations in the zinc concentration distribution and the AMMC discussed previously. The model was again run with the same five conditions but with increased pit wall flow rates assuming the higher rock permeability. A summary of the analysis is presented in Table 7.4.

Based on these results, model predictions of the mean monthly zinc level in Vangorda Creek at Faro townsite for the base case vary from 0.07 mg/L upto 0.18 mg/L under the assumed worst case condition. Similarly, model predictions for the peak monthly zinc levels vary from 0.3 mg/L to 0.77 mg/L for the assumed worst case. Using the higher pit wall seepage values, the peak monthly zinc levels in Vangorda Creek generally increased by about 30 percent.

In general, the variation in zinc levels between each of the conditions analyzed is small with the exception of the condition which assumes the Faro distribution and the worst case AMMC's. Consequently, SRK is of the opinion that the parameters used in the model presented in the July 1989 IEE remain valid and present a reasonable prediction of the impact on the water quality in Vangorda Creek after closure of the minesite. SRK also feels that the mean annual concentrations estimated for the worst case AMMC's are reasonable.

An evaluation of the alternative combination schemes discussed in section 6.0 assuming the worst case mean annual concentrations(W) and the original distribution(O) was also completed and the results are presented in Table 7.5

TABLE 7.4 : WATER QUALITY PREDICTIONS FOR ALTERNATIVE METAL CONCENTRATIONS AND FLOW DISTRIBUTIONS
BASED ON THE ORIGINAL SCENARIO

SCHEME	D I S T R I B	A M M C	DUMP AREAS (ha)	VANGORDA PIT SEEPAGES A1/A2/A3 (l/s)	VANGORDA CRK BELOW MINE		VANGORDA CRK AT FARO (ZINC)					
					MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE * FROM ALT 1.3 (+/-)	CHANGE FROM ALT 1.3 (%)
ALT. 1.3/2.2/3.1	O	O	18/25	1.25/0.50/2.25	0.22	1.09	128	425	0.07	0.53	0	0%
ALT. 1.3/2.2/3.1	O	O	18/25	2.45/0.67/4.50	0.30	1.33	173	568	0.09	0.68	45	35%
ALT. 1.3/2.2/3.1	F	FA	18/25	1.25/0.50/2.25	0.23	0.82	133	494	0.07	0.30	5	4%
ALT. 1.3/2.2/3.1	F	FA	18/25	2.45/0.67/4.50	0.32	0.86	188	744	0.10	0.44	60	47%
ALT. 1.3/2.2/3.1	F	W	18/25	1.25/0.50/2.25	0.60	1.56	345	1054	0.18	0.77	217	170%
ALT. 1.3/2.2/3.1	F	W	18/25	2.45/0.67/4.50	0.75	1.97	442	1498	0.24	1.01	314	245%
ALT. 1.3/2.2/3.1	S	O	18/25	1.25/0.50/2.25	0.23	1.21	132	461	0.07	0.59	4	3%
ALT. 1.3/2.2/3.1	S	O	18/25	2.45/0.67/4.50	0.29	1.54	171	614	0.09	0.77	43	93%
ALT. 1.3/2.2/3.1	U	O	18/25	1.25/0.50/2.25	0.22	0.69	128	336	0.07	0.34	0	0%
ALT. 1.3/2.2/3.1	U	O	18/25	2.45/0.67/4.50	0.30	0.90	174	469	0.09	0.46	46	36%

*Mean Monthly Zinc Loading

**TABLE 7.5 : SUMMARY OF WATER QUALITY PREDICTIONS FOR ALTERNATIVE SCHEME COMBINATIONS
ASSUMING ORIGINAL CONCENTRATION AND FLOW DISTRIBUTIONS BASED ON WORST CASE
MEAN ANNUAL CONCENTRATIONS**

ALTERNATIVE COMBINATION SCHEMES	VANGORDA PIT SEEPAGES A1/A2/A3 L/s	VANGORDA CRK. BELOW MINE		VANGORDA CRK AT FARO (Zinc)					
		MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	MEAN MONTH LOAD Kg/Mo.	PEAK MONTH LOAD Kg/Mo.	MEAN MONTH CONC. mg/L	PEAK MONTH CONC. mg/L	CHANGE* FROM BASE CAS (+/-)	CHANGE FROM BASE CASE (%)
ALT. 1.3/2.2/3.1**	1.25/0.50/2.25	0.62	2.83	357	1132	0.19	1.4	229	179%
ALT. 1.3/2.2/3.2	1.25/0.50/2.25	0.41	2.02	239	714	0.13	1	111	87%
ALT. 1.4/2.4/3.1	1.25/0.50/2.25	0.51	2.18	320	1020	0.17	1.21	192	150%
ALT. 1.4/2.4/3.2	1.25/0.50/2.25	0.32	1.48	312	992	0.17	1.2	184	144%
ALT. 1.5.1/2.2/3.5	1.25/0.50/2.25	0.22	0.88	125	457	0.07	0.42	-3	-2%
ALT. 1.5.1/2.2/3.2	1.25/0.50/2.25	0.24	0.97	137	486	0.07	0.46	9	7%
ALT. 1.5.1/2.3/3.2	1.25/0.50/2.25	0.2	0.68	111	326	0.06	0.32	-17	-13%
ALT. 1.5/2.2/3.2	1.25/0.50/2.25	0.27	1.17	154	523	0.08	0.57	26	20%
ALT. 1.5/2.3/3.2	1.25/0.50/2.25	0.22	0.88	128	378	0.07	0.43	0	0%
ALT. 1.2/2.1/3.1 ***	1.25/0.50/2.25	0.32	1.06	186	544	0.1	0.51	58	45%

* Mean Monthly Zinc Loading

** Base Case

*** With Water Treatment

VANGORDA PLATEAU DEVELOPMENT

ALTERNATIVE ABANDONMENT PLANS

INDEX CARD

<u>ALTERNATIVE No.</u>	<u>DESCRIPTION</u>
------------------------	--------------------

Vangorda Waste Dump

- | | |
|-----------|--|
| 1.1 | Uncovered, Unsegregated Waste Deposited in Vangorda Creek |
| 1.2 | Uncovered, Unsegregated Waste Deposited on Ridge |
| 1.3(Base) | Segregated, Till Covered Waste on Ridge and in Ravine |
| 1.4 | Segregated, Till Covered Waste on Ridge only |
| 1.5 | Replacement of Vangorda Sulphide Waste to Vangorda Pit |
| 1.5.1 | Replacement of all Vangorda Waste to Vangorda Pit |
| 1.6 | Deposit Vangorda Waste behind Engineered Dam in Vangorda Ck. and Flood |
| 1.7 | Segregated, Till Covered Waste with HDPE Geomembrane |

Grum Waste Dump

- | | |
|-----------|---|
| 2.1 | Uncovered, Unsegregated Grum Sulphide Waste |
| 2.2(Base) | Till Covered Waste cell within Main Dump |
| 2.3 | Replacement of Grum Sulphide And Altered Phyllite to Grum Pit |
| 2.4 | Till Covered Waste Cell Outside Main Dump |

Vangorda Pit

- | | |
|-----------|---|
| 3.1(Base) | Flood Pit to El. 1122.5, without Pit Wall Covers |
| 3.2 | Flood Pit to El. 1122.5, with Pit Wall Covers |
| 3.3 | Flood Pit to El. 1122.5, with Pit Wall Covers and Geomembrane |
| 3.4 | Flood Pit to El. 1122.5 and Shotcrete Walls |
| 3.5 | Construct In-Pit Dam to El. 1140 and Flood Pit |
| 3.6 | Remove Sulphide from Pit Walls |

VANGORDA PLATEAU DEVELOPMENT

ALTERNATIVE ABANDONMENT PLANS

INDEX CARD

<u>ALTERNATIVE No.</u>	<u>DESCRIPTION</u>
------------------------	--------------------

Vangorda Waste Dump

- | | |
|-----------|--|
| 1.1 | Uncovered, Unsegregated Waste Deposited in Vangorda Creek |
| 1.2 | Uncovered, Unsegregated Waste Deposited on Ridge |
| 1.3(Base) | Segregated, Till Covered Waste on Ridge and in Ravine |
| 1.4 | Segregated, Till Covered Waste on Ridge only |
| 1.5 | Replacement of Vangorda Sulphide Waste to Vangorda Pit |
| 1.5.1 | Replacement of all Vangorda Waste to Vangorda Pit |
| 1.6 | Deposit Vangorda Waste behind Engineered Dam in Vangorda Ck. and Flood |
| 1.7 | Segregated, Till Covered Waste with HDPE Geomembrane |

Grum Waste Dump

- | | |
|-----------|---|
| 2.1 | Uncovered, Unsegregated Grum Sulphide Waste |
| 2.2(Base) | Till Covered Waste cell within Main Dump |
| 2.3 | Replacement of Grum Sulphide And Altered Phyllite to Grum Pit |
| 2.4 | Till Covered Waste Cell Outside Main Dump |

Vangorda Pit

- | | |
|-----------|---|
| 3.1(Base) | Flood Pit to El. 1122.5, without Pit Wall Covers |
| 3.2 | Flood Pit to El. 1122.5, with Pit Wall Covers |
| 3.3 | Flood Pit to El. 1122.5, with Pit Wall Covers and Geomembrane |
| 3.4 | Flood Pit to El. 1122.5 and Shotcrete Walls |
| 3.5 | Construct In-Pit Dam to El. 1140 and Flood Pit |
| 3.6 | Remove Sulphide from Pit Walls |

