1/16

UR1987_22

1987/22. Stormwater drainage study at Comalco Aluminium, Bell Bay.

B. D. Weldon

Abstract

Proposed improvements to the waste and stormwater handling facilities at the Bell Bay aluminium plant required geological investigation of sub-surface conditions. Portions of the proposed pipeline route were tested by seismic refraction surveys to determine the depth at which massive basalt occurs. Possible sites for a proposed pump-house located near the edge of an unstable slope leading down to the River Tamar were examined. Test pitting was performed in the general area of a proposed treatment lagoon. Improvements to the outfall down the unstable slope to the River Tamar are recommended.

INTRODUCTION

Comalco Aluminium (Bell Bay) Ltd are seeking to improve their handling of waste and stormwater at their Bell Bay plant. They have commissioned Gutteridge Haskins and Davey (GH&D) to undertake engineering considerations for the project. GH&D subsequently sought the advice of the Department of Mines concerning several aspects relating to the geology of the site.

The site was inspected from March 4 to March 6 by Geologist B. D. Weldon, who undertook test pitting in the vicinity of a proposed treatment lagoon. Seismic refraction surveys were made along portions of the length of a proposed new pipeline in the periods March 11-13 and March 16-17. The outfalls of existing drains were inspected and proposed locations of a pumping station examined.

GEOLOGICAL SETTING

The Bell Bay site is located on ground mapped by Gee and Legge (1971) as Tertiary age sediments (comprising clay, sand and gravel). This ground forms a relatively flat to gently undulating plateau some 35 m above the level of the River Tamar. The area is classified as landslip zone II (i.e. stable ground but on soft rocks) on the advisory Tamar Valley landslip zone map sheet 3874 (Dalrymple).

The slope from the plateau down to river level is moderately steep and is classified as landslip zone V (i.e. active landslips and adjacent areas). Exposures on this slope reveal that the sediments are underlain by Tertiary age basalt which has been extruded as a flow over other Tertiary age sediments. This succession is visible in the vicinity of the Australian National Line port installation at Bell Bay. The succession has also been established by drilling for the carbon baking furnaces at Comalco. That investigation indicated that the sediments overlying the basalt vary from between six to about ten metres thick and that the basalt is in the vicinity of 15 m thick.

PROPOSED NORTH/SOUTH PIPE RUN

Tertiary age sediments, landfill and man-made materials occur at the surface along the length of this proposed pipeline. A seismic refraction survey was conducted along portions of the proposed route. The location of the seismic traverses are indicated on Figure 1. The results are presented

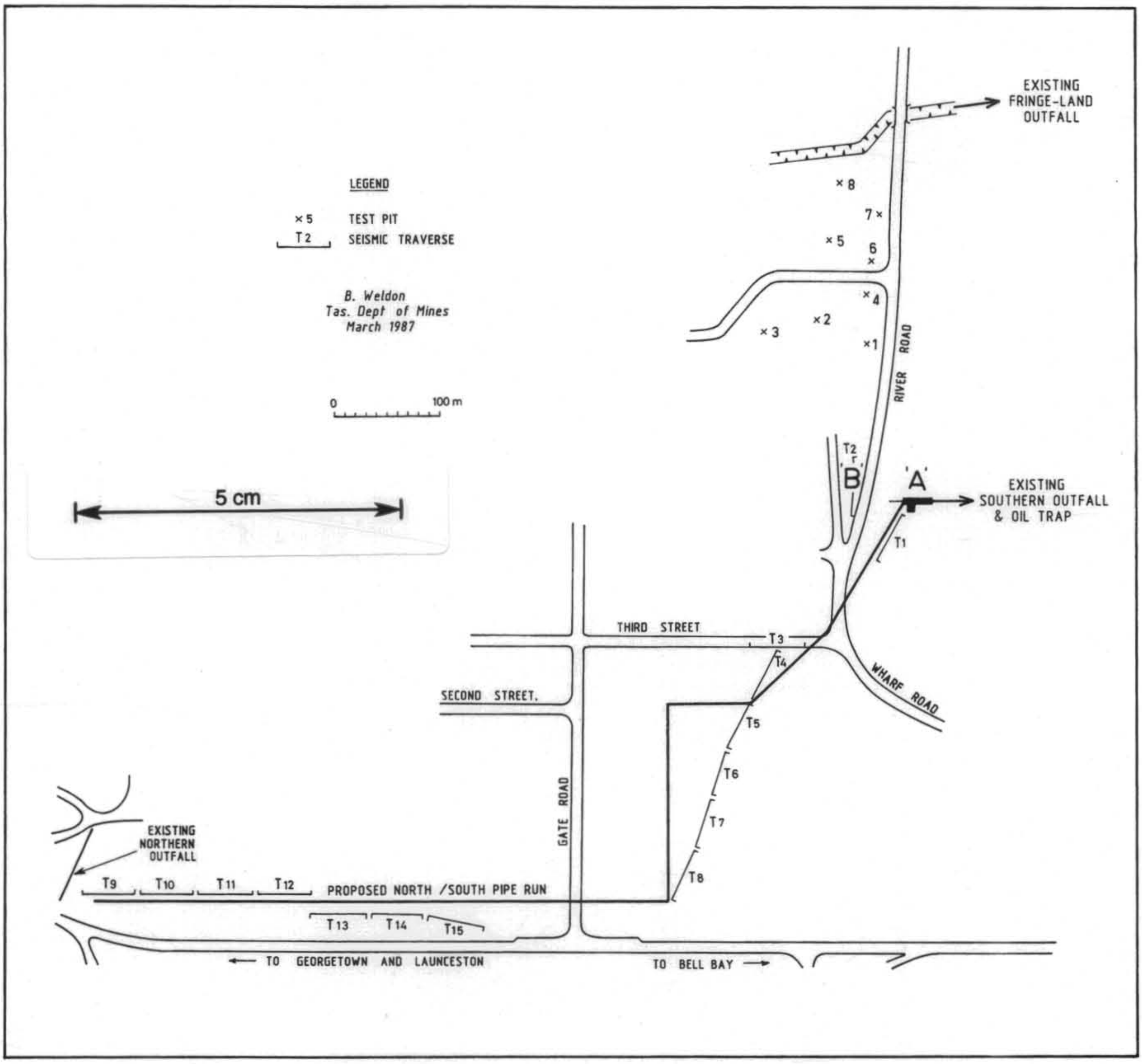


Figure 1. *Location of test pits, seismic traverses, and proposed pump house sites 'A' and 'B'.*

graphically in Figure 2.

The seismic refraction profiles generally distinguish three types of materials. The surface layer has a seismic velocity between 295-525 m/s. This indicates sandy soil materials which are dry and should be easily excavated by back-hoe or similar equipment. The second layer of material produces seismic velocities between 830-1540 m/s. These velocities are indicative of cemented sand, cemented sandy clay and, clay which are interpreted to be the Tertiary age sediments. The velocity range is also typical of an *in situ* (highly) weathered rock profile. The material should be capable of being excavated with back-hoe or heavier equipment. The third layer produced velocities between 2500 and 5000 m/s. These velocities are that of moderately weathered to fresh rock and are interpreted as representing the basalt material. This velocity range usually requires blasting as part of the excavation procedures.

For the purposes of calculating the layer thicknesses, the surface layer was assigned a velocity of 400 m/s, the intermediate layer a velocity of 1000 m/s, and the third layer 4000 m/s.

Traverses T9-T15

In this section the surface layer is usually about one metre thick, thickening to about 3.5 m some 340 m from the existing northern outfall. At about 320 m from the existing northern outfall the depth to the top of the basalt increases to between 10 m and 11 m below ground level. The top of the basalt was difficult to detect at traverse 15, indicating either the edge of the basalt flow or a palaeo-valley in the basalt.

Traverses T8-T4

In this section the surface layer is calculated to be between 1.3 and 1.7 m thick. The top of the basalt is calculated to occur between 3.4-7.2 m below the ground surface. Minor discrepancies in the calculated depth to the top of the basalt between adjacent traverses are attributed to variations in the first layer velocity.

Traverse T3

The location of the seismic traverse in this area was far from ideal due to site limitations. The results are interpreted to indicate a surface layer 2.1-2.7 m thick with the top of the basalt occurring from about 4.2 m to 8.2 m below ground level.

Traverse T1

This traverse was laid across land which varied considerably in level. A planar ground surface has been assumed for the interpretation. In the vicinity of Wharf Road, the surface layer, which here includes fill materials, is up to 5.9 m thick and directly overlies the basalt. Towards the oil trap, the surface layer is between 2.8 m and 4.2 m thick with the top of the basalt being calculated to occur between 8.9 m and 11.6 m below the natural surface.

Traverse T2

This traverse is interpreted to indicate a surface layer some 5.4 m thick at the north-eastern end and 2.8 m thick at the south-western end of the

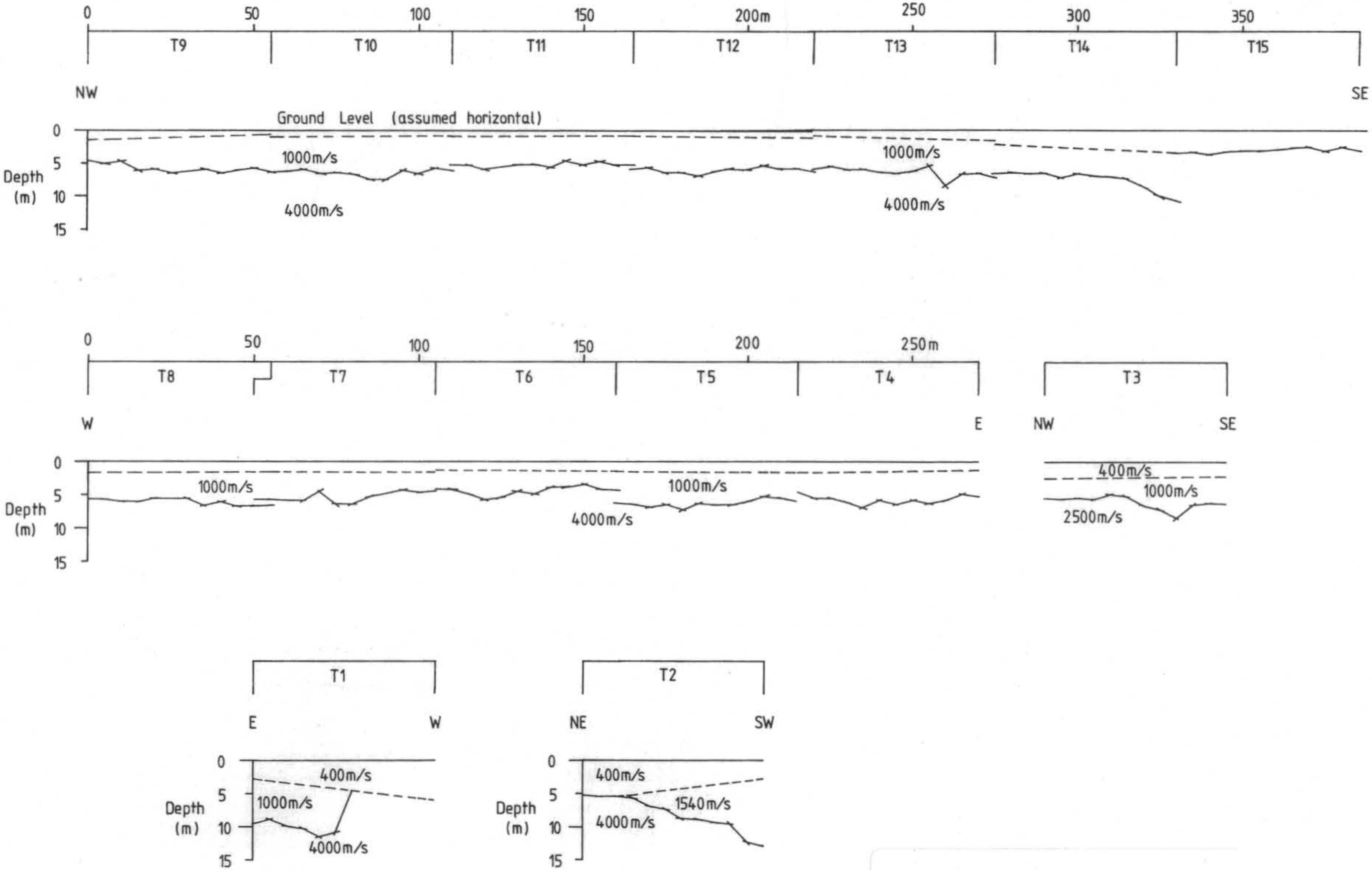
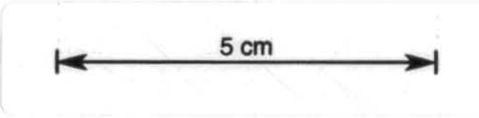


Figure 2. *Seismic reflection profiles.*



line. The intermediate layer is apparently absent in the north-east but is present on the south-western end of the traverse. The top of the basalt is calculated to occur 5.4 m below the surface on the north-eastern end of the traverse, increasing to 12.7 m below ground level at the south-western end.

PROPOSED PUMP HOUSE

Two locations (denoted 'A' and 'B' on Figure 1) were considered for the pump station.

Location 'A'

This site is in the immediate vicinity of the existing southern outfall and oil trap. The oil trap is a concrete structure which is not visibly distressed. It is located in a gully on the slope down to the River Tamar. The southern outfall flows through the trap and into a fabricated channel which extends part way down the slope. The fabricated channel is severely distressed and most of this distress appears due to slope movements in the foundation materials of the channel. Some distress may be due to turbulent flow at times of high discharge from the southern outfall (e.g. after rainstorms).

The slope movements are due to a number of active landslides on the slope down to the River Tamar. Numerous tension cracks, minor backslopes (some with ponded water), and broken ground are common on this slope.

An understanding of the process of slope degradation in this area is useful in placing the siting of the pump house on the slope in context. Tertiary age sediments occur at river level. The slope is on the outside of a curve in a river, an area which is naturally attacked by erosion. Removal of materials by erosion reduces toe-support and buttressing at the base of the slope. A failure at or near river level then 'walks' up the slope as toe-support is progressively removed. Eventually the failures reach the base of the basalt which is then undercut by the slope failures. Blocks then spall off the outer edge of the basalt flow. This spalling is assisted by relaxation of stresses in subvertical joints which run roughly parallel to the slope.

Any structure sited on the slope is therefore at risk (in the long term) from slope instability. In the absence of detailed geotechnical investigations into the thickness and condition of the basalt and other materials on the slope, a recommendation must be made against siting the pump-house in the immediate vicinity of the oil-trap.

Seismic traverse T1 indicates that the oil trap is located in an area where the depth to the top of the basalt is in excess of ten metres.

Location 'B'

This location is between River Road and the carbon production store. Seismic traverse T2 was made in this area. The profile on the top of the basalt suggests that a gully-like feature may exist sloping down from the north-east to the south-west. The materials in the gully have a seismic velocity of 1540 m/s which is indicative of clay, saturated sand, or highly weathered rock. Excavations in this material should be possible without blasting. Blasting will however be required in the fresh basalt which is calculated to occur at about five metres depth on the north-east end of the traverse. The basalt deepens in a south-westerly direction.

This location is between River Road and the carbon production store. As such, a buffer zone is created between the proposed pump-house and the slope down to the River Tamar. This location is the preferred site for the pump-house from geological considerations.

TREATMENT LAGOON

Eight test pits were dug in the area indicated as the site of the proposed treatment lagoon. The engineering logs derived from these excavations are attached as Appendix 1. The test pits encountered clayey materials beneath the surface sand, gravel and fill. These clayey materials should prove suitable for building a bund or dam. When sufficiently wetted up and re-moulded, the clayey materials should provide water-tightness to the treatment lagoon.

The lagoon, like proposed pump-house location 'B', has a buffer zone (albeit small) between itself and the slope down to the River Tamar. Provided the lagoon is not bunded excessively above the existing ground surface it should not contribute to slope instability by loading the top of the slope. A stability analysis has not been performed but should be considered by the engineers if the bunding for the lagoon exceeds two metres.

FRINGE-LAND OUTFALL

The existing fringe-land outfall will become the main outfall for the disposal of waters from the Bell Bay plant. The outfall will require attention to improve its condition. The existing southern outfall may be required to cope with flooding situations.

An inspection has been made along the length of the outfall from the culvert on River Road to the River Tamar. A sketch plan and cross-section, not to scale, is provided as Figure 3. The top of the basalt is clearly defined in the outfall and occurs beneath several metres of sandy and clayey sediments. The basalt is subvertically jointed with joints striking roughly parallel to the slope. These joints are relaxed and movement has occurred on the joints. The base of the basalt is not visible but at river level the materials are Tertiary age sediments, some having clearly moved down the slope.

The existing outfall discharges over ground which is mobile. In places the discharge disappears underground to re-appear elsewhere. This condition must be contributing to slope instability. A remedy may be rather elusive. The entire length of the slope will require attention.

Possible treatments which should contribute to stabilising the slope include:

(1) Slope grooming of a swath say some 20-30 m wide along the length of the discharge. This grooming should remove overhanging masses of materials and fill in any back-slopes where water may pond.

(2) Extensive planting not only on the groomed swath but extending along the slope in either direction away from the line of discharge.

(3) Foreshore improvements which will act so as to reduce erosion of the foreshore in the vicinity of the discharge at river level. These works would also act as a buttress for materials on the slope.

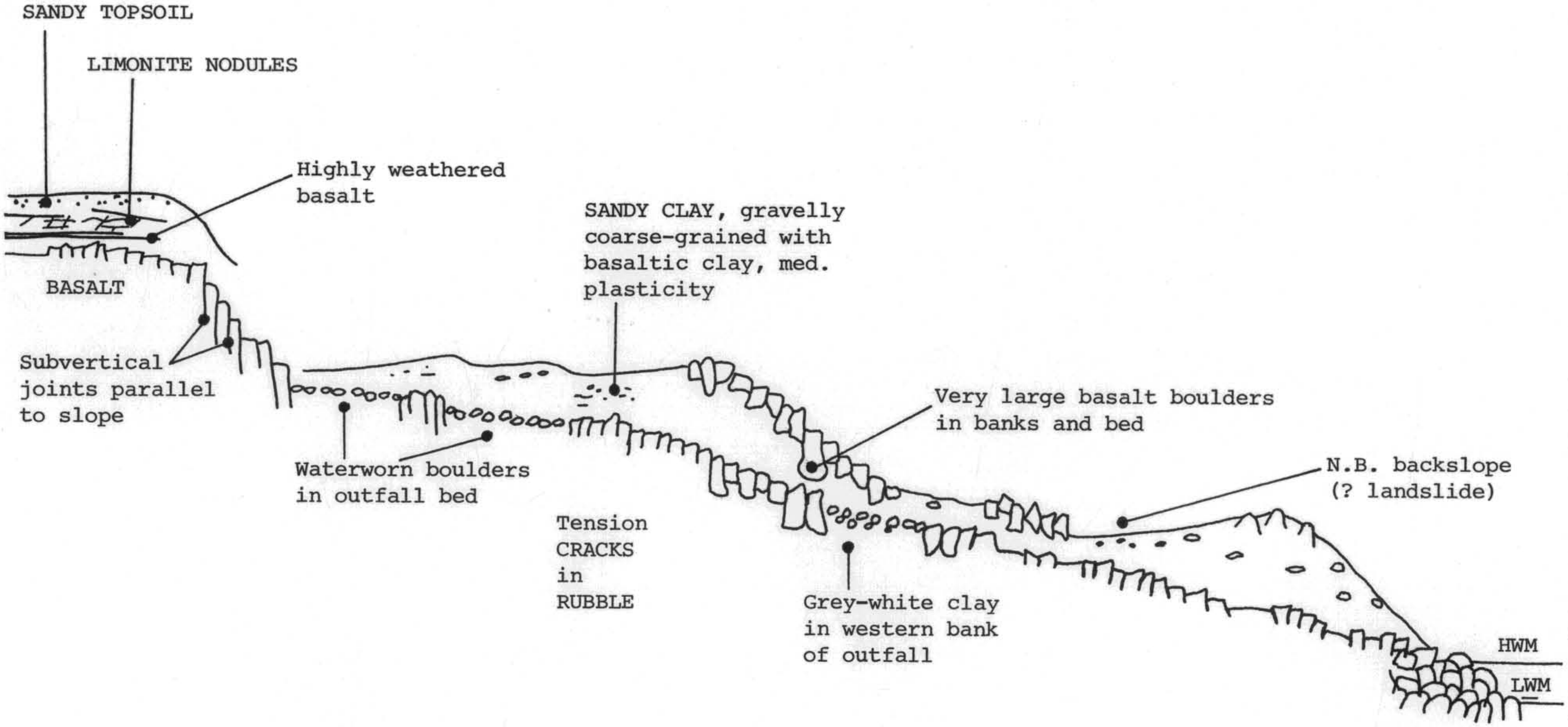


Figure 3. *Schematic long section, Fringeland Outfall, Comalco Aluminium (Bell Bay) Pty Ltd*

7/16

(4) The discharge should be contained within a structure extending from River Road to the foreshore. The structure will contribute to stability by preventing water from entering the slope. The structure will need to withstand some movement and should be easily and inexpensively repaired or replaced.

The present fringeland discharge passes through a notch cut into the basalt on the slope. Tension cracks occur both upslope and downslope of the notch. The inference, which has not been demonstrated as fact, is that the mass of basalt has moved on the slope. If this is the case, then a rather large block through which the discharge must pass is unstable.

CONCLUSIONS AND RECOMMENDATIONS

Proposed improvements to the stormwater drainage system at the Bell Bay aluminium plant require a pipeline from the existing northern outfall to the existing southern outfall. This pipeline will be placed in a trench up to six metres below existing ground level. Seismic refraction surveys indicate that the top of the massive basalt, which will require blasting, commonly occurs between four to six metres below existing ground level.

A transfer pump-house is required at the existing southern outfall. The recommended site from geological and slope stability considerations is between River Road and the carbon production store, away from the slope (and the existing oil trap).

At the proposed site of a treatment lagoon, predominantly clayey materials should provide adequate water tightness. If the lagoon needs to be elevated in excess of two metres above existing ground level then a stability analysis is recommended.

The treated water will be discharged to the River Tamar via the existing fringe-land outfall. This outfall is currently a channel achieved by natural processes. Water disappears underground in places to re-appear elsewhere. It is recommended that the discharge be contained within a structure placed on a slope which has been groomed and planted with trees.

REFERENCE

GEE, R. D.; LEGGE, P. J. 1971. Geological atlas one mile series. Zone 7 sheet 30 (8215N). Beaconsfield. *Department of Mines, Tasmania*.

[6 April 1987]

9/16

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 1
sheet 1 of 1

project COMALCO DRAINAGE STUDY location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MASSEY FERGUSON 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.15		GW	BAUXITE, compacted landfill – fine non plastic gravel	M	VD		FILL
				0.5 0.60		GW	QUARTZITE GRAVEL: compacted landfill medium grained non-plastic gravel with silt fines	M	VD		
				1.0 1.30		GM	SILTY to CLAYEY GRAVEL: fine grained limonitic gravel with variable fines ranging from low plasticity silt to medium plasticity clay; some decaying roots and rootlets;	M	D-		
				1.40		SP	SAND: fine grained quartz, grey	M	D		
				1.5 1.75		CH	CLAY: mottled grey-red-brown high plasticity, moisture content (M.C.) greater than (>) plastic limit (P.L.)	M	VSt		
			END	2.0 2.40		CH	CLAY: green-blue high plasticity moisture content > plastic limit decaying roots and rootlets	M	St		
				2.5							

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 2
sheet 1 of 1

project COMALCO DRAINAGE STUDY
location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.30		GW	FILL: top 40-50mm bauxite compacted landfill 50-300mm quartzite gravel, compacted landfill medium grained non-plastic gravel	M	VD		FILL
				0.5 0.80		GC	GRAVELLY CLAY: fine to medium grained rounded limonitic gravel (30-40%) in a brown-yellow high plasticity clay matrix moisture content > plastic limit	M	VD-D		
				1.0 1.5 1.70		CH	CLAY: mottled brown-grey high plasticity clay, moisture content approx. at plastic limit, some decaying roots and rootlets	M	VSt-H		
			END	2.0 2.40		CH	CLAY: blue-green mottled brown high plasticity clay moisture content > plastic limit	M	St		

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 3
sheet 1 of 1

project COMALCO DRAINAGE STUDY
location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.25		GW	FILL 0-10mm bauxite - compacted landfill 90-250mm quartzite gravel - medium grained non-plastic	M	VD		
				0.40			FILL: ash, coal dust, furnace by products	M	L		
				1.40		CH	CLAY: mottled brown-grey, high plasticity clay, moisture content > plastic limit some fine grained limonitic gravel	M			grey clay on slickensides
				2.15		CH	CLAY: green-blue with brown mottles high plasticity clay moisture content > plastic limit	M			
			END	2.40		GC	GRAVELLY CLAY: brown to blue high plasticity clay with moderately weathered basaltic gravel (medium-coarse grained)	M			

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 4
sheet 1 of 1

project COMALCO DRAINAGE STUDY location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.25		GW	BAUXITE – compacted landfill fine gravel, non-plastic	M	VD		
				0.55		GW	QUARTZITE GRAVEL: medium grained quartzite gravel, non-plastic compacted landfill	M	VD		
				0.75			SLAG: ferro-manganese	M			
				1.30		CH	CLAY: mottled grey-blue-brown high plasticity clay moisture content > plastic limit some medium size basalt gravel	M	St		slickensides
				1.70		CH	CLAY: blue-green with brown mottles high plasticity clay moisture content > plastic limit	M	St		
			END	2.30		GC	CLAYEY GRAVEL: medium to coarse size gravel of moderately weathered slabby basalt	M	D		

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 5
sheet 1 of 1

project COMALCO DRAINAGE STUDY
location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-86
pit completed 6-3-86
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.20			FILL – ash, coal dust, furnace by-products	M	L		
				0.40		SM	SAND – white to light grey, fine grained, non-plastic	M	D		
				0.5 0.60		GM	GRAVEL – dark brown, fine size, low plasticity, yellow-brown clay fines	M	D		
				1.0 1.5 1.80		CH	CLAY: mottled grey-brown-orange high plasticity clay moisture content > plastic limit	M	St – VSt		
			END	2.0 2.50		CH	CLAY: mottled blue-green with orange-brown, high plasticity, moisture content greater than plastic limit. Contains pockets of fine size grey sand	M	St		fine to medium size gravel on sub-vertical fissures

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 6
sheet 1 of 1

project COMALCO DRAINAGE STUDY
location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	NONE			0.10			FILL : ASH, COAL DUST, furnace products				
				0.40		SM	SAND: light grey - white, fine grained, low plasticity	M	D		
				1.70		CH	CLAY: mottled grey - brown - orange high plasticity clay moisture content > plastic limit	M	St-VSt		
				2.00		CH	CLAY: mottled green-blue and brown high plasticity clay M.C. > P.L.	M	St		
			END	2.30		GC	GRAVELLY CLAY: brown-grey, medium-high plasticity M.C. ≃ P.L.; rounded medium-coarse size basalt gravel	M	VSt		

sketch

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 7
sheet 1 of 1

project COMALCO DRAINAGE STUDY
location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B. Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
							FILL : ASH, COAL DUST, furnace products	M	L		
						SM	SAND : light grey-white, fine size, non-plastic	M	D		
				0.40		GM	GRAVEL : brown-orange fine-medium size limonite gravel non-plastic	M	D		
				0.5 1.0 1.5 1.80		CH	CLAY : mottled grey-brown-orange high plasticity clay moisture content > plastic limit some decaying roots and rootlets	M	VSt		
				2.0 2.20		CH	CLAY: blue-green with grey mottles high plasticity clay; M.C.>P.L. minor grey sand	M	St		
				2.40		GC	GRAVELLY CLAY/BOULDERS : moderately to highly weathered med-coarse size basalt in brown/blue clay	M	VSt		

sketch

5 cm

16/16

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 8
sheet 1 of 1

project COMALCO DRAINAGE STUDY location

co-ordinates
R.L.
excavation dimensions

exposure type test pit
equipment MF 50B
operator

pit commenced 6-3-87
pit completed 6-3-87
logged by B.Weldon
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
				0.20			FILL: ASH COAL DUST furnace products	M	L		
				0.40		SM	SAND: light grey-white, fine grained, non-plastic	M	D		
				0.5 0.75		GM	GRAVEL: brown-orange, fine size limonite gravel with yellow-brown medium plasticity clay fines.	M	D		
				1.0 1.5 2.00		CH	CLAY: mottled orange-brown-grey high plasticity moisture content > plastic limit	M	VSt		
			END	2.40		CH	CLAY: mottled green-blue-grey with brown high plasticity clay, M.C. > P.L.	M	St		

sketch

5 cm

22-16