Appendix D

Summary Report on Geotechnical Investigation
Trans Territory Pipeline, Northern Territory
prepared by Golder Associates

Golder Associates Pty Ltd
A.B.N. 64 006 107 857

611 Coronation Drive
Toowong, Qld 4066, Australia
(PO Box 1734, Milton BC, 4064)
Telephone (07) 3721 5400
Fax (07) 3721 5401
http://www.golder.com

SUMMARY REPORT ON

GEOTECHNICAL INVESTIGATION
TRANS TERRITORY PIPELINE
NORTHERN TERRITORY

Submitted to :

Alcan Engineering Pty Ltd
GPO Box 1016
BRISBANE QLD 4001

November 2004

019-03632228

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Under commission from Alcan Engineering Pty Ltd, Golder Associates has carried out geotechnical investigation work along the proposed Trans Territory Pipeline route. The work involved drilling of 262 auger holes along the proposed route, and was carried out over two periods, commencing in October 2003 and completed in September 2004.

The main objective of the investigation was to determine ground conditions down to 1.5 m below surface level along the route, in order to assess excavation characteristics.

At some river, road, and rail crossings the pipeline will need to be installed by directional drilling or horizontal boring. The small drill rig used was not capable of carrying out detailed investigation work at these locations, and in some instances access was not available. This report sets out details of the field work undertaken, together with an interpretation of the results with respect to excavation characteristics, or diggability. Limited advice on directional drilling is provided.

In addition, Alcan requested that the report provide subjective comment on potential sections of the route which could pose construction difficulties due to topography, water crossings, or swamp areas. Subjective comment was also requested on traffickability along the route for trucks carrying pipeline equipment.

2.0 FIELD WORK

Field work was undertaken using a Land Rover Defender 130 four-wheel drive vehicle on which was mounted a purpose designed rotary hydraulic auger rig. The rig was equipped with 10 m of 170 mm diameter spiral flight augers, and a tungsten carbide faced bit designed for maximum penetration in soil and weathered rock. The augering rig is capable of 2000 Nm torque at the auger, at a rotational speed of 50 revolutions per minute, and performs well in widely varying ground conditions, including weathered rock.

Sites for surface and sub-surface investigation were nominated by the study team leader during the route study. As a general rule, sites were located about 5 km apart along the pipeline alignment, although this interval, or the specific location of the site, was often varied according to:

- Limitations imposed by untraffickable ground or site inaccessibility
- The requirements of other members of the study team
- Cultural and other considerations of traditional owners.

Sites along the general pipeline alignment were usually augered to 1.6 m depth (a little deeper than the planned depth of the pipeline trench) or earlier refusal. In the case of auger refusal,

second and third attempts were usually made a short distance (about a metre) from the first auger location. During augering at each site, the auger was lifted from the hole at depth intervals of 250 or 300 mm, and disturbed soil or weathered rock samples were taken from the lower end of the auger flights. These samples were then placed on short lengths of timber on the ground near the auger hole for examination and logging as soon as the augering was completed. Representative disturbed samples of typical soils were retained from some of the sites examined. A digital photograph was taken of the general site area at most sites during or following the completion of augering and logging.

Test locations where auger refusal was encountered are shown on Figure 1.

At many of the major stream crossing points, attempts were made to auger to a 10 m target depth to provide ground information relevant to deep excavation or under-stream directional drilling. However auger refusal occurred on rock at a number of the major stream crossings, and at some others, time or access limitations prevented the attempting of deep augering. In some of these latter cases it was considered sufficient to record visual observations, especially where relatively strong rock was visible in the bank or bed of the stream.

Recording of the finding at each site were made in two parts:

- Observations of surface conditions
- A geotechnical log of the auger boring

In accordance with the project requirements, surface observations and auger logs were recorded using a Palm Tungsten T2 PDA (hand-held computer). Position information was obtained and recorded automatically using a Magellan GPS Companion attached to the Palm. Data was uploaded in the field from the Palm to a notebook computer daily, or every second day where only one or two sites per day were recorded. Backups of the data and digital photographs were made on USB flash drives and/or CD-ROM immediately after each uploading. Uploads of the geotechnical data and pictures were also made to the team leader's notebook computer at frequent intervals.

Data obtained during the field exercise was validated at the end of each field season. All data was stored in the client's project database.

At the end of the 2004 field season a trial was arranged to compare the penetrating ability of the augering rig used for study with that of an excavator in the 30 to 35 tonne class.

The trial was carried out at the ERS quarry, Redland Bay. Initially 13 holes were drilled at a range of locations representing easy to difficult excavation conditions. Trial excavations were carried out at 7 of these locations to correlate diggability against the auger capability as described in the field borelogs:

Rating 1 - Indicates rapid auger penetration with low machine effort

Rating 2 - Indicates slower auger penetration with medium machine effort

Rating 3 - Indicates very slow penetration with high machine effort (approaching refusal)

A similar difficulty rating was applied to the ease and rate of digging by the excavator and the comparison is set out in Table 1.

Table 1: Diggability Correlation

Location No	Depth, m	Description	Auger Difficulty	Excavator Difficulty	Assessment
1	0-0.6	Disturbed, reworked weak rock (clayey sand and gravel)	1	1	Excavator difficulty very similar to auger difficulty
	0.6-0.8	DW low strength clayey fine sandstone	2	2	
	0.8 – 1.4	DW medium strength clayey fine sandstone	2	2	
2	0-1.6	DW medium strength fine sandstone	3	2	Excavator difficulty rather less than auger difficulty
3	0-1.6	EW very low strength fine sandstone	1	1	Low difficulty experienced by both auger and excavator
4	0-0.7	EW very low strength clayey and silty fine sandstone	1	1	Excavator difficulty a little more than auger difficulty at depth
	0.7-1.5	DW low strength fine sandstone	2	1 increasing to 3	
	1.5-1.6	DW medium strength fine sandstone	3	3	
5	0-1.2	EW very low strength clayey and silty fine sandstone	1	1	Low difficulty experienced by both auger and excavator
	1.2-1.6	DW low strength fine sandstone	2	1	Excavator difficulty rather less than auger difficulty
6	0-1.0	DW medium strength fine sandstone	3 practical refusal at 1.0 m	3 practical refusal at 0.6 m	Excavator difficulty very similar to auger difficulty
7	0-0.4	DW medium strength fine sandstone	3 (practical refusal) at 0.4 m	3 (practical refusal) at 0.6 m	Excavator difficulty very similar to auger difficulty.

3.0 FIELD WORK RESULTS

As noted in Section 2.0, all field observations and borehole data were recorded in the designated Project format on hand held computers and is stored on the Project data base.

Table 2 is a tabulation of route details incorporating a summary of soil conditions encountered travelling from west to east along the route, and also including subjective comments on streams, swamps and traffickability along the route.

4.0 ENGINEERING ASSESSMENT AND RECOMMENDATIONS

4.1 Excavation Characteristics/Diggability

The results of the diggability trial indicate that a 30 tonne excavator will encounter penetration refusal (within a confined excavation) at approximately the same depth as the auger encountered penetration refusal.

On Figure 1, the maroon coloured boreholes are locations where the auger could not penetrate to 1.6 m in many cases, even after one or two attempts at moving the hole a short distance in case boulders were the cause of penetration refusal.

4.2 Crossings

It is understood that there are thirteen river or creek crossings along the pipeline route where environmental or cultural issues will most likely result in a need to directionally drill for the pipeline. In addition there are possibly four sealed road crossings and a rail crossing which will require horizontal boring.

Tabulated below are the locations of the anticipated crossings, together with information on the nearest relevant boreholes and photographs.

Crossing	Route kp, km	Relevant borehole No(s)	Photographs No(s)
Daly River	266.4	1009, 1001 (observations)	Site1009a.jpg Site1009b.jpg Site1009c.jpg Site1011a.jpg Site1011b.jpg Site1011c.jpg
Katherine River	309.5	123	Site123a.jpg Site123b.jpg Site123c.jpg Site123d.jpg Site123e.jpg
King River	370.0	138	Site138a.jpg Site138b.jpg Site 138c.jpg
Beswick Creek	401.3	No site (nearest is 65)	Site65.jpg
Waterhouse River	424.0	105, 60	Site1005a.jpg Site1005b.jpg Site60.jpg
Flying Fox Creek	506.0	No site (nearest is 189)	Site189.jpg Site 189a.jpg Site 189b.jpg
Mainoru River	549.7	39, 181 (floodplain)	Site39.jpg Site181.jpg Site 181a.jpg Site181c.jpg
Wilton River	600.1	171	Site171a.jpg Site171b.jpg Site171c.jpg Site 171d.jpg
Annie Creek	641.2	No site (nearest is 160)	Site160.jpg
Goyder river	701.2	No site (nearest is 274)	Site274.jpg Site274b.jpg Site274c.jpg Site274d.jpg
Boggy Creek	852.4	No site (nearest is 154)	Site154.jpg
Cato River	880.4	No site (nearest 246)	Site246.jpg
Giddy River	912.5	156	Site156.jpg Site156b.jpg
Florina Road	306.8	No site	No photo
Victoria Highway	321.5	No site (nearest are 127, 201)	Site127.jpg Site201.jpg
Alice springs-Darwin Rly	340.9	No site	No Photo
Stuart Highway	366.4	137	Site137.jpg
Central Arnhem Road	381.2	No site (nearest is 71)	Site71c.jpg

Consideration will need to be given to further investigations for crossings.

Geotechnical issues at each river or creek crossing (as can be assessed from existing data) are discussed below:

1. Daly River	• Strong sandstone and limestone on both banks • Rock outcrop exposed within the river
2. Katherine River	• Rock outcropping on east bank • Nearest bore 123 on west bank encountered alluvial clay, sand and gravel, then refusal on rock at 4 m
3. King River	• Nearest bore 138 encountered hard silty clays to 1.6 m • Sand noted on exposed sections of the river bed
4. Beswick Creek	• No data
5. Waterhouse River	• Nearest bore 60 encountered sand to 1.6 m
6. Flying Fox Creek	• No nearby data • Previous alignment boreholes indicate sandy soils to 1.6 m
7. Mainoru River	• Bore 181 encountered clay to 4 m, then refusal
8. Wilton River	• Nearest bore 171 encountered siltstone from surface, with refusal at 0.79 m
9. Annie Creek	• Nearest bore 160 encountered sand then clay to 3.0 m (easy drilling)
10. Goyder River	• Nearest bore 274 encountered sand to 1.6 m
11. Boggy Creek	• Nearest bore 154 encountered sand then clay to 1.6 m
12. Cato River	• Nearest bore 246 encountered clays and gravels to 1.6 m
13. Giddy River	• Nearest bore 156 encountered sand to 1.6 m

It is noted that no drilling was done at the road or rail crossings except for one shallow bore (137) near the Stuart Highway.

4.3 Sinkholes

Reference[1] indicates the possibility of sinkhole development in proximity of the pipeline route between the Victoria Highway and the Stuart Highway near Katherine. This area is near the southern extremity of the cavernous (in part) Cambrian age Tindall Limestone. No obvious sinkholes were observed on the pipeline route in this area, however in the area east of Boggy Creek (Site 252) a recently collapsed sinkhole was noted. The geological information does not indicate limestone in the vicinity of Site 252.

5.0 CLOSURE

The investigation has revealed that excavation characteristics along most of the length of the proposed pipeline should be favourable, with a bucketwheel excavator (equivalent in excavation capacity to a 30 tonne conventional excavator) achieving the required trench depth of up to 1.5 m. There are two sections where rock excavation techniques may be required over a significant length of pipeline. The first section is south of Katherine and the second section is between the Waterhouse River and the Wilton River.

Further detailed investigation may be required to establish ground conditions where the pipeline crosses rivers, creeks, roads, and rails using horizontal boring methods.

[1] "Land Degradation Associated with Sinkhole Development in the Katherine Region" D. Karp 2002, Technical Report No. 11/2002, Resource Assessment Branch, Dept of Infrastructure, Planning and Environment, Darwin

6.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information about your Geotechnical Engineering Report", which is included in Appendix A of this report. This document has been prepared by the ASFE *(Professional Firms Practicing in the Geosciences)*, of which Golder Associates is a member. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

We would be pleased to answer any questions about this important information from the reader of this report.

GOLDER ASSOCIATES PTY LTD

David K Nolan
Principal

Robert J Morphet
Principal

J:\Brisbane.03\Geotech.03\03632228\00_CORRESPONDENCE\OUT\019-03632228-SummaryReport.doc

Appendix A
Important Information about your Geotechnical Engineering Report