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Gunns Pulp Mill Effluent Pipeline Four Mile Beach Dune Crossing Geological Setting

Prepared for

Gunns Pty Ltd

February 2006

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Pitt & Sherry Ref: H05164H001. 30.1.geol rep Rev 02.doc/mjp

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1. Introduction

Gunns Pty Ltd has requested Pitt & Sherry to provide a brief report on the geological setting of the Five Mile Bluff area in the vicinity of the proposed effluent outfall pipeline shoreline crossing.

This report is a desktop description of the likely conditions to be expected in this offshore area to about the 30 m water depth. It is based on known literature of the area and general information from investigations undertaken for other infrastructure developments in the area.

The report also provides comments on the geotechnical properties of expected materials, based on limited investigations for other projects, as well as an assessment of potential problems arising from the expected materials, associated with HDD, trenching and surface dragging of a concrete coated pipe.

2. Geology

2.1 Regional Geology

The geology of the area is summarised on the Beaconsfield 1:63360[1] geological map and in the associated explanatory report[2].

The area to the west is dominated by the Tamar estuary, which occupies a NW trending graben structure formed by large-scale normal faulting in the Tertiary.

The Tippogoree Hills, on the eastern side of the graben, consist of Jurassic dolerite that has been intruded into Permian and Triassic rocks.

Tertiary basalts are associated with the graben structure and also outcrop extensively along the coastline to the east.

Lower Palaeozoic sandstones and siltstones outcrop to the south east of the area.

[1] Gee, RD and Legge, PJ. 1971. Geological Atlas 1:63 360 series, Sheet 30 (8215N). **Beaconsfield**. Department of Mines, Tasmania.
[2] Gee, RD and Legge, PJ. 1979. Geological Survey Explanatory Report. Sheet 30 (8215N). **Beaconsfield**. Department of Mines, Tasmania.

2.2 Site Geology

Tertiary basalt forms cliffs and headlands, including Four and Five Mile Bluffs, and offshore reefs along some 15 km of the coastline from the Tamar estuary to east of Beechford.

The area is backed by Cimitiere Plain, a flat landform ranging from 15 – 30 m in altitude, which is essentially an erosional surface in the Tertiary sedimentary and volcanic rocks.

Cimitiere Plain has an extensive cover of locally reworked and windblown sands, which tend to be arranged in east-west ridges.

2.3 Basalt

Basalt Types

Three basalt types are associated with the Tertiary volcanism of the Tamar Valley[3]:

- A normal massive variety of olivine and plagioclase phenocrysts in a glassy groundmass.
- A vesicular or scoriaceous variety of similar composition.
- A coarse-grained olivine-poor variety restricted to Bradys Lookout and Windermere.

Basalt Flows

A sequence including at least two basaltic flows occurs in several places in the Tamar graben of the Beaconsfield quadrangle[4].

The basalt flows occur mainly as confined lava flows that followed pre-existing river valleys.

On the east Tamar a continuous basalt horizon extends from Donovans Bay, through Bell Bay to George Town.

An upper basalt, separated from the lower by about 30 m of sediment, occurs in the Bell Bay – Point Effingham area. A similar, and probably equivalent, sequence occurs on the West Tamar.

These basalt flows, on both sides of the Tamar, dip gently to the north.

[3] Longman, MJ. 1966. Geological Survey Explanatory Report One Mile Geological Map Series, **Launceston**. Department of Mines, Tasmania

[4] Gee and Legge, 1979.

Five Mile Bluff Basalt

The basalt in this area is generally massive but has some scoriaceous layers. However, the relative extent of scoriaceous as opposed to massive basalt in this area is unknown.

The basalt probably consists of several individual flows but there is no site-specific information available on the number of flows at this site.

Coastal Basalt Features

In this area marine action on the basalt of the coastline has resulted in the production of coastal cliffs and an offshore wave-cut platform.

The gentle seaward dip of the basalt flows in the area has resulted in the formation of a wave-cut platform that merges into an offshore reef. There is an extensive offshore "platform" that extends out to about the 40m water depth in the area.

This platform and reef has an irregular surface that acts as a trap for cobbles, gravel and sand.

The mobility of surface sediment on this platform is a function of:

- Wave action.
- The degree of irregularity in the surface of the reef.
- The nature and size distribution of the surface sediment.

2.3.1 Structural Geology

Faulting in the wider area is dominated by the NNW trending structures that define the Tamar graben to the west. A number of smaller faults are associated with these major structures.

There are no faults indicated in the area of the proposed effluent outfall pipeline on the Beaconsfield Sheet of the Geological Atlas 1:63 360 series.

However, the distribution of Jurassic dolerite, together with the projection of mapped faults, would suggest that some faults may occur in the area. The occurrence of faults in the pre-Tertiary rocks is considered to be very likely. Such faulting could have provided conditions suitable for the accumulation of thick deposits during the Tertiary.

Where the Tertiary deposits are capped by basalt any undercutting could result in instability, including at the submarine terraces.

2.3.2 Seismic Activity

The major fault structures that define the Tamar graben are older structures that were re-activated in the Tertiary. There is no evidence of recent (ie historic) movement on any of these structures.

According to an earthquake risk assessment undertaken[5], microearthquakes occur throughout Tasmania but larger earthquakes occur in two distinct regions:

- The Western Tasmanian Zone.
- The West Tasman Sea Zone (extending from east of Flinders and Cape Barren Islands).

Flinders and Cape Barren Islands are considered to be the highest risk land area, followed by the northern part of western Tasmania.

3. Seabed Geology

3.1 Type

The Basslink IIAS[6] summarised information from a survey undertaken for a Telecom cable route east of Five Mile Bluff (near Beechford) as well as a survey for the Tasmanian Natural Gas Pipeline route east of Five Mile Bluff.

In this area:

- The beach consisted of sand and basalt cobble overlying solid rock outcrops and emergent cobble reef.
- The localised accumulations of cobbles coalesced into a single reef within 200 m of the shore.
- Further offshore, the seabed consisted of cobble and rock outcrops with small pooled accumulations of sediment.
- The seabed then dropped down in a series of terraces until, in about 30 m water depth, the seabed consisted of rock covered by patches of coarse gravels and cobbles with rock outcrops extending up to 1m above the seabed.

[5] Michael-Leiba, MO & Gaull, BA, 1989. *Probabilistic earthquake risk maps of Tasmania*. BMR Journal of Australian Geology & Geophysics, 11, 81 – 87.
[6] Publicly available documentation

- In about 40 m water depth, reached about 10 km offshore, the bottom consisted predominantly of rock with large patches of megarippled sand.

The IIAS concluded that seabed conditions across the area from Five Mile Bluff to the Tamar estuary were likely to be fairly uniform and that the seabed offshore from Five Mile Bluff was likely to be similar to that found in the Telecom EES and Tasmanian Natural Gas Pipeline investigations.

3.2 Areal Extent

Based on these investigations of the offshore area, the Basslink IIAS concluded that the seabed offshore from the Five Mile Bluff area, out to 40 m water depth, was likely to consist of a rocky substrate or rock outcrops interspersed with sand.

A nearshore survey, undertaken in the area between Five Mile Bluff and Low Head to about the 40 m water depth by AMOG[7], found that:

- Inshore from 10 m water depth the substrate consisted of sand.
- Emergent low and high relief reef continues almost unbroken from 10 m water depth out to about 35 – 40 m water depth, apart from a partial channel in the outer area (discussed below).
- At around 35 – 40 m water depth the seabed transitions from rocky reef to sand and silt with some shell detritus.

The series of offshore terraces in the basalt noted in the Basslink IIAS summary of the Telecom and Tasmanian Natural Gas Project investigations has also been observed (anecdotal evidence) offshore west of Five Mile Beach.

The origin of this series of terraces observed in the basalt offshore is uncertain but potential explanations include:

- The edges of individual flows in the basalt.
- Individual wave-cut platform development associated with periodic stillstands in sea level.
- Subaerially modified (Quaternary lowstand) scarps of faults associated with the Bass Strait structure.

[7] AMOG Consulting. Supporting Studies #25 and #26, Basslink IIAS.

3.3 Palaeochannels

3.3.1 Channels

There are potentially two palaeochannels in the area, one between Four Mile Bluff and Five Mile Bluff, and one east of Five Mile Bluff.

The channel east of Five Mile Bluff was probably an extension of the Curries Rivulet and Curries River drainage systems.

The channel to the west of Five Mile Bluff was probably an extension of the existing creek through the dune system at the proposed crossing site. This existing creekline may have previously collected all drainage from the British Creek area but this drainage system has since been modified. This drainage channel may also have collected drainage that currently flows out at Bellbuoy Beach, to the west of Four Mile Bluff.

The channel west of Five Mile Bluff does not appear to run all the way through the entire length of the offshore reef but rather runs in to about 22 m water depth before the bed becomes exposed rock. Between this channel and the shoreline there is a zone of low relief in the reef between areas of higher relief.

3.3.2 Five Mile Bluff Channel Fill

Depth of Fill

The AMOG survey, using sub-bottom profiling, assessed sediment depth cover in the channel offshore from Five Mile Bluff to be:

- 1 – 3 m between 25 and 40 m water depth.
- 0.1 – 0.3 m between about 22 and 25 m water depth.

The bed of this channel became exposed rock at around 22 m water depth.

Nature of Channel Fill

The AMOG survey did not determine the nature of the fill material in the channel off Five Mile Bluff. However, in line with the Telecom survey findings from east of Five Mile Bluff, the channel fill is likely to consist of coarse gravels, cobbles and sand.

The variable thickness of the channel fill observed in the AMOG survey may be a reflection of:

- Variations in the surface expression of the floor of the channel over which the sediments have accumulated.
- Variations in the areal distribution of the channel fill materials.

- Variations in the degree of consolidation experienced.

The extent and thickness of sand sized material, in particular in the channel, may show significant variations over relatively short periods of time, in response to storm events.

Variations in the distribution of coarser materials may require longer periods of time.

Implications
Based on existing information, it is considered highly likely that the fill in the channel off Five Mile Bluff:

- Is not a homogeneous material
- May well show considerable lateral and vertical variations in material size.
- May show rapid or even abrupt changes in material sizes throughout the section of the channel out to 30 – 40 m water depth.

4. Geotechnical Properties of the Materials

4.1 Basalt

Geotechnical comments are based on relatively fresh basalt, as observed in a limited number of boreholes associated with other investigations undertaken on land and in the nearshore area within the general area.

Description
The rock is massive, generally medium to fine grained, blue-grey when fresh and vesicular in part. Colour becomes brownish with weathering.

Degree of weathering
The rock varies from extremely weathered to fresh.

Borehole observations from the area generally indicate a highly to extremely weathered layer (4 – 8 m in thickness) overlying fresher rock.

Limited seismic investigations in the area support these observations, indicating a general trend of velocity increasing with depth. (ie increasing strength and quality of rock with depth).

Variability of weathering

Observations based on the limited boreholes and seismic investigations undertaken in the area indicate that weathering of the basalt is likely to vary both laterally and vertically.

Density

No site-specific density measurements have been undertaken on the basalts in this area.

However, Tertiary volcanic rocks have been estimated to have a density of 2.90 – 3.00 g/cm^3, if present as massive basalt flows [8]. The flows at Four and Five Mile Bluffs may have similar density values.

Rock Strength (UCS)

There are no site-specific point load strength test results available for the basalt.

Estimated unconfined compressive strength (UCS) of the fresh basalt observed in a limited number of boreholes varied from low (2.4 – 7 Mpa) to high (24 – 70 Mpa), with the majority of observed material being of at least medium strength (7 – 24 Mpa).

Unconfined compressive strength appeared to increase nonlinearly with depth. This variation in the observed trend may reflect heterogeneity (scoriaceous layers, corestones) and the distribution of joints and fractures within the material examined.

a number of factors including the presence of more scoriaceous layers, the distribution of corestones within the basalt, .

The limited seismic investigations undertaken in the area also indicated a general trend of velocity increasing with depth (i.e. increasing strength and quality of rock with depth).

Defects

The dominant defect in the basalt, based on the limited vertical borehole investigations, was intense horizontal jointing. This apparent jointing may, in fact, not be a joint pattern but instead reflect mechanical breakdown during drilling. Oblique and vertical joints, although present, were much more limited in occurrence.

Defect spacing observed was variable, ranging from < 30 mm to 3000 mm but commonly being 300 mm or less.

[8] Longman, MJ and Leaman DE. 1971. *Gravity Survey of Northern Tasmanian Tertiary Basins*. Geol Survey Bulletin, Department of Mines, Tasmania.

Rock flow thickness assessment

The breakdown of weathered basalt into both granular and cohesive materials, observed in the limited number of boreholes from the area, probably reflects differences between individual flows in the basalt. This information is not sufficient, however, to make any estimations of the thickness of the basalt flows in the area.

No other site-specific evidence is available regarding the thickness of flows in the area.

Mechanical Breakdown

Based on observations during the limited borehole investigations in the area, the weathered basalt breaks down to sands and clays by mechanical action during drilling.

The highly jointed fresh material also appears to be broken up to some extent during the drilling process. As noted above (*Defects*) this horizontal jointing may, in fact, not be a joint pattern but instead simply reflect mechanical breakdown of the rock during drilling.

4.2 Other Materials

Clay

The extremely weathered basalt observed in some boreholes has been classified as medium plasticity clay that is gravelly in parts.

Cobbles and Gravels

No specific investigations of the nature and properties of the cobble and gravel materials in the area have been undertaken.

These materials are assumed to be dominantly basaltic in origin and exhibit varying degrees of weathering.

Much of this material is likely to be reasonably well rounded, as the likely source of much of the rounded material is the corestones weathered out of the basalt. These corestones will have been further rounded by abrasion as they are likely to have been on the reef platform for some considerable time. Given the high energy nature of this area, only the relatively fresh basalt material will remain on the platform for any length of time.

Any material broken off the existing reef as a result of impact between cobbles and the reef is likely to be quite angular, with fresher basalt likely to retain its angularity for some considerable time.

5. Improved Understanding

Site-specific investigations could be undertaken to improve understanding of the geological conditions prevailing in the area of the proposed effluent outfall. Such investigations, although not necessarily required, would provide more specific information on the geological conditions in the area of the proposed pipeline and, therefore, greater certainty for engineering design purposes.

Investigations that could be undertaken to improve this understanding include:

- *Mapping, augering and sampling program*

Determine the extent and nature of outcrop on the seabed from high water mark to low water mark, the depth of surficial materials, obtain samples of surficial materials, sample the basalt and determine the extent of weathering and the nature of the basalt.

- *Marine drilling program*

Obtain detailed information on seabed geology, particularly the basalt, and samples of the material for determination of geotechnical properties.

- *Seismic program*

Determine seabed geology and the depth of surficial sediments.

- *Jetting*

Determine the depth of surficial sediments (that is, depth to bedrock).

- *Sediment sampling*

Identify the type of surface material over which the pipe will be dragged.

- *Submarine Video*

Obtain a visual image of the seabed along the pipeline route.

6. Conclusions

6.1 Expected Geotechnical Conditions

6.1.1 Shoreline to 20 m water mark, 3 m depth

In this area the following conditions can reasonably be expected:

- Weathered basalt to depths well in excess of 3 m where there is an existing surficial cover.

- Depth of weathered basalt may be considerably less where wave action is relatively constant.

- Basalt is likely to be highly fractured and probably break down mechanically relatively easily.

- Basalt is likely to have a thin surface component of sands/gravels/cobbles.

In view of the nature of fresh basalt experienced at depth, it is considered unlikely that drilling and blasting would be required to pre-fragment any relatively fresh rock that may occur along this zone within 3 m of the seafloor.

6.1.2 Drilled Installation Method (HDD), 30 – 40 m depth

In the deeper area required for a drilled installation method the following conditions can reasonably be expected:

- Clay, sand and cobble layers of variable thickness, with a total thickness of several metres, depending on entry point.

- A deep layer (several metres up to 8 – 9 m) of weathered basalt that is likely to break down mechanically to sand and clay.

- Fresh basalt at depths of around 9 m that is highly jointed (dominantly horizontally) and that is likely to break up mechanically to smaller, angular pieces.

- The possible presence of gravels and cobbles at the seaward end, depending on the exit site.

The geotechnical conditions that could reasonably be expected at a deeper level are considered likely to be problematic, at least in part, for a drilled installation method such as HDD.

6.1.3 Seabed Rock Surface

The following conditions can reasonably be expected along the seabed surface:

- A variable rock surface with numerous small and large hollows in the surface.

- Many of the edges of the hollows likely to be rough rather than smooth.

- Breakage of the rock surface likely to produce jagged edges and angular pieces.

- Considerable potential for a pipeline across the surface to freespan; potential lengths of freespans may range up to many metres or possibly tens of metres.

- Variable amounts of sand, gravel and cobbles in the hollows.

- The seabed rock surface is unlikely to be a suitable surface over which to tow (assume drag) a pipeline with a concrete weight coating without significant preparation/modification of the surface.

The seabed rock surface is likely to present some difficulties for the placement of a concrete coated pipeline across the seabed, resulting in the potential risk of damage to the pipe during construction.

It will also provide considerable potential for freespan if the surface is not appropriately modified beforehand.