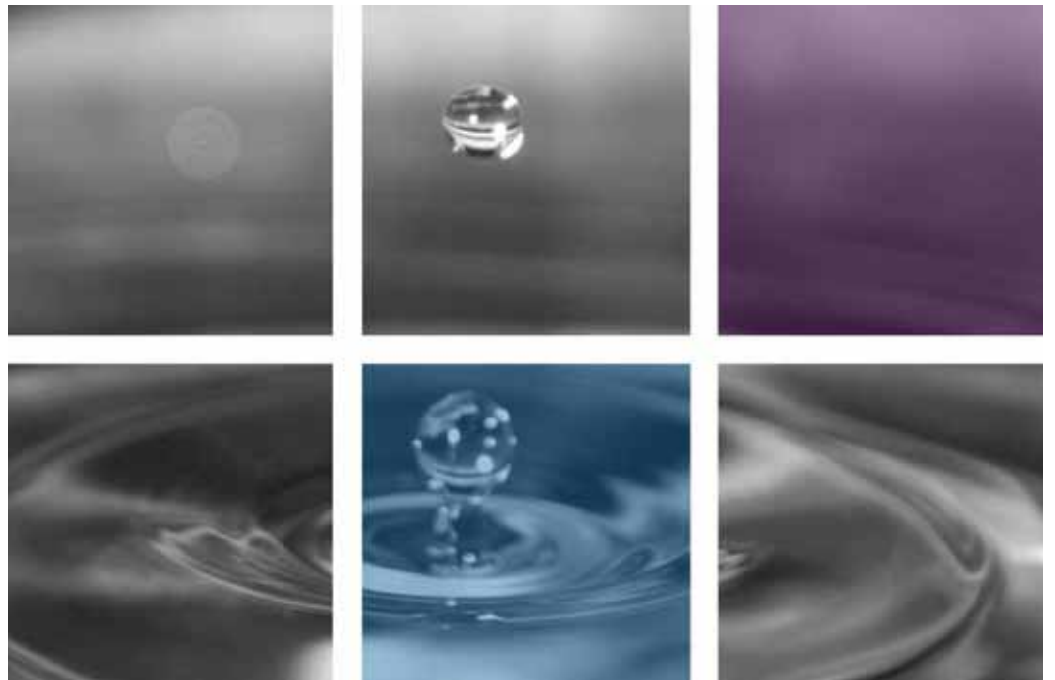




SUGARLOAF PIPELINE PROJECT

GEOTECHNICAL ASSESSMENT

FEBRUARY 2008





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Limitations

This Report:

- has been prepared by Melbourne Water, GHD Pty Ltd, Sinclair Knight Merz Pty Ltd, and John Holland, the participants in the Sugarloaf Pipeline Alliance (the 'Alliance');
- has been based on information provided up to 8 February 2008;
- has been produced as part of the Sugarloaf Pipeline Project Impact Assessment report and is for the purpose of identifying preferred pipeline corridors and associated management and mitigation measures for the Sugarloaf Pipeline Project;

This Report should not be altered, amended or abbreviated, issued in part or issued incomplete in any matter whatsoever without prior checking and approval by the Sugarloaf Pipeline Alliance. The Alliance expressly disclaims responsibility for any liability which may arise from the issue of this Report in part or incomplete or its modification in any way whatsoever.



Executive Summary

Objectives of the Study

This study has been conducted to assist in identifying preferred pipeline corridors, key issues and potential management and mitigation measures that should be incorporated into the design and construction evaluations and Environment Management Plan (EMP) for the Sugarloaf Pipeline Project.

The objective of this study is to characterise the engineering geology and geotechnical engineering behaviour along the pipeline corridors, analyse potential interactions and identify areas that require ongoing investigations.

Further investigations and assessment will enable refinement of the design and construction methods and facilitate completion of the EMP.

Legislative Requirements

The following legislation and guidelines will determine the scope of landslide mitigation, landform protection, excavation methodologies; spoil management and erosion management needed during the remaining planning, alignment selection, and design and construction phases.

- Goulburn Broken Regional Catchment Strategy 2003,
- Victoria Planning Provisions - Significant Landscape Overlay,
- Victoria Planning Provisions - Erosion Management Overlay,
- Groundwater in Victoria is managed primarily through the following legislation:
 - *Environmental Protection Act 1970*,
 - State Environmental Protection Policy - Groundwaters of Victoria (1988); and
 - State Environmental Protection Policy - Waters of Victoria (1997).
- EPA (Vic) Publication 480: Environmental guidelines for major construction sites,
- EPA (Vic) Publication 275: Construction techniques for sediment pollution control,
- EPA (Vic) Publication 347: Bunding Guidelines,
- DSE Publication: Your Dam, Your Responsibility - A Guide to Managing the Safety of Farm Dams.
- AGS (2007) Guideline for landslide susceptibility, hazard and risk zoning. Australian Geomechanics Society Vol 42, No1. 1-36.
- AGS (2007) Practice note guidelines for landslide risk management 2007. Australian Geomechanics Society Vol 42, No. 1, 63-114.



Existing Conditions

The pipeline corridor is oriented generally in a north south direction and extends from the Goulburn River at Yea to the Sugarloaf Reservoir at Yarra Glen, a total length of approximately 70km. The corridor for the pipeline comprise predominantly cleared land (Sections A, B, C and D) forest (Sections E and F) and rural living areas. The topography is undulating with steep, low lying hills, gullies and waterways. The pipeline corridor south of Yea generally follows the path of the Melba Highway (Sections B, C, D and E) through the Yea River valley. The corridor (and the Melba Highway) crosses the Great Dividing Range at approximately right angles, to the south of Glenburn (SPA 2007c).

The study area is characterised by Ordovician to Middle Devonian quartz sandstones and mudstones that were simply folded and faulted during the early to Middle Devonian. The sediments were intruded by granites during the Devonian and then subject to prolonged erosion. Younger, Quaternary age alluvial sediments and colluviums derived from erosion of the older rocks have been deposited in valleys and low lying areas (SPA 2007a).

Three hydrogeological models have been recognised (SPA 2007a) and nine major land systems are mapped along the corridor (SPA 2007b). Parts of the corridor lie within Extractive Industries Interest Areas (EIIA), and are located close to or within current and proposed extractive industries operations. Parts of the corridor also lie within current mineral exploration licence areas and mineral regions.

Values

Two sites of geological and Geomorphological significance have been identified in the vicinity of the pipeline corridor (SPA 2007b). Both sites lie along the Yarra River, in the area to the south - east of Sugarloaf Reservoir. Some alignment options may interfere with one site which comprises colluvial gravels associated with the Yarra Fault.

The topography through which the Melba Highway passes contains numerous road cuttings which currently exhibit few signs of instability and slope creep. The mature trees adjacent to the highway exhibit few signs of stress due to land creep and soil instability. There are several rock fall zones along the highway in the southern area of the Great Dividing Range that are currently monitored by VicRoads for movement of slopes. The colluvial slopes adjacent to the highway in the central section of the Great Dividing Range exhibit some signs of active surface slumping and historical slope failure.



Threats

Existing Landslip and induced Instability

Numerous landslips (The movement of a mass of rock, debris, or earth (soil) down a slope (AGS 2007, p14) have been identified by Coffey Partners Int (1999) in the Shire of Yarra Ranges, south of Kinglake plateau. Initial field investigations indicate some of these landslips are active and others inactive. Active landslips are present in the Steels Creek catchment and active soil creep has been observed on southern sections of the eastern side of the proposed saddle crossing from the Yarra Valley into Sugarloaf Reservoir.

Landslips, soil creep and rock falls are all potential threats along the steep slopes in the narrow valley sections of the Yea River at the Great Dividing Range, the saddle crossing from the Yarra Valley into Sugarloaf Reservoir and Dixons Creek headwaters at the escarpment south of Kinglake plateau. Soil creep may occur on additional low angular colluvial slopes (SPA 2007b). Excavation across these slopes may trigger instability of both existing landslides and currently stable inactive regolith, colluvial and rock slopes.

Landslips may occur in the regolith and colluvial as translational failures and debris flows. Translation failures may occur on along first time or existing rupture planes in the regolith and colluvial. Failure planes can exist within the colluvium or at the base of the regolith. Translational failures may also occur along bedding or fracture planes containing soft clays in bedrock if the geological structure is oriented parallel with the slope such as occurs in the Sugarloaf Reservoir area.

Block slide, rock fall and toppling are possible mechanisms of failure in the bedrock, mainly on very steep rock slopes and road cuttings in the Great Dividing Range. These mechanisms can also be created by bench excavations in rock slopes.

Significant risk mitigation measures will be required in these areas if benching is to occur, especially above the Melba Highway. A Landslide Risk Management (LRM) framework involving hazard zoning, landslide risk analysis, assessment and on going management (treatment) has commenced for these areas. Tunnelling through this section of the Great Dividing Range would remove these hazards from the pipeline corridor.

Excavation of the Trench and Shafts

The pipeline corridor predominately passes through areas of siltstones and sandstones. In the alluvial areas the trench excavation will mainly be in soils and weathered rocks. The fine matrix materials in the alluvials significantly decreases in shear strength once saturated and trench wall failures may occur after significant rain events.



In the hilly and mountainous areas excavatability is expected to be a major design issue in planning construction cost and timing. Trench excavation and shaft sinking is required (at stream crossings) in these areas may require blasting and heavy rock breaking. Blasting will generate ground vibrations, air blast and fly rock during construction. Blast fracturing may lead to groundwater impacts and surface water inflows into the excavation.

Groundwater Inflows

Groundwater inflows into the trench and into shaft excavations will impact on dewatering requirements and trench stability during construction. Significant groundwater seepage may create conditions unable to be controlled by simple excavation dewatering. As the trenches are constructed generally across-slope, there is likely to be a need for groundwater drainage upslope of the temporary and permanent slopes.

Another potential groundwater impact is the possibility that the pipeline trench backfill material, which is a comparatively high hydraulically conductive material, will act to intercept and divert groundwater. There would be consequent decline in groundwater levels down gradient of the trench, and in areas of potentially acid generating materials, this may result in acid rock drainage.

Dewatering effort for construction purposes may be required. Dewatering effort is unknown at this time, however it is expected that greater dewatering effort would be required in the alluvial aquifers than the bedrock and perched regolith aquifers.

The influence of dewatering is unknown at this time; however it has the potential to have a number of impacts, as noted below (SPA 2007a):

- Groundwater dependent ecosystems;
- Subsidence of unconsolidated sediments;
- Settlement near trenches and shafts.

Figure 2 is a map indicating topographically derived watertable depth and can be considered as a shallow inflow hazard map.

Spoil Management and Stability

It is likely that the development of the pipeline will generate significant quantities of spoil materials which will be required to be removed off-site and either disposed-of or contained in stable storage and fill areas. This will include temporary and permanent fill areas, which will need to be managed with respect to landslide stability, embankment stability, drainage control, erosion protection (wind and water) and sediment.



Acid Sulphate Rocks

The geology of the Sugarloaf pipeline corridor comprises predominantly Humevale Siltstone, Dargile Formation and the Melbourne Formation. Sulphide enrichment is associated with Silurian aged siltstones (Vic EPA Pub 655). These rocks are Devonian or Silurian aged siltstones and sandstones formed in ancient marine depositional environments. The presence of Silurian and Devonian aged rocks indicate the potential for acid sulphate rocks, however in areas within the corridor which have exposed rocks, such as road cuttings, significant oxidation of the rocks does not appear to be occurring (SPA 2007c).

Soil Erosion

Soil erosion, especially gully and tunnel erosion, is a threat at inclined areas with little vegetation cover and significant soil depth. Duplex soils are particularly sensitive to gully and tunnel erosion. Once initiated, gully development is difficult to stop (SPA 2007b).

Erosion of excavated slopes, spoil stockpile areas, construction laydown areas, access roads and the pipeline alignment both during and after construction represent a significant threat.

The shaft sinking, pipe-jacking and trenching operations at the stream crossings represent an erosion and stability threat to the stream beds and banks.

Extractive Industries and Mineral Tenements

The majority of the study area consists of cleared land used for either agricultural purposes such as cattle grazing or vineyards, vegetated areas such as state forest and conservation reserves and residential areas. Although parts of the corridor passes through a current extractive industry operations area, the corridor does not appear to go through the two quarries located close to the corridor. Parts of the corridor lie within current mineral exploration licence areas and mineral regions. Investigation of possible existing blasting operations in relation to the quarries is required.

Key Issues

The pipeline corridor is predominately through areas of siltstones and sandstones; therefore excavatability is expected to be a major design issue in planning construction cost and timing. Characterisation of the surface profile in respect to depth to rock and associated excavation issues is an essential task in construction planning and costing.

The long-term and short-term stability of any benching is a critical geotechnical design issue. Once the alignment is refined a comprehensive geotechnical investigation will be required at sites where benching is required to assess the impacts on stability of the natural and constructed slopes.

The groundwater and alluvial sediments that occur at the stream crossings are potentially vulnerable to the proposed development. Detailed geotechnical and hydrogeological assessment of



the suitability and stability of trench excavation, tunneling and pipe-jacking will be required at select locations such as:

- Adjacent to the Goulburn River trench (i.e. at the off-take);
- Within the valleys of the Yea River, Rellimeiggam Creek, Dixons Creek and Steels Creek; and
- At the main stream crossings and wetland areas.

The conditions at the proposed crossings, extent of soft alluvial sediments and presence of very difficult excavation materials will require the refinement of the pipeline alignment and the optimisation of the number, location, and length of any crossings.

Groundwater quality, specifically high salinity, also has the potential to impact on pipeline materials including concrete/ and cement aggressivity and suitability of pipeline materials.

These key areas all constitute significant data gaps for site specific hazard identification and risk mitigation measures.

High Level Control Measures

The identified impacts have been classified into those occurring during the construction phase, and those post construction. In most cases in terrain with low slope angles the impacts can be mitigated largely by engineering controls:

Excavation Methods

- Characterise the surface profile in respect to depth to rock and associated excavation issues during construction planning and costing.
- Optimise the pipeline alignment to avoid areas of difficult excavation and blasting.

Soft Alluvial and Poor Drainage areas

- Carry out detailed investigation of stream crossings, alluvial and poorly drained areas.
- Optimise the pipeline alignment where possible to avoid those areas requiring significant trench support and dewatering, thus minimising dewatering and construction effort (construction methods, complexity, durations).
- Select pipeline alignment based on land systems, groundwater and engineering geology overlays.

Quality Control

- Carry out detailed geotechnical and hydrogeological investigations of the final pipeline alignment to Industry Standards.



- Implement Environment Management Plan in accordance with EPA Guidelines for construction and sediment control.
- Select appropriate pipe materials, and select suitable temporary pavement and backfill materials.

Erosion and Stability

- Minimise the area of disturbance, in particular the extent of vegetation clearing.
- Optimise the pipeline alignment where possible to avoid steep slopes in order to reduce the potential for erosion of the natural landforms, cuttings and fill embankments.
- Carry out geomorphological and geotechnical investigations at waterway crossings to determine the stability of the streambed and banks and make recommendations on control measures required to minimise erosion impacts.
- Carry out geotechnical and hydrogeological investigations at proposed hillside cuttings and benching locations to determine the stability of the natural slopes and make recommendations on risk mitigation and stabilisation measures, according to the National LRM Framework for Australia (AGS, 2007a and b).

Knowledge Gaps

It is considered that the information within this report is appropriate to select preferred pipeline corridors. It is based upon information available to date, site inspections generally limited to observations from fieldwork and some geotechnical drilling and mapping. The desktop review has identified a number of knowledge gaps where further geotechnical and related investigations are required to assess risks and provide information for final alignment selection as follows:

- The pipeline corridor predominately passes through areas of siltstones, sandstones and alluvium; therefore excavatability is expected to be a significant design issue in planning construction cost and timing. Characterisation of the surface profile in respect to depth to rock and associated excavation issues is an essential task in detailed construction planning and costing.
- The long-term and short-term stability of any benching is a critical geotechnical design issue. A comprehensive geotechnical investigation will be required at sites where benching is required (Sections A, E and F) to assess the impacts on stability of the natural and constructed slopes. A landslide risk assessment is required to consider identified hazards during and post construction of the pipeline, according to the National LRM Framework for Australia (AGS, 2007a and b). Initially, eight areas have been identified as landslip preliminary hazard zones (Appendix A) that have been assigned a risk estimation in the preliminary qualitative landslide risk analysis (SPA, 2007d).



- The detailed assessment of the suitability of tunneling or pipe jacking at select locations will depend on refinement of pipeline alignment and the number, location, and length of any waterway crossings. Water levels adjacent to the creeks, the degree of surface water groundwater interaction and groundwater salinities adjacent to the streams will determine pipe jacking or open trenching feasibility;
- A detailed geotechnical investigation to provide geotechnical parameters for foundation design and assess the excavatability of rock where subsurface structures are required. A detailed site investigation shall confirm the foundations and excavation stability of the Goulburn River pump station structure.
- In general, the potential for acid sulphate rock within the study area is not considered to pose significant environmental risk or management issues; however, in areas where rock is to be disturbed, analytical tests of the acid rock potential shall be performed.



1. Introduction

1.1 The Sugarloaf Pipeline Project

The Sugarloaf Pipeline Project will deliver additional water supply to Melbourne. The Project is a key component of the Victorian Government's *Our Water, Our Future The Next Stage of the Government's Water Plan* (DSE, 2007), which aims to secure Victoria's water supplies in the face of drought, climate change and a growing population.

The pipeline will transfer a maximum of 75 gigalitres of water per year from the Goulburn River into the Melbourne water distribution network via Sugarloaf Reservoir in the Yarra Ranges. Water for the Sugarloaf Pipeline Project will be sourced from savings achieved through the Food Bowl Modernisation Project, which involves modernisation of irrigation infrastructure in the Goulburn-Murray Irrigation District.

The project will involve the construction and operation of a water pipeline, approximate 70km in length, pump stations, a balancing storage and associated electrical infrastructure to deliver water to Sugarloaf Reservoir. The planning, design and construction phases of the Sugarloaf Pipeline Project will be undertaken by the Sugarloaf Pipeline Project Alliance formed by SKM Pty Ltd, GHD Pty Ltd, Melbourne Water Corporation and John Holland.

1.2 Report Structure

This report has been prepared to provide background information on the geology and geotechnical conditions within the pipeline corridor. The information will be used to evaluate potential risks to the geo-environment as a consequence of the project, support the various approval applications required for the project, and provide inputs into the construction process (SPA 2007a).

Chapter 1 serves as an introduction, describing how this report forms the first component of the geotechnical assessment and provides an outline of the geotechnical aspects of the project. Chapter 2 presents the scope of work and identifies appropriate assessment criteria.

Factual information regarding the pipeline corridor has been presented in this report as follows:

- Chapter 3: Pipeline corridor description - a description of the preferred corridors of the pipeline, including topography, waterways and landforms;
- Chapter 4: Geology - a summary of the regional stratigraphy, geological structure, corridor geology, hydrogeology (SPA 2007a) and geomorphology (SPA2007);

The latter section of the report presents an interpretation of the available factual information and develops a work plan based on data gap analysis. Information in this section may change (or will be supported) by on-going site investigation works. This section of this report also identifies those



areas that represent a particular concern and require further investigation in the field. This includes the following information:

- Chapter 5: Geotechnical and Design Considerations - a discussion of the key issues for design and construction;
- Chapter 6: Geotechnical Impact Assessment - a discussion of the conceptual geotechnical model, potential construction impacts and constraints on pipeline corridor, data gaps and recommended work program;

Figures have been attached to the end of the document.

1.3 Legislative Framework

The following legislation and guidelines will determine the scope of landslide mitigation and LRM, landform protection, excavation methodology, spoil management and erosion management needed during the planning, alignment selection, design and construction phases.

- Goulburn Broken Regional Catchment Strategy 2003.
- Significant Landscape Overlay.
- Erosion Management Overlay.
- Groundwater in Victoria is managed primarily through the following legislation.:
 - *Environmental Protection Act (1970)*;
 - State Environmental Protection Policy - Groundwaters of Victoria (1988); and
 - State Environmental Protection Policy - Waters of Victoria (1997).
- EPA (Vic) Publication 480: Environmental guidelines for major construction sites.
- EPA (Vic) Publication 275: Construction techniques for sediment pollution control.
- EPA (Vic) Publication 347: Bunding Guidelines.
- DSE Publication: Your Dam, Your Responsibility - A Guide to Managing the Safety of Farm Dams.
- AGS (2007a) Guideline for landslide susceptibility, hazard and risk zoning. *Australian Geomechanics Society* Vol. 42, No. 1, 1-36.
- AGS (2007b) Practice note guidelines for landslide risk management 2007. *Australian Geomechanics Society* Vol. 42, No. 1, 63-114.

Other Related Legislation

A Significant Landscape Overlay is a planning control that requires special consideration to be given to buildings, earthworks and vegetation removal in areas it identifies (SPA 2007a). An Erosion Management Overlay (EMO) is a planning control that requires special consideration to be



given to land in order to protect areas that have been identified as prone to erosion, landslip or other degradation processes, by minimising land disturbance and inappropriate development (SPA 2007a). The landslide risk assessment, according to the National LRM Framework for Australia (AGS, 2007a and b), will examine site specific hazards associated with EMO areas and other locations identified from field investigations within the pipeline corridor.

Groundwater in Victoria is managed primarily through the following legislation:

- *Environmental Protection Act (1970)*;
- State Environmental Protection Policy - Groundwaters of Victoria (1988); and
- State Environmental Protection Policy - Waters of Victoria (1997).

The *Hydrogeology Assessment* (SPA 2007a) evaluates and presents information within the framework of the above legislation.



2. Scope of Works

The aim of this report was to characterise the surface and subsurface conditions within the pipeline corridor with respect to engineering geology and geotechnical engineering behaviour. The study was undertaken primarily as a desk top review of available information, although several site inspections along the length of the proposed corridor were undertaken.

The scope of work included the following activities:

- Compile geological and geotechnical data from published maps, plans and air photos, consultant reports, Melbourne Water borehole records, and state and local government records;
- Review the existing data sets;
- Review geodata compiled by the hydrogeology (groundwater aquifers and flow) and geomorphology (Landforms, waterways, landslides and erosion) specialists, as these relate to the engineering geology of the project;
- Conduct an inspection of the proposed pipeline corridors to identify and record surface features, topography and soil and rock outcrops related to engineering geology and geotechnical engineering behaviour;
- Document relevant information which describes the engineering geology along the pipeline corridors and develop appropriate data layers for a Geographic Information System (GIS);
- Identify potential geological and geotechnical “hot spots” that may be impacted by, or represent a potential risk to, the project;
- Identify data gaps to allow for timely and effective site investigations in the potential high impact areas;
- Pro-actively interact with other teams to communicate multi-disciplinary issues and impacts so that overall knowledge is enhanced in preparation for corridor selection and to analyse construction impacts and assess mitigation options;
- Identify mitigation options;
- Design a preliminary investigation program and commence geotechnical investigations using seismic and drilling techniques;
- Prepare a desktop and field study report which describes the potential geological and geotechnical impacts of the construction and operations stages of the project, including possible mitigation measures and a site investigation plan;
- Present preliminary conclusions.



2.1 Methodology

The desktop study utilised existing published information and a visual inspection of the pipeline corridor to define conceptual geotechnical models relevant to ground conditions along the corridor. In assessing potential groundwater issues a 2 - 4km wide study area encompassing the corridor was adopted for the investigation because of the lack of geotechnical information within the specific pipeline corridor and the need to correlate and extrapolate information from adjacent or similar land systems (landforms) and geological formations.

Each geotechnical model developed was based on the land systems developed in the *Geomorphological Assessment* (SPA 2007b). These are primarily distinguished by location, geology, physiography, soils, landform stability and erosion potential. During this process critical data gaps were identified.

Based on the engineering geological models developed:

- Risks to the geo-environment (landforms, surface soils, subsurface soil layers and rock strata),
- Impacts to natural assets and the made environment by the proposed development, and,
- Risks to the proposed development from the geotechnical behaviour of the sub-surface materials,

were qualitatively evaluated, and potential mitigation options identified. Additionally, a preliminary scope of works to address the identified critical data deficiencies was developed.



3. Pipeline Corridor Description

3.1 Study Area

The study area is shown in Figure 1.

3.2 Topography

A summary of the topography for each of the 8 sections of the pipeline corridor is provided below.

Section A

The pipeline corridor originates on the south bank of the Goulburn River north of Killingworth, where the Goulburn River flows along the foot of hilly terrain at an elevation of about 165m. From the Goulburn River pump station the corridor extends southwards, traversing an area of low rolling hills which rise to a maximum elevation of about 200m near Killingworth, after which topography declines gradually towards Yea. The corridor joins the Yea River valley north east of Yea at an elevation of 170m.

Section B

The corridor crosses the Yea River south-east of the township at a point to be determined. The pipeline corridor south of Yea follows the Melba Highway, traversing the lower eastern slopes of low rolling hills, at an elevation of about 175m. Immediately east of the Melba Highway is the incised trench of the Yea River, which is at an elevation of about 170m.

Section C

The topography gradually rises as the corridor follow Rellimeiggam Creek to avoid a narrow section of the Yea River valley. From here, the road extends southwards away from the Creek, crosses two low saddles, and rejoins the Yea River at Glenburn, which is at an elevation of 230m (SPA 2007a).

Sections D and E

The corridor crosses the Yea River at Devlins Bridge, which is at an elevation of about 210m. After this it follows the road and is elevated approximately 10m above the river valley floor. The topography gradually increases to an elevation of 270m at the foothills of the Great Dividing Range. The road, corridor and Yea River then rise into the Great Dividing Range along a narrow valley with steep slopes.

■ Figure 1 – Locality Plan

