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Wannon Water

Shaw River Power Station Project Water Supply Pipelines

Groundwater Impact Assessment

September 2009

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 Background

Shaw River Power Station Pty Ltd (“Shaw River Power”), a wholly owned subsidiary of Santos Ltd (“Santos”), proposes to develop a gas-fired power station of 1,500 megawatts (MW) capacity near the town of Orford, approximately 30 km north of Port Fairy in western Victoria. This power station will require a gas supply and a water supply during operation. In light of the potentially significant effects on the environment associated with this proposal, the Victorian Minister for Planning required Shaw River Power to prepare an Environment Effects Statement (EES) under the *Environment Effects Act, 1978*.

Wannon Water will be providing process water and amenity water to the Shaw River Power Station. Wannon Water has engaged specialists to undertake the necessary environmental assessments for the water infrastructure works as outlined within the EES Scoping Requirements released by the Minister for Planning in July 2009.

The aim of this report, prepared for Wannon Water, is to characterise the groundwater existing conditions relevant to the water supply pipelines and associated water infrastructure for the Shaw River Power Station and identify possible impacts to groundwater caused by the construction, operation and eventual decommissioning of the water supply pipeline.

1.2 Project Overview

The proposed new water infrastructure for the Shaw River Power Station will include:

- A recycled water treatment plant (RWTP) including a process water pump station located at the existing Port Fairy Water Reclamation Plant (WRP);
- An amenity water supply pump station located at the WRP;
- An upgrade to the existing Port Fairy Water Treatment Plant (WTP) to allow the Port Fairy water supply to supply the RWTP in an emergency;
- A 200 mm diameter PVC pipe delivering process water connecting the RWTP and the Power Station. The pipe will be approximately 28 km in length and the trench is expected to be 650 mm wide x 1100 mm deep;
- A 110 mm diameter HDPE pipe delivering amenity water connecting the RWTP and the Power Station. The pipe will be installed in the same trench as the process water pipe; and
- A 225 mm diameter PVC pipe delivering emergency and amenity water connecting the WTP and the RWTP. The pipe will be approximately 2.5 km in length and the trench is expected to be 600 mm wide x 1000 mm deep. A section of the pipe will be installed in the same trench as the process and amenity water pipelines, which will be widened to 1000 mm.

1.3 Scoping Requirements and Project Objectives

Scoping Requirements for the Shaw River Power Station Project (Scoping Requirements), released by the Minister for Planning in July 2009, provide guidance on the matters to be addressed in the EES. Objectives and the requirements relating to the water supply pipelines and associated water infrastructure detailed in the Scoping Requirements were used as a guide for evaluation of impacts. This report addresses the following scoping requirements:

- Assess potential risks to existing hydrogeological conditions along the pipeline route that may be adversely affected by pipeline construction (including adjoining areas), particularly in relation to any significant sites, features or resources, including sub-surface channels;
- Identify proposed mitigation measures to minimise the effects of the project on groundwater quality and beneficial uses and any monitoring requirements.

The objectives of the preliminary groundwater impact assessment report are as follows:

- Characterise the hydrogeological setting surrounding the Water Supply Pipeline Corridor;
- Identify potential impacts of the project on the underlying groundwater systems and their receiving environments;
- Assess appropriate mitigation measures to compensate for actual and potential impacts on the groundwater systems and their receptors in accordance to the SEPP (Groundwaters of Victoria) and other relevant legislation;
- Assess the likely short term and long-term impacts of the project taking into account the appropriate mitigation measures; and
- Prepare recommendations for further hydrogeological studies, if required.

The report has been drafted with its structure split into two parts. Factual information regarding the Water Supply Pipeline Corridor options has been presented in the first half. This includes the following specific technical information:

- Overview of the Geological setting;
- Hydrogeology, including:
  - Groundwater occurrence;
  - Aquifer types;
  - Water quality and use;
  - Depth to groundwater and long-term trends.

The second part of the document synthesises and interprets the information presented in the first part with respect to groundwater flow systems, vulnerability and risk. A risk assessment is undertaken and mitigation measures identified to address key groundwater risk issues. Figures and other appendices have been attached to the rear of the document.

2. Methodology

2.1 Tasks

To describe the existing conditions, the following tasks were undertaken:

- Review published and unpublished hydrogeological reports pertaining to the area in the immediate proximity to each of the Water Supply Pipeline Corridor;
- Access the State Groundwater Database for available drilling information in the along the pipeline corridor;
- Provide a description of the geology and relationships between aquifers at the local and regional scale, including the degree of confinement of the systems, the protection offered to the aquifers by the soil profile, unsaturated zone or aquitards or the potential for downward seepage through to the aquifers via fissures, permeable soils etc;
- Describe the groundwater flow systems through the distribution of groundwater potentials, watertable depth and morphology, directions and rate of groundwater flow and seasonal fluctuations;
- Describe interpreted/inferred recharge, discharge and interactions between surface water and groundwater;
- Describe the groundwater chemistry/quality in relation to the interpreted geology and flow systems;
- Identify the groundwater segment and list the protected beneficial uses of the groundwater in relation to the SEPP (Groundwaters of Victoria);
- Identify the location of users/receptors of groundwater such as bore owners, streams and wetlands.
- Provide a concise summary of the conceptual hydrogeological model for the pipeline corridor study area;
- Identify possible and likely impacts on receptors (beneficial uses) of the groundwater by evaluating sources of contamination or alteration to the flow regimes as a result of construction of the pipeline corridor;
- Prepare a list of mitigation measures to compensate for actual or potential impacts to the groundwater resources or their receptors;
- Undertake a risk assessment of the short and long term impacts of the project on the groundwater systems taking into account the mitigation strategies prepared; and
- Recommendation of additional hydrogeological works, if required.

2.2 Hydrogeology Data Sources

The hydrogeological investigations have relied upon the following data sources:

- Published geological and hydrogeological mapping;
- State Groundwater Management System (Victorian Data Warehouse); and,
- Published geological reports.

3. Legislation and Policy

Groundwater in Victoria is managed primarily thorough the following legislation:

- *Water Act* (1989);
  - Permits to access groundwater and manage groundwater resources sustainably;
- *Environmental Protection Act* (1970);
  - State Environment Protection Policy - Waters of Victoria (1988) – to prevent any water discharge or pollution into waterways. There have been subsequent amendments and variations, which are also appropriate;
  - State Environmental Protection Policy - *Groundwaters of Victoria* (1997) – to maintain and where possible improve groundwater quality sufficient to protect existing and potential beneficial uses; and
  - State Environment Protection policy (Prevention and Management of Contamination of Land).

This report evaluates and presents information within the framework of the above legislation. EPA guidelines for the documentation and description of groundwater conditions are presented in:

- EPA (Vic) Publication 668: Hydrogeological Assessment (Groundwater Quality) Guidelines;
- EPA (Vic) Publication 840: The Clean-up and Management of Polluted Groundwater;
- EPA (Vic) Publication 669: Groundwater Sampling Guidelines; and
- EPA (Vic) Publication 441: A guide to the sampling and analysis of waters, wastewaters, soils and wasters.

In addition, there are EPA guidelines, which directly or indirectly protect groundwater during construction activities:

- EPA (Vic) Publication 480: Environmental Guidelines for Major Construction Sites:
  - These guidelines provide general information on how to avoid and minimise environmental impacts from construction activities;
- EPA (Vic) Publication 275: Construction Techniques for Sediment Pollution Control :
  - The guidelines provide recommendations on structures and strategies that reduce sediment export from constructions site preventing contamination of aquatic environments;
- EPA (Vic) Publication 347: Bunding Guidelines:
  - These guidelines specifically apply to above ground storage and transfer areas used for refuelling during construction.

In the assessment of impacts to groundwater quality the following guidelines are relevant:

- ANZECC, 1992. *Australian Water Quality Guidelines for Fresh and Marine Waters; and*
- ANZECC and ARMCANZ, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

The SEPP (Groundwaters of Victoria) specifies groundwater investigation objectives for various beneficial uses. For the majority of beneficial uses, these objectives are the ANZECC (1992). For the protection of aquatic ecosystems, reference is made to the SEPP (Waters of Victoria). The SEPP (Waters of Victoria) has been updated and refers to the ANZECC (2000) guidelines.

4. Existing Conditions

4.1 Study Area

The study area is shown in Figure 1. The study area is considerably larger than the Water Supply Pipeline Corridor alignments and this is necessary as groundwater processes need to be considered in both a regional and local scale context.

4.2 Topography

The study area can be characterised into the following three principle physiographic regions:

- Basalt plains

  The topography in this area can be quite undulating, especially between Orford and Port Fairy associated with stony rises.
- Limestone plains

  These are generally located west of the Water Supply Pipeline Corridor. These areas tend to be flatter and less undulating than the volcanic terrain, with drainage patterns being less well defined. In some parts of the Western Districts, the limestone plains can have karstic (sinkhole) landforms.
- Clay flats and alluvium

  These are associated with current river valleys and generally found as relatively thin deposits draped over the basalt or limestone.

4.2.1 Land use

The land use is predominantly dryland grazing / perennial pasture, with irrigation of pasture for dairying and cropping. Forestry plantations are also located within the study area.

4.2.2 Climate

Climate data was obtained from the Victorian Bureau of Meteorology from Station 090175 at Port Fairy (Latitude: -38.39^{o}S; Longitude: 142.23^{o}E).

The mean data is summarised in Table 1 (Port Fairy), which suggests that the region gets approximately 0.64 m of rainfall annually.

Table 1 Summary of Climate Data – Port Fairy

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily max temp^{o}C	22.3	23	21.3	19.4	16.8	14.6	14.3	15.2	16.5	18.1	19.5	21.1	18.5
Mean daily min temp.^{o}C	13.9	14.5	13	10.7	9	7.6	7.1	7.2	8.2	9.2	10.9	12.4	10.3
Mean monthly rainfall (mm)	33.6	28.3	33.6	45.3	60	78	83.2	78.3	69.3	52.2	48.3	35.6	644.7

Note: Data set ranged from 1990 to 2008

4.3 Site Location With Respect to GMAs and WSPAs

The principle management unit for groundwater resources in Victoria is the Groundwater Management Unit or GMU. A GMU may be a Groundwater Management Area (GMA), a Water Supply Protection Area (WSPA) or an Unincorporated Area (a region falling outside of a GMA or WSPA). These are declared under the *Water Act* (1989) to protect groundwater resources.

Under the *Water Act* (1989), the Minister may declare the total volume of groundwater (and/or surface water), which may be taken in an area. This is termed the Permissible Consumptive Volume (PCV). Depending upon the amount of licensed groundwater allocations in an area, the Minister may declare a Water Supply Protection Area (WSPA) to enable tighter management of groundwater resources. Within a WSPA, caps or moratoriums on the issue of additional extraction licenses are existent.

The study area falls within two recognised groundwater management units:

- Portland GMA
  - This is defined by the Lower Tertiary Aquifers (Mepunga and Dilwyn Formations) and has a depth limit of greater than 200 m. Owing to its depth of occurrence, it is not relevant to the Water Supply Pipeline study.
- Hawkesdale GMU
  - Based on information supplied by the DSE, the Hawkesdale GMA is intended to cover all depths, except in those areas where it overlies the Portland GMA, where the GMA is limited to a depth of 200 m. It has a PCV of 16,161 ML, declared in 2006, which was based on the existing allocations.
  - This GMU is relevant to the construction and operation of the Water Supply Pipeline.
- Yangery WSPA
  - This is defined by the Newer Volcanics and Port Campbell Limestone formations.
  - The WSPA is relevant to the southern part of the study area.

4.4 Geology and Structural Setting

The study area is located within the Western District of Victoria. It lies within the Tyrendarra Embayment, one of the major structural subdivisions recognised in the Otway Basin. The surface geology of the study area comprises a combination of Tertiary and Quaternary age sediments and volcanics (refer **Error! Reference source not found.**). The stratigraphic profile / hydrostratigraphy for the GMA is presented in Table 2 and a discussion of the key units, from oldest to youngest is presented below:

Upper Cretaceous and Lower Tertiary

The Upper Cretaceous and Lower Tertiary sedimentary aquifers are defined by the Portland GMA. The Water Supply Pipeline will not interact with this geology. It is therefore considered irrelevant for this assessment and has been omitted, for brevity, from Table 2.

Mid Tertiary

The Gellibrand Marl is a mid Tertiary marine sequence that is widely distributed throughout the Otway Basin. The low permeability marls, silts and clays are generally considered to form an aquitard and thus essentially define the base of the Hawkesdale GMU. The Clifton Formation is a facies equivalent of the Gellibrand Marl. The Gellibrand Marl and the Clifton Formation comprise the bottom units within the Heytesbury Group (Table 2).

The Water Supply Pipeline will not interact with the Mid Tertiary geology and therefore it has not been discussed further.

Upper Tertiary

The Port Campbell Limestone comprises the upper part of the Heytesbury Group and is a major aquifer in the region. It is generally blanketed by the Newer Volcanics, or younger sediments throughout the study area. The limestone does outcrop in small areas between Yambuk and Orford, close to the Water Supply Pipeline study area. With increasing depth the limestone grades into marl and marlstone (Gellibrand Marl) and differentiation of the two can be difficult.

The thickness of the Port Campbell Limestone aquifer that is suitable for groundwater development is typically less than 100 m, however there are some notable exceptions. Some recently installed irrigation bores to the north of Orford have been drilled to depths up to 150 m into the Port Campbell Limestone. With increasing development pressure, irrigators are drilling deeper into the formation to assess its resource potential (GHD 2008).

Upper Tertiary - Quaternary

The bulk of the study area is covered by the Newer Volcanics. The Newer Volcanics have emanated from numerous eruption centres located remote from the Water Supply Pipeline. Across the general plains region the volcanics are generally up to 50 m in thickness but may thicken to in excess of 100 m in close proximity to the eruption centres. The volcanics consist of a number of phases. There is a phase of basalt of Late Tertiary and Quaternary age, which comprises extensive lava plains across the region. The most recent phase consists of the blocky and jumbled textured ‘stony rises’. The stony rise flows are common within the study area. Morphologically, the Newer Volcanics have transformed the terrestrial landscape, with the lava flows imparting controls on the surface water drainage systems.

In the Western Districts a number of younger, upper Tertiary and Quaternary sedimentary sequences have been differentiated. These sediments have been either predominantly deposited under dune or alluvial environments or under varying marine environments. The Whalers Bluff / Werrikoo Limestone Formation and Hanson Plain Sands are interpreted as being principally Pliocene or younger formations (Birch 2003). Stratigraphically these units overlie the limestone and marl of the Heytesbury Group and are partly overlain by the Pliocene basalts.

In the lower Quaternary (Pleistocene) the Bridgewater Group was deposited under aeolian conditions. These are in turn overlain by the Malanganee Sands and Bridgewater Formation. These sediments can be difficult to differentiate as depositional environments change laterally westwards (e.g. in places the Hanson Plains Sands can be considered lateral equivalents of the Whalers Bluff Formation), but can be grouped from a hydrogeological perspective owing to the inferred hydraulic connection between units.

Table 2 Hydrostratigraphy of Water Supply Pipeline Corridor Study Area

Period	Sub Period	Division	Group	Rock Unit		Depositional Environment	Broad Lithology
	Holocene			Undifferentiated sediments	Newer Volcanics	Fluvial and lagoonal	Sands, clays, silt
				Malanganee Sands		Dune	Present day beach and dune sands, grey to white fine grained siliceous sands.
Quaternary						Igneous extrusive	Basalt; Olivine and iddingsite
	Pleistocene			Bridgewater Formation		Aeolian	Calcarenites, calcareous sands, shell beds, clays and marls.
				Whaler's Bluff Fm.			Dune limestone, calcarenites, calcareous sands, fossiliferous clays
	Pliocene			Hanson Plains Sand / Moorabool Viaduct Formation		Marine and paralic (regressive)	Quartz sand, silt, calcareous silt and minor limestone
	Miocene	Early					
		Late		Port Campbell Limestone		Transgressive neritic marine.	Pure to marly limestone, minor chert
Tertiary			Heytesbury	Gellibrand Marl		Marine (transgressive phase). Transitional to Port Campbell Limestone	Marl
	Oligocene	Early					
		Late		Clifton		Littoral to shallow marine transgressive. Sharp of transitional contact with the G. Marl	Limonitic sandy limestone to glauconitic limestone, limonitic quartz sand

Note: Shading denotes formations relevant to the Study Area. Adapted from Wopner *et al* (1971).

4.5 Hydrogeology

4.5.1 Identified Aquifers

The principle aquifers in the region are highlighted in Table 2. They are located within the:

- Newer Volcanics;
- Sediments interpreted as being the:
  - Undifferentiated alluvial sediments, swamp and lagoonal deposits;
  - Malanganee Sands;
  - Bridgewater Formation;
  - Hanson Plains Sands / Moorabool Viaduct Formation;
  - Whalers Bluff Formation;
- Port Campbell Limestone (Heytesbury Group).

The undifferentiated shallow Quaternary sediments may form aquifers of local extent adjacent to streams but are not regionally significant from a resource development perspective.

4.5.2 Conceptual Hydrogeological Model

The Newer Volcanics represent an unconfined, fractured rock aquifer with variable hydraulic properties. Water is transmitted and stored within the basalt within both primary porosity (e.g. vesicles) or secondary porosity (e.g. faults, fractures, lava tunnels and other discontinuities) within the rock mass. The formation would be recharged by infiltrating precipitation with a lesser component of recharge from flood events from surface water features.

The basalt is suspected to be hydraulically connected to the underlying Port Campbell Limestone to varying degrees as is the case with similar, nearby geological settings (e.g. Yangery and Nullawarre WSPAs).

Discharge from the basalt may occur as spring flows from base of slope topographic features, leakage to the underlying Port Campbell Limestone, or to streams incised into the basalt. There are a number of low-lying, swampy areas east along Tarrone Road and this may be local groundwater discharge features. Regionally groundwater flow is expected to be southwards, reflecting the natural topography, however the flow direction may be locally influenced by surface water features (e.g. Ware Creek, Shaw River) and the effects of groundwater extraction.

4.5.3 Level of Confinement

The aquifers in the study area have been generally considered to be unconfined. On a local scale the aquifers may vary significantly from these conditions. Confinement of aquifers may occur where:

- Clayey layers and interflow materials occur within the Newer Volcanics; and
- Marly or clayey sequences hydraulically separate the Port Campbell Limestone from overlying units.

The level of confinement of the deeper units in the profile, particularly the Port Campbell Limestone, is unknown but suspected as being semi-confined. Under stress (e.g. aquifer pumping) leakage and interaction with overlying units is expected.

4.5.4 Aquifer Parameters and Bore Yields

GHD is not aware of any geological survey or Mines Department pumping tests undertaken in the Hawkesdale GMA. Bore yields can be spatially highly variable, and there are many factors, which could locally influence flow, such as:

- Thickness of aquifer intersection;
- Contact between Newer Volcanics and Port Campbell Limestone;
- Port Campbell Limestone lithology (e.g. cavernous zones, marly zones);
- Newer Volcanics flows (e.g. stony rises, scoria cones); and
- Bore construction and method of testing (relevant to the Groundwater Database information).

Some of the larger irrigation bores may yield between 10 L/s to 30 L/s based on GHD's experience with irrigation licensing assessments in the region, however it could be reasonably expected that most bores are at the lower end of this range.

4.5.5 Groundwater Flow Direction

The direction of groundwater flow in a regional sense, is assumed to be generally southwards towards the coast. Streams and topography (and extraction) will have some local influence on groundwater flow, however, there is insufficient existing information to accurately spatially characterise the potentiometric surface of the shallow aquifers in key areas.

4.5.6 Recharge and Discharge Areas

Groundwater recharge and discharge processes within the study area are generally poorly understood. Recharge to the system occurs broadly from infiltrating rainfall and on a more local scale from seasonal streambed infiltration. Recharge rates are expected to vary markedly across the study area. In the scoria dominated basalt terrains and stony rises, recharge rates are expected to be high. Conversely on planar basalt flows, groundwater recharge would be significantly reduced where a thicker residual basaltic soil profiles may be expected.

Some of the Quaternary sediments tend to be sandy and permeable, allowing relatively high rates of rainfall recharge locally. Groundwater within these sediments may discharge locally to waterways, swamps and the lower lying areas, or contribute through flow or recharge to deeper underlying materials. The latter is potentially the case when the sediments overlie the Newer Volcanics. In a similar manner, groundwater discharge from the margins of the stony rise flows is likely.

Discharge from the aquifer system occurs along the edge of the formations (e.g. flow boundaries of the volcanics) to wetlands and streams and via vertical leakage to underlying units. Discharge from the aquifer systems also occurs due to extraction.

Groundwater discharge is expected to form a component of base flow to the surface water features or into one of the many swamps and lower lying topographic areas. Interaction between the Quaternary sediments, the volcanics, and the underlying Port Campbell Limestone is largely unknown although it is expected that vertical flow directions between the different aquifers will vary across the region.

4.5.7 Potential for surface water interaction

The potential for surface water interaction is considered to be high in the region. The watertable is also noted as being close to surface in some parts of the study area. The degree of surface water – groundwater interaction, however is poorly understood to date.

4.5.8 Existing Groundwater Users

A search of the Department of Sustainability and Environment's (DSE) Groundwater Management System (GMS) was undertaken to identify and characterise groundwater use in the region. A rectangular search was undertaken for bores within 500 m of the Water Supply Pipeline corridor.

Approximately 27 bores were identified within a 500 m offset from the line of the Water Supply Pipeline. The bore locations are shown in Figure 3**Error! Reference source not found.** and have been coded based on the bore use recorded on the GMS. A summary of the bore details has been provided in Table A1.

The following should be noted:

- The GMS only contains information on registered bores. Bores installed prior to the proclamation of the original *Water Act* (1969) may not necessarily be recorded;
- The GMS does not provided information regarding the bore operational status. Bores may have been decommissioned, replacement bores installed, or simply no-longer used; and
- The bore use is only that recorded at the time of installation. Dairy and irrigation uses are required to be licensed and have an attached allocation. No information regarding active licensed bores was available at the time of reporting i.e. a bore indicated as having an irrigation use may not have an attached entitlement.

The results of the bore search indicated that most bores near the Water Supply Pipeline are used for stock and/or domestic purposes. Dairy and irrigation use bores were identified. It is understood that irrigation areas are present in the Orford region (northern part of study area).

Bores range in depth from 6 m to 55 m with most bores greater than 30 m depth. In general terms most stock and domestic bores develop the Newer Volcanic basalt aquifer, which is generally less than 30 m in thickness. The deeper bores generally develop the Port Campbell Limestone.

4.5.9 Groundwater Quality

Information regarding regional groundwater quality was available from a number of bores which reveal that the salinity of the groundwater in the watertable aquifer in this area ranges between 1,000 mg/L to 3,277 mg/L Total Dissolved Solids (TDS), with most bores having a salinity less than 1,500 mg/L TDS.

The water quality is dependent upon local flow process and recharge areas (e.g. stony rise basalts tend to be fresher than the planar basalt flows). Anecdotal evidence suggests that the water quality in the Port Campbell Limestone tends to deteriorate with depth, a function of longer residence times within the aquifer.

SKM (2007) applied a piper trilinear analysis of groundwater to characterise ionic differences in the groundwater chemistry of the Newer Volcanic Basalt and Port Campbell Limestone, however they concluded that the limited available information was insufficient to identify significant differences.

Under the Environment Protection Act (1970), and upon the recommendation of the EPA the State of Victoria enacted a State Environment Protection Policy (Groundwaters of Victoria). The policy provides that groundwater is categorised into segments with each segment having a particular identified use. The segments and their beneficial uses are summarised in Table 3.

Table 3 Protected Uses of the Segments

Use	Segment (mg/L TDS)				
	A1	A2	B	C	D
	0 – 500	501 – 1,000	1,001 – 3,501	3,501 – 13,000	>13,000
Maintenance of Ecosystems	✓	✓	✓	✓	✓
Potable Water					
Desirable	✓				
Acceptable		✓			
Potable Mineral Water Supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock Watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation (eg. swimming / bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

The EPA may determine that these beneficial uses do not apply to groundwater where:

- There is insufficient yield;
- The background level of a water quality indicator other than TDS precludes a beneficial use;
- The soil characteristics preclude a beneficial use; or
- A groundwater quality restricted use zone has been declared.

The SEPP (Groundwaters of Victoria) also requires that occupational health and safety (OH&S) and odour and amenity be considered, due to the fact that vapours sourced from impacted groundwater may present a potential risk to workers, and that odours or discolouration may result in degradation of overall beneficial use.

Based on the groundwater quality of the neighbouring bores the groundwater generally falls within Segment B.

4.5.10 Depth to Water

Information regarding the depth to water within the Water Supply Pipeline study area, and thus the likelihood of interaction of the pipeline with the groundwater environment is poorly understood. Standing groundwater levels have been recorded for some bores, at the time of their construction, in Table A1. These water levels do not take into account disruption due to the bore construction itself, season of installation (i.e. water levels are lower in late summer) or prevailing conditions within the aquifer (i.e. drought response, over development of resource).

The water levels in Table A1 range from 1.5 m to 13 m, with most water levels greater than 2 m below the natural surface. It is noted that when groundwater levels become within 2 m of the surface, the effects of evaporation, concentration of salts and land salinisation may be manifested. There is also the potential for the existence in the area of ecosystems dependent on groundwater for either part or all of their water requirement..

4.5.11 Groundwater Level Trends

A search to identify nearby State Observation bores was undertaken and two nested sites were identified, to the north and south (Princes Highway, Aringa) of the study area. The bore sites are summarised in Table 4.

Table 4 State Observation Bore Locations

Bore Id	GDA 94 Co-ordinates		Screen (m)		RL TOC (m AHD)	Aquifer
	Easting	Northing	From	To		
Princes Highway Site (South of study area)						
141298	603,551.3	5,751,136.3	11	14	6.86	Newer Volcanics
141299	603,555.0	5,751,143.0	32	36	6.86	Port Campbell Limestone
Woolsthorpe – Heywood Road (north of study area)						
111523	600,993.7	5,778,721	23	26	98.85	Newer Volcanics
111522	600,989.4	5,778,720	11	14	98.85	Newer Volcanics

Note: GDA94. RLTOC – Reduced Level Top of Casing, datum: Australian Height Datum

Although the bores are located remote from the pipeline they develop the same formations as those within the study area, and therefore may provide water level information (e.g. seasonal response) relevant to the region. The monitoring bore hydrographs are presented in Figure 4 and Figure 5 for the sites south and north of the study area.

Both nested monitoring site have only a short monitoring recording, being less than 10 years. The Princes Highway site shows a strong seasonal water level response, however such seasonality is not obviously identified in the northern site. Water levels in each nested bore are similar. The hydrographs exhibit no obvious trend in water levels.

5. Impact Assessment

5.1 Risk Assessment

A detailed Environmental Risk and Impact Assessment (risk assessment) has been conducted as part of the EES for the Water Supply to the Shaw River Gas Fired Power Station. The risk assessment process provided a staged, risk-based approach for evaluating the potential impacts that the Project could have on a wide range of environmental, social and economic assets and beneficial uses. This study has contributed to this risk assessment process and the results of the risk assessment have been used to form the conclusions of this study.

In summary:

- The risk assessment was conducted to identify the potential environmental, social and economic impacts on the wider environment and community of implementing the Water Supply Pipeline project element. It should be noted that the risk assessment did not consider the risks posed by the proponent or the delivery of the Project. The assessment therefore did not assess reputation, financial delays or organisational effectiveness;
- The risk aims to heighten confidence and provide rigor for decision making and planning;
- The risk assessment was based on the Project Description and the outputs of the risk assessment represent the risk and impacts of implementing the Water Supply phase of the overall project, as described in the Project Description; and
- The risk assessment was conducted in close consultation with all of the technical specialists and is based on input provided by those technical specialists. All of the risk assessment inputs including consequence and likelihood ratings were provided by the technical specialists.

The objectives of the EES risk management framework are to:

- Identify key project risks which require detailed investigation;
- Facilitate a consistent approach to risk assessment across the various project disciplines; and
- Ensure that the level of investigation, including mitigation, is proportionate to the relative risk of EES issues.

The risk assessment approach used a multi-disciplinary group of technical specialists to identify and assess risks through a series of risk workshops. To assess risks consistently, a risk matrix was developed, defining the level of risk posed by project activities in terms of their ‘credible worst case’ consequence and the likelihood of that consequence occurring.

Levels of consequence for different assets and beneficial uses were clearly defined, from negligible to catastrophic, in terms of magnitude, space and time. A level of consequence was determined for each risk, taking into consideration all controls that would be in place to minimise or avoid the risk and having regard to ‘reasonable worst- case scenarios’. Risk pathways addressed both construction and operational phases of the project.

Likelihood rankings were defined, from ‘rare’ to ‘almost certain’, to describe the likelihood of the selected consequence occurring (note: this applies to the likelihood of that consequence occurring and not the likelihood of the activity occurring). The defined level of consequence and likelihood were used to form the risk matrix and assign a level of risk, ranging from low to extreme, to each identified environmental effect.

The definition for the level of consequence for each asset or beneficial use was developed specifically for the Water Supply Pipeline was based on consultation and advice from the technical specialists. The likelihood table was developed to incorporate the EES scoping requirements for the Water Supply Pipeline.

The consequence levels, likelihood levels and risk matrix relevant to this study are shown in Table 5, Table 6 and Table 7 respectively. The risk outputs relevant to this report are presented in the following section and Appendix B. The key issues identified through the risk assessment process will receive a higher level of attention in the technical reports.

Table 5 Consequence Rankings

Consequence Level		1- Negligible	2 – Minor	3 – Moderate	4 – Major	5 – Catastrophic
Category	Sub Category	*Minimal, if, any impact which have an overall negligible net effect*	*Localised, short term reversible event with minor effects that are contained to an on-site level*	*Localised, long term but reversible event with moderate impacts on a local level*	*Extensive, long term, but reversible event with high impacts on a regional level*	*Long term, extensive , irreversible with high level impacts at potential state wide levels*
Groundwater	**Groundwater Flow Regime**	Negligible change to groundwater regime and availability	Changes to groundwater regime and availability but no significant implications (short lived)	Changes to groundwater regime and availability with minor implications (localised)	Groundwater regime or availability significantly compromised	Widespread groundwater resource depletion and subsidence
	Groundwater Quality	Applicable ground water quality standards met across the region	Isolated exceedance of ground water quality standards that is short lived	Exceedance of applicable ground water quality standards in a local area	Exceedance of applicable ground water quality standards in a number of local areas	Widespread exceedance of ground water quality standards across the region

Table 6 Likelihood Rankings

Likelihood	Description
Rare	The event may occur only in exceptional circumstances
Unlikely	The event could occur but not expected
Possible	The event could occur
Likely	The event will probably occur in most circumstances
Almost Certain	The event is expected to occur in most circumstances

Table 7 Risk Assessment Matrix

Likelihood	Consequence Level				
	Negligible	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Medium	High
Unlikely	Low	Low	Medium	Medium	High
Possible	Low	Medium	Medium	High	High
Likely	Medium	Medium	High	High	Extreme
Almost Certain	Medium	Medium	High	Extreme	Extreme

5.2 Impact Assessment Methodology

5.2.1 Identifying Potential Impacts

An initial step in the method was to identify and describe cause and effect pathways for the potential groundwater impacts of the project. These pathways were identified giving consideration to the details of the proposed project and the assets, values and uses requiring protection.

In terms of the consequence levels for groundwater quality, the applicable guidelines for assessing the impact are those referred to in the SEPP Groundwaters of Victoria i.e. the ANZECC (1992) guidelines, and ANZECC / ARMCANZ (2000) for the protection of aquatic ecosystems. Small changes in groundwater quality are likely to be minor to insignificant, whereas large changes in groundwater quality may result in risk to groundwater beneficial use, and possibly the need for groundwater remediation.

A change in groundwater flows, groundwater level, or dislocation of groundwater flows may have adverse effects on existing groundwater users, may result in the degradation of flora and fauna habitats, and can even result in subsidence / differential settlement. Some changes in groundwater availability (flow and water level) may be minor or insignificant, with recovery or equilibrium being regained. Some changes may impart stress (i.e. slight impacts) to water bore operation, but which are tolerable or manageable. Other changes may be more severe with subsidence or loss of ecosystem habitat.

The methodology used to identify and assess the potential impacts to groundwater from the construction and operation of the Water Supply pipeline site is documented as follows:

- Categorise impacts based on groundwater fundamentals i.e. level, quality, availability;
- Understand the potential infrastructure to be constructed at the site (and its likely permanency, method of construction and likelihood of interacting with the groundwater environment) (i.e. pathways);
- Review available data regarding existing conditions;
- Identify how groundwater can be impacted (i.e. receptors);
- Assess the likelihood and consequence of the risk;
- Consider potential measures that could be implemented to mitigate risk; and
- Assess the risk of the impact occurring taking into account the mitigation measures.

This process is partly based on that described by EPA (2006) which is a source – pathway – receptor model, which is appropriate for evaluating impacts on water quality. A modification of this process has been adopted to account for impacts to water availability (i.e. quantity), and considers the physical activity, mechanism to affect the groundwater physical system, and impact on the groundwater regime.

5.2.2 Classification of Potential Impacts to Groundwater

Potential impacts to groundwater have been identified and classified as follows:

- Availability
  - Changes in groundwater recharge.

    Activity: Removal of confining beds and aquifer exposure by Earthworks;

    Mechanism: Increase in surface infiltration;

    Impact: Increased recharge;
  - Changes in groundwater discharge

    Activity: Cuts below the water table to construct the Water Supply pipeline and related infrastructure

    Mechanism: Changes to hydraulic gradients and an increase in flow towards the cutting / excavation

    Impact: Aquifer drainage / depletion with resultant water level change.
  - Changes groundwater levels through use

    Activity: Construction dewatering (for trench dewatering). It is understood that groundwater will not be developed to service Water Supply pipeline construction

    Mechanism: Reduction in groundwater level as a result of groundwater pumping.

    Impact: reduced groundwater availability
  - Changes to the groundwater supply to flora and fauna habitats.

    Activity: On-site groundwater use (i.e. dewatering) or aquifer drainage through earthworks

    Mechanism: Reduction in groundwater level

    Impact: groundwater availability for flora and fauna habitats may be impacted
  - Changes to surface and groundwater systems e.g. creeks, wetlands

    Activity: Earthworks intersecting the water table

    Mechanism: Reduction in groundwater availability, base flow to waterways or springs, aquifer flow and down-gradient discharge processes

    Impact: Changes to the natural flow regimes occurring between surface and groundwater systems

- Quality
  - Changes in groundwater quality that impact beneficial uses.

    The maintenance of aquatic ecosystems is a protected beneficial use. This includes the quality of groundwater supplying Groundwater Dependent Ecosystems (GDEs). Other beneficial uses (e.g. on-site or offsite extractive use) may be impacted and a number of source – pathway – impact receptor situations are considered.
  - Construction practices and activities

    Source: Handling and storage of hazardous materials, maintenance and refuelling, construction practices, generated waste water (e.g. wash downs, toilet and amenities),

    Pathway: Leakage of contaminants into aquifer via surface infiltration,

    Impact on receptor: Degradation of groundwater quality for the beneficial use and down-gradient receptors e.g. flora and fauna habitats
  - Water derived from construction dewatering,

    Source: Disposal / management of groundwater derived from construction dewatering

    Pathway: Leakage into aquifer via surface infiltration from storages, storage of water in the aquifer;

    Impact on receptor: Degradation of groundwater quality for the beneficial use and down-gradient receptors.
  - Water Supply Pipeline operation.

    Source: Handling and storage of hazardous materials, rupture of pipeline,

    Pathway: Leakage into aquifer via surface infiltration,

    Impact on receptor: Degradation of groundwater quality for the beneficial use and down-gradient receptors, or water table mounding and water logging.
  - Creation of acid sulphate conditions.

    Source: Acid sulphate soils

    Pathway: Lowered water level, exposure of acid generating materials to oxidation

    Impact on receptor: release of acid for may adversely impact groundwater quality and down-gradient receiving environments (e.g. flora and fauna habitats)
- Subsidence.
  - Whilst this is not strictly an impact to groundwater, it is a side effect of groundwater removal in unconsolidated, compressible sediments.

It is considered that the impact to groundwater could be grouped into either of two categories:

- Those impacts occurring as part of construction activities which are likely to be short term;
- Long term or permanent impacts.

A description of the potential impact, mitigation measures and risk has been presented in the next section.

5.3 Impact Assessment Results and Mitigation

5.3.1 Water Availability – Changed Recharge Conditions

Risk Pathway Description	***Description of Consequences***
Removal of perching layers, changing of surface conditions, changed floodplain conditions as a result of construction earthworks.	Potential for water table rise.

Definition

Unconfined aquifers are recharged by infiltrating rainfall. The infiltration and groundwater accessions can be influenced by:

- Topography and gradients;
- Site drainage;
- Vegetation; and
- Surface conditions and run-off character.

Earthworks including pipeline excavations may also remove low permeability materials (e.g. clays or cemented bands which form a perching layer), or expose the aquifer or permeable zones within the aquifer.

Assessment

The likelihood of this occurring along the Water Supply Pipeline is considered rare to unlikely given the broad understanding of the depth to water (>1.5 m) and the depth of the pipe. The footprint of most of Water Supply Pipeline is likely to be small relative to the overall intake area for the regional water table aquifer (be it the Quaternary / Tertiary aquifers) and therefore the overall depletion in recharge is expected to be negligible.

Mitigation Measures

A number of mitigating measures are available.

- Management of backfilling / rehabilitation; and
- Installation of trench cut-offs.

A schematic example of cut-off installations in an excavation is shown in Figure 6. The schematic shows water flowing into the trench from above and below a perched layer. The installation of cut-offs mitigates the lateral migration of this groundwater along the permeable backfill sands.

Excavations should be reinstated appropriately:

- Rehabilitation of vegetation / grasses;
- Grading for erosion control;
- Allowances for subsidence with backfilled excavations; and
- Removal of temporary access tracks and rehabilitation of ground conditions.

Conclusions Regarding Impact to Groundwater Availability – Changed Recharge Conditions

The risk of the construction and operation of the Water Supply Pipeline adversely impacting groundwater availability in terms of recharge conditions is considered to be low.

5.3.2 Water Availability - Site Use and Other Users / Receptors

Risk Pathway Description	*Description of Consequences*
Excavation below the water table requiring construction dewatering.	Dewatering (construction and on-going) impacting other groundwater users (e.g. irrigators, stock and domestic users). Dewatering (construction and on-going) exposing acid sulphate soils. Dewatering (construction and on-going) disrupting spring flow / base flow to surface water systems, dislocating groundwater flow. Dewatering (construction and on-going) causing subsidence and differential settlement. Dewatering (construction and on-going) disrupting or depleting groundwater supply resulting in degradation of flora and fauna habitats.
Extraction of groundwater for construction water supply	Impact to other groundwater users, subsidence, supply to flora and fauna ecosystems

Definition

The extraction of groundwater (from either a bore or excavated trench) results in a decline in groundwater levels surrounding the bore. The decline in water level is referred to as the ‘drawdown cone’ or ‘cone of depression’ around the pumping bore, or drawdown zone around a trench. The drawdown decreases with distance from the bore or trench and expands in size whilst pumping occurs until steady-state conditions are reached.

The extent of drawdown depends primarily on the nature of the aquifer, the pumping rate and pumping duration. If the aquifer system consists of fractured rock, or is of odd shape, the shape and extent of drawdown may vary in certain preferential directions. If the drawdown extends such a distance from the extraction centre such that it intersects other bores or in the case of unconfined aquifers, environmental features (e.g. creeks, rivers, coastline, dependent ecosystems), it is said to have interfered with these features (i.e. interference has been manifested). The altering of the hydraulic gradient may result in changes to the groundwater movement from these features, thus affecting water availability.

Assessment

Accurate determination of the depth to water along the Water Supply Pipeline corridor is required to identify those areas that may be potentially impacted, however the regional water level information, and pipeline burial depths suggest that interaction is either negligible or likely to be confined to small, localised areas. Determination of aquifer parameters is required to assess the development of the cone of depression and for dewatering methodology design. The requirement for construction dewatering is discussed as follows:

- Presence of Neighbouring groundwater users (e.g. bores, spring-fed dams):

- The likelihood of impact is low to negligible give that there are few bores within 500 m of the Water Supply Pipeline. Springfed dams may be present, particularly on the margins of the stoney rise terrain.
  - Most groundwater bores are likely to target aquifers deeper than those within the influence of the Water Supply Pipeline excavation, a number of farm dams have been identified near the corridor. Where these dams are spring-fed or deep enough to intersect the water table, potential for impact exists;
- Developing groundwater resources for a construction or site water supply;
  - It is understood that groundwater is not to be used as a construction water supply
- Construction dewatering:
  - Dewatering may be required for shafts and excavations that intersect the groundwater table. The likelihood of dewatering requirements during construction is not known but expected to be negligible to unlikely over much of the pipeline route given the depth to water and pipeline depth. However this will vary along the pipeline route and locally there are likely to be zones where there is either natural groundwater discharge or groundwater close to the surface.
  - It is suspected that trench sumps could be used to dewater excavations should such be required. In addition, the duration of dewatering, and imposed drawdown from dewatering are expected to be minor to negligible.
- Degradation to flora and fauna habitats:
  - Refer to Section 5.3.4;

Mitigating Measures

The impacts of construction dewatering are likely to be temporary with the duration dependent upon construction progress. Upon the cessation of dewatering pumping, groundwater levels could be reasonably expected to recover to pre-pumping levels.

Any groundwater bores installed for construction water supply or permanent water supply will need to be licensed by Southern Rural Water in accordance with the *Water Act* (1989), and thus be subject to their licensing determinations. Such determinations require assessment of impact to neighbouring users, surface water flows and water availability.

Acceptable interference limits between bores (or due to dewatering by aquifer drainage) have been generally adopted from the guidelines recommended by the Rural Water Corporation (1993). The acceptable limits typically adopted by licensing authorities e.g. Southern Rural Water, are 10% to 20% of the available drawdown in the bore being impacted. The limit applied depends upon the understanding of the aquifer.

The size of the area impacted is dependent upon the ground conditions, the extent of influence of pumping / dewatering, the level of drawdown required and duration of pumping. Unconfined aquifers tend to have a limited zone of influence owing to high aquifer storage properties. Low flow rates could be expected from clayey geological materials, or excavations that partially penetrate the upper parts of the aquifer. Non-continuous pumping / dewatering may allow water level recovery during pumping quiescence.

Should dewatering be required, impacts can be mitigated through a number of means:

- Supplying the affected party with an alternate water supply e.g. carting water, deepening the pump intake setting depth;
- Altering the construction technique to reduce the need for dewatering e.g. use of sheet piles / contiguous piles, ground freezing;
- Careful design of the dewatering methodology e.g. multiple closely spaced bores may create a localised cone of depression;
- Increase construction effort e.g. reduces the duration over which dewatering may be required;
- Careful timing of the works to periods where water levels may be at their lowest; and
- Re-injection of the pumped groundwater between the excavation site and impacted part to impart hydraulic control.

In addition to the impacts of dewatering there are issues associated with the management of extracted groundwater and how it is disposed. Disposal options include re-use in construction activities (e.g. dust suppression, concrete batching, wash down, fire water, compaction control), aquifer re-injection, irrigation of neighbouring pastures or offsite disposal. The disposal options (including alternative use) will be determined by the groundwater quality and subject to conformance with the SEPP (*Groundwaters of Victoria*).

In those areas where the trench excavation intersects a perched aquifer, and which may result in the drainage of perched layers, trench cut-offs can be installed to prevent loss of water from the system via the lateral migration along permeable backfill and bedding materials.

Conclusions Regarding Impact to Groundwater Availability - Site Use and Other Users / Receptors

It is expected that little construction dewatering will be required given the depth to groundwater and proposed pipeline burial depth. Temporary dewatering works are not expected to result in adverse impacts to groundwater availability. Mitigation measures are available to reduce the risk of construction dewatering impacts. With increasing distance from the dewatering area, the risk of adverse impact to other groundwater receptors (bores, spring fed dams, GDEs) is considered to be low.

5.3.3 Availability - River Crossings

Risk Pathway Description	***Description of Consequences***
Excavation below the water table at river crossings.	Dislocation of groundwater flow / interaction with waterway.

Definition

The Water Supply Pipeline will cross a number of ephemeral waterways and drainage lines, which may or may not be flowing at the time of construction. The processes occurring at each crossing in terms of surface water and groundwater interaction is poorly understood. At some crossings:

- Groundwater flow from shallow aquifers may form base flow to the surface water (influent or gaining conditions);
- Surface water may leak into the groundwater system (effluent or losing conditions); or

- A degree of hydraulic isolation occurs between surface and the regional groundwater table.

Assessment

The depth of groundwater, river bed conditions / geology and interaction between the river and groundwater are key elements in determining the impact to groundwater from a crossing. The crossing construction methodology will determine the amount of potential interaction that may occur. Timing of the construction is another factor, particularly with ephemeral streams.

The construction techniques that may be employed include aerial crossings (i.e. pipe bridges) or standard trenching (i.e. dry or low flow conditions), trenching with/without stream flow diversion and directional drilling. Some techniques such as aerial crossings, or crossing 'dry' / ephemeral waterways will not impact groundwater.

Mitigating Measures

Whilst it is acknowledged that groundwater and surface water interactions are poorly understood at specific crossing sites, there are measures which can be implemented to mitigate construction and on-going pipeline operation impact to groundwater.

During and following pipeline construction, ground conditions must be achieved that maintain the pre-construction groundwater flow (and quality) conditions, but also to prevent scour and erosion. Trench cut-offs are one identified mitigation measure that can be implemented to achieve this in terms of preventing lateral migration of groundwater (or hydraulically connected surface water) along permeable pipeline backfill materials.

Site specific investigations may be required at crossings to inform the engineering design which will assist in determining the most appropriate management measure that needs to be implemented, when the Water Supply Pipeline location and construction details are finalised.

Conclusions Regarding Impact to Groundwater Availability – River Crossings

Depending upon the hydrogeology of at river crossings, potential exists for the dislocation of groundwater flow and disruption to surface and groundwater hydrodynamics.

Mitigation measures are available to reduce the risk of adverse impact occurring and therefore the risk is considered low.

5.3.4 Availability - Interaction with flora and fauna habitat

Risk Pathway Description	***Description of Consequences***
Excavation below the water table requiring construction dewatering.	Dewatering (construction and on-going) disrupting or depleting groundwater supply resulting in degradation of flora and fauna habitats.

Definition

A groundwater dependent ecosystem (GDE) is an ecosystem which has its species composition and natural ecological processes determined by groundwater (ARMCANZ & ANZECC, 1996). That is, they are natural ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (SKM, 2007). If the availability of groundwater to GDEs is reduced, or if the quality is allowed to deteriorate, these ecosystems will be impacted (Hatton & Evans, 1998).

It is widely acknowledged that a poor understanding exists in recognising GDEs, or understanding the hydrogeological processes affecting GDEs. A variety of flora and fauna may be dependent directly and indirectly upon groundwater. There are four basic types, and the potential systems within the Transfer Pipeline study area which are broadly classified as follows:

- Terrestrial Vegetation

  Terrestrial vegetation such as trees and woodlands may be supported either seasonally or permanently by groundwater. These may comprise shallow or deep rooted communities that use groundwater to meet some or all of their water requirements. Animals may depend upon such vegetation and therefore indirectly upon groundwater. Groundwater quality generally needs to be high to sustain the vegetation growth. Preliminary mapping of GDEs in southwest Victoria suggests that potentially there may be extensive areas of terrestrial GDEs, although this needs to be confirmed by ground truthing.

- Swamps, Wetlands, Tidal Flats and Coastal Inshore Waters

  Swamps and wetlands can be sites of groundwater discharge and may represent GDEs. The sites may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution to water ponding or shallow water tables. Tidal flats and inshore waters may also be sites of groundwater discharge. Wetlands can include ecosystems on potential acid – sulphate soils and in these cases maintenance of high water levels may be required to prevent waters from becoming acidic. These types of GDEs are known in the region.

- Base Flows in Streams

  These are similar to swamps and wetlands, and are sites that may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution to flow. The specific interactions of groundwater and the various surface water systems near the Water Supply Pipeline are unknown. There is known to be significant groundwater base flow to rivers in the region. Interaction would depend upon the nature of stream bed and underlying aquifer material and relative water level heads.

- Aquifers

  These are referred to as hypogean ecosystems. Micro-organisms in groundwater systems can exert a direct influence on water quality. There is little understanding of these systems within the study area.

Assessment

The likelihood of water availability and quality impacts being realised on flora and fauna ecosystems is variable and depends upon a number of factors:

- Location of habitats of sensitive fauna and flora
  - Excavations undertaken on the Water Supply Pipeline may intersect water tables or perched water systems which supply flora and fauna habitats and therefore potential exists for the alteration of the hydraulic regime of perched aquifer systems;
  - Riparian vegetation.

- Acid Sulphate Soils
  - The presence of acid sulphate soils along the Water Supply Pipeline corridor is under investigation and reported under separate cover.
- Base flows to surface water features
  - Refer to above discussion on river crossing.

It is understood that the DPI (2009) has undertaken preliminary mapping of GDEs in the Glenelg – Hopkins Catchment Management Area (CMA). These GDEs have been defined as being wetland or terrestrial GDEs and are based on regional depth to water table mapping and vegetation analysis.

Mitigating Measures

It is expected that little construction dewatering will be required given the depth to groundwater and proposed pipeline burial depth. Temporary dewatering works are not expected to result in adverse impacts to groundwater availability to flora and fauna habitats.

In terms of construction dewatering or construction water supply activities, the impacts are likely to be temporary with the duration dependent upon construction progress. Upon the cessation of pumping, groundwater levels could be reasonably expected to recover to pre-pumping levels and this will mitigate impacts. Concern exists that with buried structures (e.g. underground services) the excavation may dislocate groundwater flow.

Under the *Water Act* (1989), works upon waterways, or allocating groundwater resources, consideration of the need to protect the environment, including the riverine and riparian environment, existing and projected availability of water, and existing and projected quality of water.

Whilst it is acknowledged that the understanding of groundwater and flora and fauna habitat interactions is poor, there are measures, which can be implemented to mitigate construction and on-going pipeline operation impact to groundwater.

Earthworks and construction, and Water Supply Pipeline operation are to be managed so that groundwater impacts (and resulting impacts to flora and fauna habitats) are mitigated. This may include:

- During and following pipeline construction, ground conditions must be achieved that maintain the pre-construction groundwater flow (and quality) conditions (refer reinstatement of trench materials); and
- Minimising magnitude (and duration) of dewatering effort (refer construction dewatering mitigation measures).

Conclusions Regarding Impact to Groundwater Availability – Degradation of Flora and Fauna Habitats through groundwater impacts

Temporary dewatering works are not expected to result in adverse impacts to flora and fauna habitat through effects to groundwater availability. Mitigation measures are available to reduce the risk of such dewatering impacts, but also to prevent the dislocation of groundwater flow through migration along permeable backfill materials. It is therefore concluded that the risks, as a result of groundwater impacts are low. Where shallow water tables are intersected (i.e. 1.0 m depth), further investigations including ground truthing and assessment of GDEs may be required to confirm the suitability of the mitigation measures.

5.3.5 Quality – Maintenance of Beneficial Uses

Risk Pathway Description	***Description of Consequences***
Contamination of groundwater from construction activities (e.g. spillage, dust suppression)	Impact to groundwater quality / breach of SEPP (Groundwater of Victoria)
Management of contaminated groundwater encountered during construction	Impact to groundwater quality / breach of SEPP (Groundwater of Victoria)
Exposure of Acid Sulphate Soils	Impact to groundwater quality / breach of SEPP (Groundwater of Victoria)

Definition

As required by the *EPA Act* (1970), and the SEPP (*Groundwaters of Victoria*), groundwater has defined beneficial uses dependent on its salinity. The groundwater quality must be protected to preserve the identified beneficial uses. Potential groundwater quality changes (and their timing) may arise from:

	Construction	***Operation***
◗ Spillage, improper handing, storage and application of hazardous materials;	✓	✓
◗ Disposal of fluids or waste to groundwater;	✓	✓
◗ Exposure of Acid Sulphate Soils;	✓	✓
◗ Intersection of contaminated groundwater	✓	
◗ Incompatibilities with construction materials (e.g. imported backfill);	✓	
◗ Establishing hydraulic connection between two aquifers of differing water quality which were previously hydraulically isolated;	✓	✓

Changes to groundwater quality are assessed by groundwater quality objectives. The SEPP (Groundwaters of Victoria) refers to ANZECC (1992) and ANZECC (2000), the later for the protection of aquatic ecosystems at the point of groundwater discharge.

Assessment

There is a high likelihood of chemicals being used during various parts of the construction, including the storage of fuels e.g. diesel used for on-site power generation. It is possible that construction activities may result in localised groundwater quality impacts as a result of spillage or improper application of hazardous materials, and the refuelling and maintenance of plant and equipment. Work procedures would reduce this likelihood to unlikely or rare. These would be tend to be localised, and emergency services response is likely to be rapid thereby reducing the potential for migration to the groundwater system.

The exposure of acid sulphate soils is considered unlikely to occur during construction or on-going operation of the Water Supply Pipeline. For these materials to represent an on-going impact to groundwater, infiltrating waters (e.g. stormwater, rainwater) need to be present to generate a plume, oxidising conditions need to be maintained, and favourable conditions (i.e. rapid movement, little retardation / attenuation) to down-gradient receptors (i.e. bores, groundwater discharging to waterways). These factors make the exposure of acid sulphate soils and on-going impact to groundwater unlikely.

The remote setting and historical land use (predominantly pastoral / cropping) suggest the contaminated groundwater is unlikely.

Incompatibilities between construction materials may result in leaching of constituents into the groundwater system. This is considered unlikely given that:

- Most construction materials would be relatively inert (e.g. concrete), or be designed / engineered for the anticipated conditions if aggressive conditions are expected;
- Be of similar make-up i.e. clean backfill, earthen materials derived from similar geologies; and
- Require significant contact with groundwater, or significant fluid to leach and migrate to groundwater.

The changing of groundwater quality as a result of the Water Supply Pipeline construction penetrating confining beds is considered to be an unlikely to rare event as it requires:

- A significant (deep) cut between aquifers of grossly different water quality; and
- Penetration of perched beds, with perched and regional aquifers being of grossly different water quality.

Mitigation Measures

Environmental Management Procedures can be applied to minimise the likelihood of adverse impacts to groundwater quality e.g. refuelling procedures, bunding, erosion controls, hazardous materials handling, application of dust suppressants, and herbicides, and waste management.

Environmental Management Procedures can be applied should acid sulphate soils be encountered e.g. handling and management, bunding of stockpiles. If oxidation occurs during groundwater dewatering activities, these conditions would be removed at the cessation of pumping with water level recovery.

Environmental Management Procedures can be implemented in regards to the management of backfilling, including the sourcing and use of certified clean fill as backfill material, spoil from excavations, the order of backfilling and re-instatement works.

Disposal to groundwater e.g. soakage pits must be licensed e.g. EPA Waste Discharge Licence. If impacts to groundwater quality (and thus beneficial use) are manifest, management actions have to be implemented (e.g. groundwater clean-up).

Conclusions Regarding Impact to Groundwater Quality

The risk of the construction and operation of the Water Supply Pipeline adversely impacting groundwater quality is considered to be low.

5.3.6 Subsidence Impacts

Risk Pathway Description	***Description of Consequences***
Extraction of groundwater during dewatering activities (or site use) located in compressible sediments.	Depressurisation leading to settlement and damage to built structures.

Definition

Depressurisation of aquifers may occur through construction activities (trench dewatering along the Water Supply Pipeline corridor.

Aquitard drainage leads to compaction and land subsidence, which is in part dependent upon the stress history of the geology. Tertiary formations tend to be over-consolidated, whereas Quaternary sediments tend to be under-consolidated. If drawdown occurs under built up areas, under some soil conditions, (differential) ground movements could be a concern to the integrity of structures (e.g. residential housing), other roads and underground services.

Assessment

To assess the likelihood of subsidence, an understanding of the magnitude of dewatering, soil types and rheology, impact to the saturated conditions, aquifer hydraulic parameters, and land use is required. Limited understanding of these elements exists for the study area and this is an identified data gap.

There are a number of factors, which suggest that there is a low to negligible likelihood for groundwater induced subsidence associated with the Water Supply Pipeline:

- Much of the corridor is either above the water table, or requires limited drawdown;
- Dewatering activities if required, will be of temporary nature; and
- The pipeline is generally located remote from existing buildings and infrastructure.

The likelihood of subsidence is considered low based on the perceived amount of dewatering effort required. Furthermore, dewatering would not be permanent and water levels would recover post construction.

Mitigating Measures

To mitigate against subsidence, similar controls to those applied to dewatering activities for minimising drawdown should be applied. These controls (refer above) should be coupled with a monitoring program.

Conclusions regarding Subsidence

The environmental impact of subsidence (soft and compressible soils) from groundwater depressurisation owing to construction dewatering within the Water Supply Pipeline corridor is considered low to negligible.

5.4 Next Stage of Groundwater Assessment

Throughout the documented existing conditions a number of limitations of the investigation have been identified. A field investigation program will be required to resolve the gaps in geotechnical and hydrogeological data where there is potential for elements of the Water Supply Pipeline to interact with the groundwater environment. Data from these investigations is not expected to alter the conclusions of this impact assessment, but rather inform the selection of appropriate mitigation measures and to inform the engineering design. The primary objective would be to confirm the depth to groundwater and therefore likelihood of interaction, in those areas where the Water Supply Pipeline intersects the water table.

A discussion on some of the data gaps, and implications to the project and the reliability of the conclusions made.

- Depth to Groundwater

  The depth to groundwater is a key unknown in the Project study area as it determines whether the Project will likely interact with groundwater. The proposed pipeline depth of burial is shallow (<1 m) and unlikely to interact with groundwater. Knowing where these interactions may occur will assist the construction phase of the project in terms of planning (e.g. resourcing, construction effort), timing (e.g. scheduling to avoid or minimise dewatering), and economics (e.g. dewatering effort / methodology). In the long term, it will provide information for assessing the impacts on sites of groundwater recharge and discharge.

  To inform the engineering design of the Water Supply Pipeline, geotechnical investigations will be undertaken. These investigations will provide additional information regarding the depth to water and likelihood of interaction of the construction works with the groundwater environment.

- Seasonal groundwater fluctuation and drought response

  There can be a marked difference between groundwater levels between seasons. Water levels are usually at their highest in the late spring following recharge by winter rainfall. Water levels tend to be at their lowest in late summer as a result of a lack of rainfall, and possibly the effects of abstraction (e.g. irrigation over summer). Drought conditions are expected to have a significant impact on water levels. Where water levels are within 2 m of the surface, salinity effects are commonly manifested.

  To determine fluctuations requires the long term (> 12 months) monitoring of water levels. This cannot be achieved prior to the proposed construction of the Project. A 1 m to 2 m change in water level may affect whether an investigation is undertaken under dry or saturated conditions and thus the level or amount of dewatering effort required.

  A higher water table may mean an increase in the dewatering effort. The seasonal fluctuation may mean however, that areas currently above the water table and that may be constructed under dry conditions, may become saturated sometime post construction and during site operation. A number of mitigation measures have been documented to minimise adverse impacts arising from groundwater dewatering. Again, given the proposed depth of burial of the Water Supply Pipeline, for water table fluctuations to potentially effect construction areas, the area would possibly exhibit obvious evidence or historical evidence of water logging and salinisation.

A potential ramification is identifying areas that may become saturated (e.g. resumption of average rainfall conditions / end of drought conditions) and the need to install cut-offs. To overcome this, excavations during construction will need to be inspected and mitigation measures reviewed and adjusted as construction is undertaken i.e. mitigation measures documented in this report will not change, but rather effort in their application.

- Groundwater Quality

  To assess impacts to groundwater quality, an understanding of the background water quality is required. Knowledge of the groundwater quality can therefore be subsequently applied to determine the beneficial uses of the aquifer and the impact of quality changes, should they be manifest.

  A lack of understanding of groundwater quality will not affect the mitigating measures documented in terms of maintaining groundwater quality. Should a spill of hazardous material occur during the construction or operation phase of the Project, knowledge of groundwater quality may be required to remediate groundwater quality impacts arising from the hazardous material. Management of the spill may require investigations where appropriate in order to characterise the background water quality.

- Groundwater Dependent Ecosystems (GDEs)

  Considerable scientific effort is required to identify, characterise and understand the dependence of ecosystems on groundwater. In this document, flora and fauna habitats are treated as if they are recognised GDEs in terms of identifying appropriate measures mitigating against impact to groundwater which may affect the ecosystem e.g. construction of a pipeline may dislocate flow and therefore affect groundwater availability to a receiving ecosystem. Therefore trench cut-offs or permeable beds are required to be installed to maintain discharge / groundwater connectivity at locations of identified need.

6. Conclusions

Desktop hydrogeological investigations have been undertaken to describe the existing conditions along the Water Supply Pipeline corridor. The investigations have relied upon the State Groundwater Database, published geological and hydrogeological mapping, and reports.

The Water Supply Pipeline corridor traverses across the Tyrendarra Embayment, a structural subdivision of the Otway Basin. The geology comprises a series of stacked sedimentary (and volcanic) aquifers of Quaternary and Tertiary age. Groundwater is widely used in the region for stock, domestic, dairy and irrigation purposes. Most bores develop either the Newer Volcanic basalt or Port Campbell Limestone. The depth to groundwater is poorly characterised, but typically ranges from 1.5 m to 10 m. The groundwater quality is generally good and typically forms within Segment B (1,001 to 3,000 mg/L TDS). Intensive development of groundwater has been recognised by the DSE with the study area falling within the Yangery WSPA, and Hawkesdale GMU.

In assessing the impact to groundwater, availability (based on groundwater level) and quality were considered the key elements. Classification of impacts was made by considering both the construction or short term nature of impacts, and the long term potential with on-going Water Supply Pipeline operation. Risk of impact to groundwater was considered in terms of:

- Groundwater quality e.g. contamination through spillage, improper application of hazardous materials; and
- Groundwater availability e.g. dewatering through construction activities (excavation, use) or the dislocation of groundwater flow caused by the permeable backfill materials.

With the Water Supply Pipeline generally being buried at depths of around 1 m below the natural surface, the likelihood of interaction with the groundwater environment is considered low. It is considered that as construction activities are temporary, many of the impacts to groundwater are correspondingly temporary. It is also concluded that mitigation measures are available to reduce significant groundwater impacts during both construction and operation of the Water Supply Pipeline.

A number of data gaps exist in the hydrogeological understanding, however these gaps are not expected to alter the conclusions of the impact assessment, but rather inform the selection of appropriate mitigation measures and level of design uncertainty. The impact of data gaps has been discussed and the following recommendations are made for further investigations during the design phase:

- Geotechnical investigations to include determining the watertable depth and elevation; and
- Identification of localised groundwater dependant ecosystems that may need protection through the use of trench cuttoffs.

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8. Limitations

This technical report has been prepared to assess the existing hydrogeological condition of the Shaw River Gas Fired Power Station water supply pipeline corridor for Wannon Water. The advice provided herein relates only to these purposes and must be reviewed by a competent professional, experienced in hydrogeological investigations, before being used for any other purpose. GHD Pty Ltd (GHD) accepts no responsibility for other use of the advice.

Where borehole construction details, groundwater laboratory analysis, geophysical or pumping tests and similar work have been performed and recorded by others, the data is included and used in the form provided by others. GHD accepts responsibility for satisfying itself that the data is representative of conditions on the site but does not warrant the accuracy of the information.

The advice tendered in this report is based on information obtained from the publicly available groundwater bore information maintained by others and is not warranted in respect to the conditions that may be encountered across the site at other locations. It is emphasised that the actual characteristics of the subsurface, surface and groundwaters may vary significantly between adjacent boreholes and at locations other than where observations, explorations and investigations have been made. Sub-surface conditions, including groundwater levels and quality can change over time. This should be borne in mind when assessing the data.

It should be noted that because of the inherent uncertainties in the evaluations of aquifer hydraulic properties, changed or unanticipated hydrogeologic conditions might occur that could affect total project cost and/or execution. GHD does not accept responsibility for the consequences of significant variances in the conditions between test points or with time.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site-specific, some structure-specific and some experienced-based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of the report that has been modified in any way as outlined above.

Figures

600,000 610,000

Legend

Pipeline Alignment	Major Road	**Elevation Contour(m)**	50
	Minor Road	10	60
	Parish Boundary	20	70
	Waterway	30	80
		40	90

1:110,000 (at A4)

0 0.5 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 54

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Wannon Water
Shaw River Power Station

Job Number 31-23602
Revision A
Date 27 MAR 2009

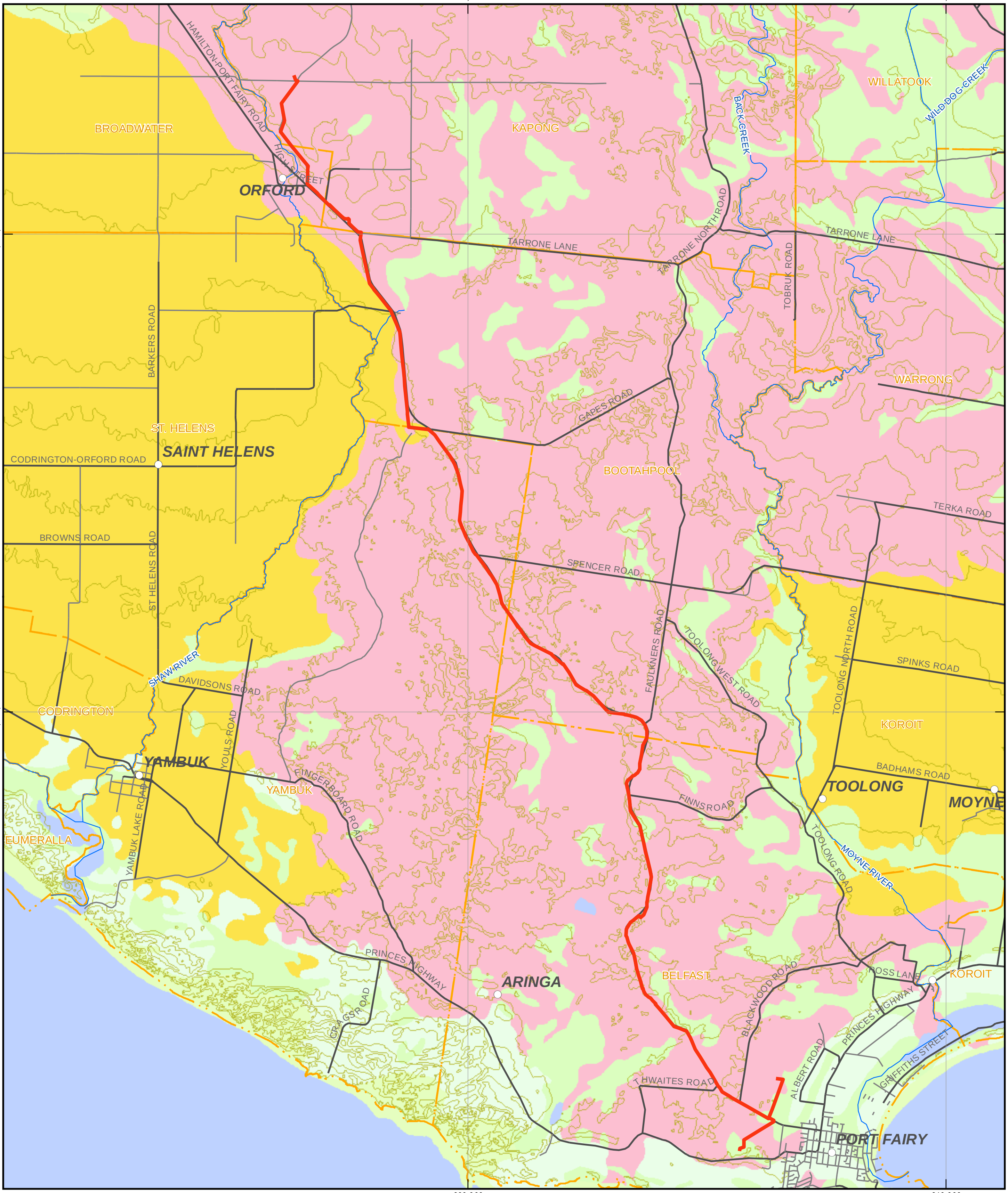
Study Area

Figure 1

G:\31\23602\CADD\GIS\Projects\PE18- Groundwater\001_Study_Area.mxd

180 Lonsdale Street Melbourne VIC 3000 **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com.au **W** www.ghd.com.au

Data source: VicMap. Created by: alovell



Legend

- Pipeline Alignment
- Parish Boundary
- Major Road
- Minor Road
- Waterway
- Elevation Contour

Geology

- Heytesbury Group
- Quaternary (Mostly Holocene) (Sedimentary)
- Newer Volcanics
- Quaternary (Pleistocene,Holocene) (Sedimentary)
- Quaternary (Pleistocene) (Sedimentary)

1:110,000 (at A4)

0 0.5 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 54

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Revision A
Date 27 MAR 2009

Study Area Geology

Figure 2

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180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Data source: VicMap. Created by: alovell

Legend

Bore Use

- Dairy
- Dairy, Domestic & Stock
- Domestic & Stock
- Irrigation
- Use Unknown

- Pipeline Alignment
- Major Road
- Minor Road
- Waterway
- Elevation Contour
- Parish Boundary

1:110,000 (at A4)

0 0.5 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 54

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Shaw River Power Station

Job Number	31-23602
Revision	A
Date	27 MAR 2009

Bore Location Plan

Figure 3

G:\31\23602\CADD\GIS\Projects\PE18- Groundwater\003_Bore_Location.mxd

180 Lonsdale Street Melbourne VIC 3000 **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com.au **W** www.ghd.com.au

Data source: VicMap. Created by: alovell

Figure 4 State Observation Bore Nested Site: Princes Highway

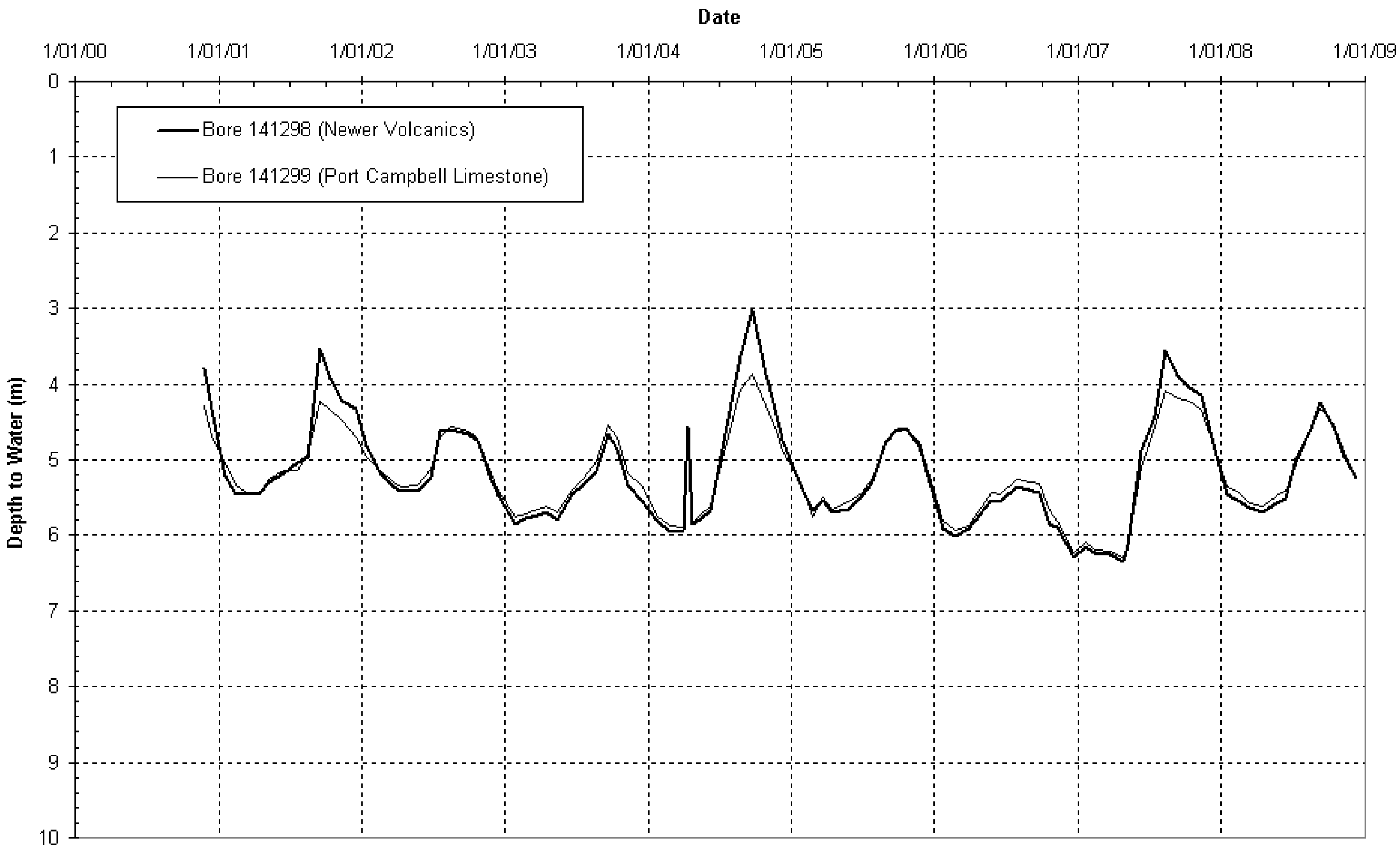


Figure 5 State Observation Bore Nested Site: Woolsthorpe – Heywood Road

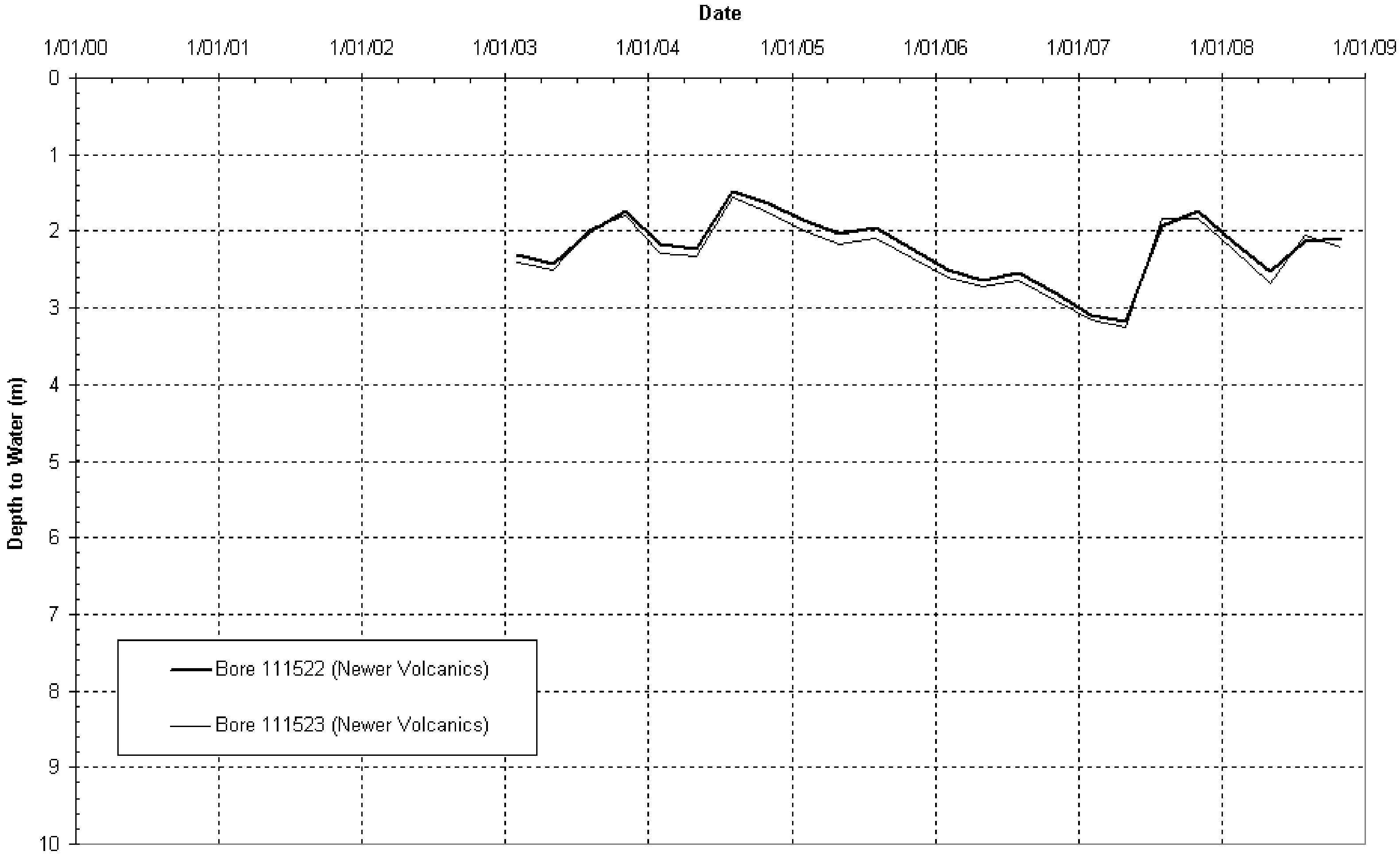
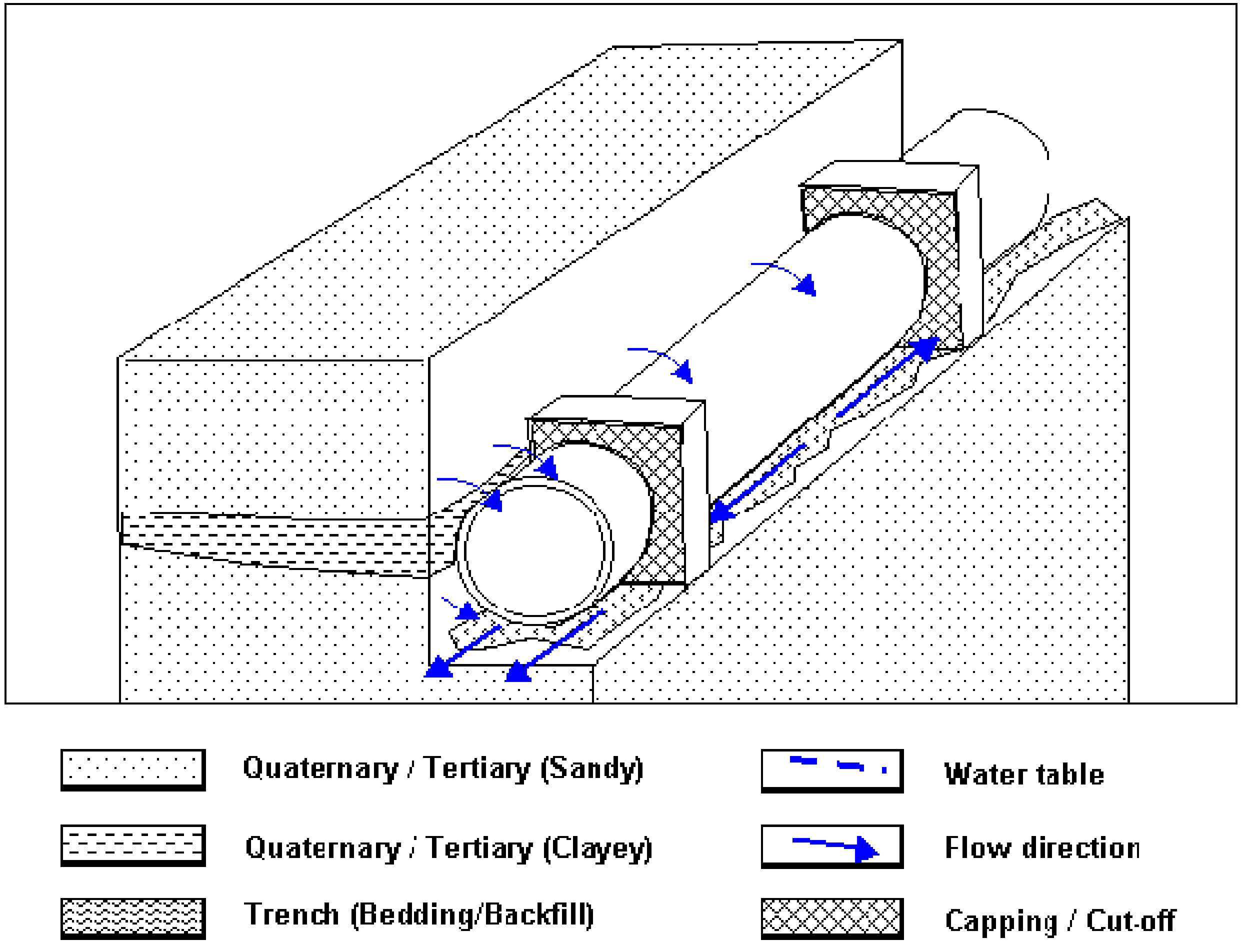


Figure 6 Schematic of Trench Breaker / Cut-off



Appendix A

Summary details of bores within 500 m of Pipeline Corridor

Table A1 Summary of Neighbouring Bore Details

Bore ID	AMG Co-ordinates		Total Depth (m)	Date Completed	Bore Use	Screen Interval (m)		Lithology	SWL (m)	Bore Yield (L/s)	Salinity (mg/L)
	Easting	Northing				From	To				
106594	600,259.34	5,764,197.43	45	11.03.1971	ST	36.57	44.50	NOT	9.1	-	1,441
106616	600,834.34	5,762,830.43	46	18.02.1975	ST DM	42.67	45.72	NOT	10.1	-	1,014
106629	600,215.33	5,764,655.43	49	21.02.1980	ST	29.86	48.76	NOT	8.5	-	1,543
106631	600,276.34	5,762,826.43	33	17.10.1980	ST DM	29.56	33.48	BASALT	5.4	1.3	1,135
106640	599,671.33	5,764,576.43	53	10.03.1983	ST DM	37.49	53.33	LMST	12.8	1.3	1,430
106654	599,871.33	5,765,176.43	49	18.02.1984	ST	37.19	48.76	LMST	12.2	1.3	1,430
106678	599,994.33	5,764,145.43	45	01.01.1988	ST	-	-	-	-	-	-
106737	600,273.34	5,762,680.43	24	01.01.1988	ST	-	-	-	-	-	-
106738	599,499.33	5,764,499.43	12	01.01.1988	ST	-	-	-	-	-	-
106741	599,645.33	5,763,609.43	26	01.01.1988	ST	-	-	-	-	-	-
106771	599,968.33	5,764,915.43	46	01.01.1988	DM ST	-	-	-	-	-	-
106772	600,034.33	5,764,842.43	-	01.01.1988	ST	-	-	-	-	-	-
113386	605,251.36	5,752,056.39	26	19.04.1992	DM ST	2.00	25.90	BASALT	8		3,277
113606	605,521.36	5,751,976.39	54	23.04.1992	DM	36.00	53.50	LMST	-		-
114927	606,301.36	5,750,546.39	31	26.10.1992	DM	12.49	31.09	-	-		1,040
115592	603,521.35	5,757,106.41	55	08.05.1993	ST	9.10	55.47	-	-		1,885
115602	606,491.36	5,750,626.39	29	09.03.1993	DM	10.62	28.95	-	-		1,885

Bore ID	AMG Co-ordinates		Total Depth (m)	Date Completed	Bore Use	Screen Interval (m)		Lithology	SWL (m)	Bore Yield (L/s)	Salinity (mg/L)
	Easting	Northing				From	To				
124449	599,581.33	5,765,936.44	7	01.01.1800	DY ST	-	-	-	-	-	-
124475	603,921.35	5,753,526.40	10	01.01.1800	DY ST	-	-	-	-	-	-
124604	601,521.34	5,761,376.42	6	01.01.1800	DY	-	-	-	-	-	-
131773	604,111.35	5,752,996.40	47	31.01.1997	IR	3.91	47.24	CLAY	1.2		2,015
135051	598,791.33	5,770,246.45	55	13.02.1996	DY ST	36.58	54.86	-	2.4	1	-
139871	598,866.33	5,769,806.45	24	13.11.1998	DM ST	17.37	24.38	-	1.5	-	-
141933	601,621.34	5,760,976.42	26	23.02.1999	ST	13.10	25.90	-	7.6	-	-

Notes: DY – Dairy, ST – Stock, IR – Irrigation, NOT – Not Known, LMST – Limestone. Some salinity measurements obtained by correcting available electrical conductivity information. SWL – Standing Water Level (m), Salinity as mg/L Total Dissolved Solids (TDS)

Table A2 Driller Logs

Bore Id	Screen (m) From	Screen (m) To	Lithology
106594	0	27.3	ROCK AND BOULDERS DRILLED BY T. DIGUT PRE 1969
	27.3	34.1	BASALT
	34.1	36.6	BROWN CLAY
	36.6	37.8	SAND STONE LIMESTONE SHLOCK CLAY
	37.8	39.6	SAND STONE LIMESTONE SHLOCK CLAY
	39.6	42.1	LIMESTONE
	42.1	44.5	LIMESTONE
106616	18.9	32	BASALT
	32	36	SANDY SOIL
	36	39.9	CLAY
	39.9	42.7	MARL MUD
	42.7	45.7	LIMESTONE
106629	0	0.3	BLACK TOP SOIL
	0.3	29.9	BASALT
	29.9	32.9	RED BROKEN ROCK AND SAND
	32.9	34.7	RED CLAY
	34.7	36.6	YELLOW CLAY
	36.6	48.8	LIMESTONE
106631	0	0.3	TOP SOIL
	0.3	0.6	RUBBLY STONE
	0.6	22.6	BASALT
	22.6	26.2	BROWN CLAY
	26.2	28	YELLOW CLAY
	28	33.5	LIMESTONE
106640	0	0.6	RUBBLY STONE
	0.6	30.5	BASALT
	30.5	32	SAND

Bore Id	Screen (m)		Lithology
	From	To	
	32	34.7	BROWN CLAY
	34.7	35.9	YELLOW CLAY
	35.9	53.3	LIMESTONE
106654	0	0.6	RUBBLY STONE
	0.6	30.5	BASALT
	30.5	32.9	BROWN SAND
	32.9	34.7	RED CLAY
	34.7	35.9	YELLOW CLAY
	35.9	48.8	LIMESTONE
106678			Data not available
106737			Data not available
106738			Data not available
106741			Data not available
106771			Data not available
106772			Data not available
113386	0	2	TOP SOIL & LOOSE BASALT
	2	24.4	SOLID BASALT
	24.4	25.9	CAVITY & AQUIFER
	25.9	0	BASALT
113606	0	0.3	TOP SOIL
	0.3	0.6	VOLCANIC WEATHERED ASH
	0.6	35	TUFF (SCORIA)
	35	36	BROWN STIFF CLAY
	36	53	LIMESTONE & AQUIFER
	53	53.6	MARL
114927	0	0.9	TOP SOIL
	0.9	7	SANDSTONE

Bore Id	Screen (m)		Lithology
	From	To	
	7	11.5	SAND
	11.5	31.1	STONE
115592	0	43.3	STONE
	43.3	52.1	CLAY & STONE
	52.1	55.5	LIMESTONE
115602	0	0.3	TOP SOIL
	0.3	8.8	SAND
	8.8	28.9	BLUE STONE
124449			No Log Available
124475			No Log Available
124604			No Log Available
131773	0	1.2	PEET
	1.2	3.6	CLAY
	3.6	15.8	BLUESTONE
	15.8	16.5	CLAY
	16.5	39.5	LIMESTONE
	39.5	47.2	MARL (HARD)
135051	0	0.6	TOP
	0.6	1.8	CLAY RED BROWN
	1.8	9.1	CLAY RED
	9.1	19.5	CLAY & STONE
	19.5	24.4	CLAY BROWN
	24.4	29.6	CLAY YELLOW
	29.6	29.9	CLAY GREEN
	29.9	35.6	LIMESTONE SEDIMENTS
	35.6	35.9	CLAY YELLOW GREEN
	35.9	54.9	LIMESTONE GREEN & WHITE

Bore Id	Screen (m)		Lithology
	From	To	
139871	0	0.6	TOP SOIL
	0.6	8.8	CLAY
	8.8	16.8	CLAY & LIMESTONE
	16.8	24.4	LIMESTONE
141933	0	0.3	RUBBLY STONE
	0.3	16.8	BASALT
	16.8	25.9	BROKEN ROCK

Appendix B

Risk Register

	Shaw River Water Pipeline Risk Register	
Date	11 March 2009	**Job Number** 31-23602
Activity	**Groundwater**	

Item	Cause	Consequence	Safeguards	Rating L	Rating C	Rating R	Recommendation	Owner	Rating L	Rating C	Rating R
5.1	Excavation of trench intersects contaminated groundwater	Disposal of contaminated groundwater	Review site history. Identify areas where shallow water tables may exist SEPP (Groundwaters of Victoria)	Rare	Minor	L					
5.2	Spillage of hazardous material during construction refuelling / maintenance activities	Localised impact to groundwater quality	EMP to address hazardous materials handling SEPP (Groundwaters of Victoria)	Un-likely	Minor	L					
5.3	Water pipe ruptures causing leakage to groundwater,	Water table mounding / logging, and salinity (what happens?)	Regular maintenance during operation of pipeline	Rare	Minor	L					
5.4	Excavation of pipeline trench intersects groundwater	Displacement of groundwater flow, dewatering, loss of supply to spring fed dams	Trench breakers.	Un-likely	Minor	L					

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Document Status

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