Hume Highway Duplication

GROUNDWATER MANAGEMENT PLAN

- IN90304-000-PL-EW-0010-E
- December 2008

Hume Highway Duplication

GROUNDWATER MANAGEMENT PLAN

- IN90304-000-PL-EW-0010-E
- December 2008

HUME HIGHWAY
SOUTHERN ALLIANCE

PO Box 5126 MSMSC
LAVINGTON NSW 2708

100 Christie Street,
St Leonards, NSW

Contents

Distribution List of Registered Copies

Issued To	Date	Name
Southern Alliance – Alliance Manager		Cameron Silverthorne
Southern Alliance – Construction Manager		Jason Moran
Southern Alliance – Environment and Sustainability Manager		Jo Moss
Southern Alliance – Construction Environmental Manager		Jenny Butler
Southern Alliance – Community Relations Manager		Carol Bartley
Environmental Management Representative		Toby Hobbs
Department of Planning		Lisa Chan
Department of Water & Energy		Marwan El-Chamy
DECC		Mark Enright
RTA Representative		Andrew Cook

Plan Approved By Jo Moss

Environment & Sustainability Manager

1. Introduction

1.1 Background

The Hume Highway Duplication Project is a federally funded upgrade of the existing Hume Highway between Tarcutta and Table Top. The project is being delivered through two alliances. This document relates to the section of highway between Woomargama and Table Top (the Project) to be delivered by the Southern Alliance. The Southern Alliance comprises the RTA (the Owner Participant), and Abigroup and Sinclair Knight Merz (the Non-Owner Participants). The scope of work includes design and construction, and excludes operation and maintenance. The Project measures approximately 32 km in length and principally involves construction of a second carriageway. Access will be provided with local roads and properties and an interchange will be constructed in the vicinity of Bells Road.

The Mullengandra to Table Top section is part of the National Highway project approved by the Minister for Planning on 23 January 1998. The Woomargama to Mullengandra section, assessed under Part 3A of the Environmental Planning and Assessment Act 1979, was approved by the Minister for Planning on 29 August 2007.

There are three Minister's Conditions of Approval (MCoA) that apply to the Hume Highway Duplication Project from Woomargama to Table Top:

- MCoA for new section of National Highway between Albury & Wodonga (1998)
- Concept Approval under Section 75O of the EP&A Act 1979 between Sturt Highway and Mullengandra (2007)
- Project Approval under Section 75J of the EP&A Act 1979 between Woomargama and Mullengandra (2007)

Where applicable, specific Ministers Conditions of Approval for the Mullengandra to Table Top section will be prefixed by M2TT (e.g. M2TT MCoA 62). Those for Woomargama to Mullengandra will be pre-fixed W2M (e.g. W2M MCoA 2.7). Conditions relating to the Concept Plan will be pre-fixed CP.

1.2 Purpose

The purpose of this Groundwater Management Plan is to provide practical impact mitigation principles and measures for the design and construction of this project consistent with Minister of Planning approval conditions.

This plan establishes a groundwater monitoring program from which the progressive incorporation of appropriate groundwater management controls can be implemented.

1.3 Context

1.3.1 Regional Geology

The regional geology of the Hume Highway Duplication Project – Southern Package comprises Quartenary alluvium, colluvium and residual soils, Silurian granites and other quartz bearing volcanic rocks, and Ordovician- gneiss and schist.

From Woomargama to Mullengandra the route is predominately underlain by Ordovician turbidite sediments, with quaternary alluvium on valley floors associated with Four Mile Creek, Mullengandra Creek and Sweetwater Creek.

- **Table 1-1: Summary of Regional Geology from Woomargama to Mullengandra**

Age	Geological Unit	Description of Material	Occurrence
Woomargama to Mullengandra			
Ordovician		Residual and colluvial soils (silty and sandy clay) from granites and low grade metamorphic rocks.	South of Fairbain Road to Four Mile Creek.
Quaternary	Alluvium	Clay, silts, sands, and gravels	In the vicinity of Four Mile Creek approximately chainage 132 700.
Ordovician		Generally residual soil (mainly sandy clays) and weathered rock derived from Granite	Four Mile Creek to Ryan's Creek.
Quaternary	Alluvium	Clay, silts, sands, and gravels	Ryan's Creek to Sweetwater Creek.
Ordovician		Residual and colluvial soils (silty and sandy clay) from granites and low grade metamorphic rocks. Bedrock is at a relatively shallow depth in places on the upper ridge-lines away from the creeks.	Sweetwater Creek to Sweetwater Road

From Mullengandra to Tabletop the route predominantly traverses quaternary colluvium and residual soils (predominantly clays), derived from Ordovician gneiss and granites (north of Knox Road) along with quartz bearing volcanic rocks and low grade metamorphosed sandstones and siltstones (quartz mica schists). There are sections of quaternary river terrace material from

Mullengandra to Mullengandra Creek (3km length) and a 2.5km long section at Bells Interchange. Floodplain deposits are also found in the area around Bells Interchange.

- **Table 1-2: Summary of Regional Geology from Tabletop to Mullengandra**

Age	Geological Unit	Description of Material	Occurrence
Tabletop to Mullengandra			
Silurian		Residual and colluvial soils (silty and sandy clay) from quartz bearing volcanic rocks.	Bowna Road to approximately Chainage 158200 (1.5km north of Perrymans Lane).
Quaternary	Alluvium (deep)	Clay, silts, sands, and gravels	Approximately Chainage 158200 to Tabletop Creek
Silurian		Generally residual soil (mainly sandy clays) and weathered rock derived from Granite	Tabletop Creek to Yellow Creek/ Knox Road
Quaternary	Alluvium	Clay, silts, sands, and gravels	Near the surface either side of Newtons Road and in the vicinity of Tabletop Creek and Yellow Creek (between Tabletop Creek and Yellow Creek).
Silurian		Residual and colluvial soils (silty and sandy clay) from granites and low grade metamorphic rocks. Bedrock is at a relatively shallow depth in places on the upper ridge-lines away from the creeks.	Yellow Creek/Knox Road to Mullengandra Creek (before Sweetwater Road)
Quaternary	Alluvium	Clay, silts, sands, and gravels with sections underlain by shallow granite and gneiss	Mullengandra Creek to Sweetwater Road

1.3.2 Groundwater

Groundwater levels in the vicinity of the alignment are dependent on landuse, local topographic, soil and geological conditions, water levels in waterways, rainfall and evaporation rates.

There are two main types of groundwater aquifers along the alignment, alluvial aquifers present in major alluvial deposits and fractured rock aquifers which exist within the bedrock.

The alluvial aquifers are the main water bearing aquifer systems within the project area and within in the catchments surrounding the project area. Some groundwater resources exist in the fractured rock in the project area (both Ordovocian sediments/rock and Silurian fractured granite), however flows (and therefore yields) are expected to be low, and unpredictable.

Tabletop to Woormagama

Groundwater levels vary significantly along the length of the alignment due to the variation in geology along the route. Groundwater levels have been recorded in standpipes along the route since 1994. Measured groundwater levels in low lying areas characterised by alluvial material (Tabletop to just past Bells Interchange), Mullengandra Creek and Four Mile Creek vary from 1m to 6m of the surface, with higher levels close to creeks (Douglas Partners, 2007). It is expected that most groundwater levels will have fallen as a result of the current drought. Some perched groundwater and springs are expected in through the ridge line in the Mullengandra Hills between Yellow Creek to Mullengandra. However in general groundwater resources in the rock is likely to be minimal and will only be perched groundwater distributed unpredictably through the fractured rock (RTA, February 2007).

1.3.3 Impacts on Groundwater

The Albury Wodonga EIS (1995) and the Woomargama to Mullengandra EA (2007) found that the Project would have a localised impact on groundwater conditions, with the extent of the impact dependent on the vertical alignment of the route and existing groundwater levels. Cuttings during construction of the route could result in localised lowering of the water table while the use of fill could result in a raising of groundwater levels.

1.4 Groundwater Flows

The main potential impact on groundwater as a result of construction of the roadway would be associated with the potential for impediment to flow or severance of groundwater flow (RTA, 2007a). Groundwater levels are generally two or three metres below ground level and there are no cuts proposed in areas where shallower groundwater levels occur (<2m). Large cuts are located in rock formations where little or no groundwater is expected. Therefore it is expected that dewatering is not likely to be required during construction, as groundwater is not anticipated to be intercepted during construction. Good drainage would be required in under the road in low-lying areas within to ensure groundwater flows are not impeded. These issues are addressed in the design component of the project.

1.5 Saline Groundwater and Interception of Groundwater

Construction activities associated with the project have the potential to cause release of saline or contaminated groundwater onto land and into surface drainage systems eventually reaching waterways with potential consequences such as vegetation die-off, freshwater habitat degradation, fish kills and overall degradation of water quality for human use. This is generally likely to occur where construction activities are in low lying areas with shallow groundwater levels, or in areas where significant cuts may result in exposure of groundwater (although based on geology the quantities of groundwater associated in areas of significant cuts is likely to be minimal). Details on where this is expected to occur along the alignment are presented in **Table 1-3** and **Table 1-4**. It should be noted that due to the current drought, it is difficult to predict groundwater levels in the area due to the resultant extreme lowering of the groundwater table and uncertainty of recent data.

In the event that groundwater is intercepted it will be managed in accordance with CMS 20 Dewatering and CMS 25 Reuse and Management of Groundwater.

Table 1-3: Locations of Significant cuts along alignment and Geological information*

Chainage	Maximum cut	Location	Rock type	Other Comments
Woomargarma to Mullengandra				
132850-133050	2.1m at 132900	Blue Metal hill	Phyllite, slate, siltsones, metasiltstones and sandstone and metasandstone.	Reported spring fed dams in area
133500-134150	9m at 134000	Blue Metal hill		
134460-134650	2.6m at 134550	Blue Metal hill		
134720-134870	3m at 134800	Blue Metal hill		
Mullengandra to Tabletop				
147800-148400	22m at 148150	Wrights Property	Quartz mica schist, granite and fractured granite	Report of many spring fed dams in area. Potential for pressurised groundwater to be exposed, however due to drought conditions difficult to assess risk. Standpipes in this area were dry in March and April, except well at Chainage 148600. Highest GW level in well at 148600_ at RL266.3m which is still below level of cut.
148420-148750	7m at 148550	Wrights Property	Granite and fractured granite	
148870-149550	10m at 149150	Wrights Property	Anticipated granite and fractured granite (no geotechnical drilling carried out to date in this cut)	

Note: Based on 100 day design

*Geotechnical information provided by Douglas Partners for TOC submission

Table 1-4: Locations of Low Lying areas

Chainage	Location	RL range
159000 - 162800	Bells Road Interchange to Tabletop Creek	RL193 to RL220
150300	Yellow Creek Crossing	RL 210-220
144000	Mullengandra Creek Crossing	~RL 220
132700	Four Mile Creek	~RL 220

1.6 Contamination of Groundwater

Construction activities also include use of fuel in plant and equipment. This represents the potential for fuel leakage and therefore the potential to result in contamination of the groundwater in the event any leakage reaches groundwater.

1.7 Groundwater Drawdown

The only other potential impact of the project is potential extraction of groundwater for the construction phase which has the potential to impact water supply aquifers and other groundwater users, especially in areas affected by salinity such as Mullengandra Creek (RTA 2007). This will be managed by minimising installation of new bores particularly near existing supply bores, and investigation and monitoring of existing areas prior to installation if new wells are being considered. Any bores would be licensed according to the requirements of the Department of Water and Energy (DWE). Details of proposed measures to minimise these impacts are presented in **Sections 5 and 6.1.**

The lowering of groundwater levels due to either pumping or interference with groundwater flows can result in settlement of surrounding soils which in turn may impact public and private infrastructure such as building as roads. However, as the project is unlikely to result in significant groundwater lowering and there are very few buildings or other structures potentially affected the risk of property damage is very low.

1.8 Contaminated Groundwater

There is also potential for exposure of contaminated groundwater at one location along the route, where the alignment crosses over Mullengandra landfill. Exposure of contaminated groundwater and contaminated land has the potential for the following impacts:

- Contamination of surface water in the event exposed (contaminated) groundwater reaches local water courses
- Release of contaminants from rainwater runoff or leachate from exposed contaminated material into the groundwater and/or surface water bodies

Mullengandra landfill will be subject to a contaminated site investigation and this sub-plan will be updated with a summary of investigation results, and if appropriate will be covered by a separate Remediation Action Plan (RAP).

1.9 Existing Groundwater Users and Bores

Groundwater is used in the general area predominantly for farming applications such as water supply for stock and livestock, and for irrigation.

A search of the DWE database was undertaken to identify existing groundwater bores within the vicinity of the route alignment. A summary of registered bores in proximity to the route are provided in **Table 1-5** below.

- **Table 1-5 Existing Registered Groundwater Bores in the Region**

Groundwater Monitoring Well Information from the DWE Groundwater Works Database									
Bore Id	Date Installed	Distance from proposed project boundary as at 15 May 07 (m)	Location	Total Depth (m)	Depth to groundwater (m)	Salinity (mg/L or descriptive	Geology	Work Status	Use
Tabletop to Woomargama									
GW049151	1/04/1978	1470	N: 6022343 E: 501726	37.5	31m (Granite)	No details	Topsoil/clay/silty clay	Unknown	Domestic Stock
GW503228	20/09/2004	N/A	N: 6022230 E: 502666	46.0	11.0m	No details	Clay to 4m /weathered granite/granite	New Bore	Domestic stock
GW011093	1/2/1955	Inside proposed boundary	N:6024300 E:501049	46.9	No details	0-500 ppm	Unconsolidated Clay/ silt/Clayey Sand/Sand	Unknown	Stock
GW006471	1/11/1938	1370	N:6025620 E:503398	35.7	No data	Slightly Brackish	Earth/Gravel	Unknown	Not known
GW027607	1/1/1967	190	N:6024429 E:502909	1.8	No details	unknown	No details	Supply Obtained	Stock
GW055384	1/5/1981	35	N:6024210 E:505935	50	No details	Fair	Clay/Sandy clay/\decomposed granite/ sandstone/granite	Unknown	General use

Groundwater Monitoring Well Information from the DWE Groundwater Works Database									
Bore Id	Date Installed	Distance from proposed project boundary as at 15 May 07 (m)	Location	Total Depth (m)	Depth to groundwater (m)	Salinity (mg/L or descriptive	Geology	Work Status	Use
GW061234	01/06/1985	N/A near Wymea Road	N: 6022325 E: 508560	39.6	25.6	No details	Topsoil/Clay/Granite Decomposed clay/Slightly weathered Granite	Unknown	Domestic Stock
GW029027	01/02/1968	N/A near Wymea road	N: 6022173 E: 509612	14.6	8.5	No details	Topsoil/Sandy Loam/Sandy Clay/ Sand Gravel/Clay/Gravel	Unknown	Stock
GW057636	1/4/1983	540	N:6024555 E:512250	8.8	No details	Excellent	Silty Clay/Gravel/Sand	Unknown	Domestic Stock
GW0502433	11/2/2004	990	N:6024126 E:511844	5.1	2.2	No details	Loam/Medium coarse sand	Unknown	Domestic Stock
GW035693	01/05/1971	1450	N: 6023662 E: 511485	6.7	3.0	No details	Silt/Sand Gravel	Unknown	Domestic Stock

Groundwater Monitoring Well Information from the DWE Groundwater Works Database									
Bore Id	Date Installed	Distance from proposed project boundary as at 15 May 07 (m)	Location	Total Depth (m)	Depth to groundwater (m)	Salinity (mg/L or descriptive	Geology	Work Status	Use
GW056821	01/04/1983	N/A	N: 6022975 E: 511925	29.3	18.9	No details	Clay/Limestone seams/Decomposed granite/Soft granite	Unknown	Domestic Stock
GW059382	1/9/1983	640	N:6024520 E:513030	21	No details	Good	Clay/water bearing clayey sand/ sand and granitic gravel	Unknown	Recreational (groundwater)
GW045389	1/1/1976	1020	N:6024130 E:512991	28.3	No details	Very Good	Silty Clay/Gritty Clay	Unknown	Domestic Stock
GW064107	1/3/1987	45	N:6025910 E:514210	72.1	No details-	(unknown)	Topsoil/Clay/Weathered Granite/Granite	Unknown	Domestic Stock
GW0500024	21/1/1995	110	N:6026850 E:514650	11.8	10	(unknown)	Topsoil/Clay	Unknown	Industrial
GW060551	1/10/1984	30	N:6026855 E:514740	12.5	7.9	(unknown)	Topsoil/Clay/ /Granitic Valley/Clay	Unknown	Domestic
GW064591	1/01/1988	150	N:6034240 E:519740	54.9	51.3	Very Good	Topsoil/Clay/Shale/Slate	Unknown	Domestic Stock

In addition to the above registered bores, there are also unregistered monitoring wells along the alignment which were installed as part of projects implemented by Landcare and/or Murray Catchment Management Authority.

A summary of the known (unregistered) monitoring boreholes which are located within 1km of the alignment or proposed construction activities are presented in **Table 1-7**.

1.10 Baseline Groundwater Quality

Groundwater monitoring is proposed as part of the groundwater monitoring program. This will include pre-construction monitoring to establish baseline levels. The proposed groundwater monitoring program approach and details are presented in **Section 6.1** and **Appendix A.**

Limited groundwater monitoring was performed in some areas as part of the Environmental Assessment of the Mullengandra to Woomargama section of the alignment (RTA, 2007). The resultant data summarising the characteristics of the groundwater in the region (predominantly around Mullengandra and north of Mullengandra is presented in **Table 1-6**.

Groundwater level and salinity monitoring has also been carried out in wells managed by Landcare and Murray Catchment Management Authority. A summary of the data provided by Murray Catchment Management authority is presented in **Table 1-8** and **Table 1-9**. A selection of these unregistered wells will be monitored against the data presented in **Table 1-8** and **Table 1-9** as part of the monitoring program (see **Section 6.1**).

Table 1-6: Groundwater Quality in Mullengandra area.

	Unit	Upper Limit for Irrigation[1]	Upper Limits for livestock[2]	Alluvial Bore Range	Fractured Aquifer Bore Range
EC	uS/cm	2900-5200		538-1614	2,718
Conductivity	mg/L		2000-10000	356-1118	1,962
pH		>5-6	-	4.6-6.2	6.7
Sodium	mg/L	460	-	40-193	216
Potassium	mg/L	-	-	1-2	4
Calcium	mg/L	-	1,000	6-19	143
Magnesium	mg/L	-	-	22-72	188
Chloride	mg/L	700	-	99-459	404
Bicarbonate	mg/L	-	-	12-58	342
Sulphate	mg/L	-	1,000	36-82	690

1. ANZECC (2000) presented for tolerant crops (such as cotton)

2. ANZECC (2000) presented upper limit for Livestock for long term use (higher levels may be tolerated for short periods)

Source: Hume Highway Upgrade, Groundwater Assessment, Prepared by Parsons Brinkerhoff for RTA, February 2007

- **Table 1-7 Existing (Unregistered) Groundwater Monitoring Wells within the vicinity of the alignment**

Bore Id	Date Installed	Distance from proposed project boundary at 15 May 07	Location	Total Depth (m)	Depth to groundwater (m)	Salinity (uS/cm)
Woomargama to Tabletop						
MUP82E	2001	520m	N:6025967 E: 511666	12.5	4.06-4.67	800-4700
MUP Lind1	1991	95m	N: 6025221 E: 511330	3.22	0.55-3.09	2300-4350
MUPLind2	1991	Well destroyed		8.86	0.3 to 1.07 or dry	1300-1800
MUP Lind3	1991	135m	N: 6025162 E: 509206	6.89	3.4 to 6.52	2900-7550
MUP Lind4	1991	Inside		4.36	0.1 to 2.52	400-3600
MUP Lind 5	1991	10m (but potentially inside depending on data accuracy)	N: 6025492 E: 509443	4.85	0.15 to 2.90	2150-2900
MUPLind6	1991	290m	N: 6025777 E: 509466	5.7	5.68 to dry	4800-5340
MUPLind7		325m	N: 6025799 E: 509331	4.5	3.26 to 5.01 or dry	200-234
MUPLind8	1991	205m	N: 6025626 E: 509115.6	4.83	1.4 to 5.47 or dry	300
MUPLind9a	1991	135m	N: 6025523 E:509038	4.4	1.08 to 4.96	No data

Bore Id	Date Installed	Distance from proposed project boundary at 15 May 07	Location	Total Depth (m)	Depth to groundwater (m)	Salinity (uS/cm)
MUPLind9b	1991	145m	N: 6025507 E: 508970	No data	Dry	-
MUP55E	2004	185m	N: 6032858 E: 516606	5.5	3.25-3.77	No data

Source: Murray Catchment Management Authority

- **Table 1-8: Salinity Data for Monitoring Wells within 1km of the alignment**

Well ID	Approximate Chainage	Distance from alignment (boundary) as proposed at 15 May 07	Salinity µS/cm						
			10/05/91	04/09/91	17/02/92	03/07/00	02/05/02	02/02/04	06/02/07
MUPLind1	145370	95m	2560	4350	2900	2300	-	3580	-
MUP Lind2	Well destroyed		1720	1800	1600	1300	-	-	Well Destroyed
MUPLind3	147580	135m	7550	7180	3800	2900	-	4170	-
MUPLind4	147430	Inside	3130	2920	3600	400	-	1180	3500
MUPLind5	147250	10m	2150	2150	2900	2300	-	-	-
MUPLind6	147220	290m	5340	5280	4800	Dry	-	Dry	-
MUPLind7	147330	325m	234	217	200	Dry	-	Dry	-
MUPLind8	147500	205m	Dry	Dry	-	300	-	Dry	-
MUPLind9a	147600	135m	Dry	-	-	-	-	-	-
MUPLind9b	147650	145m	Dry	Dry	Dry	Dry	-	Dry	-
MUP55E	136650	185m	-	-	-	-	-	-	-
MUP82E	145050	520m	-	-	-	-	800	1200	4700
MUP56E	134970	615m	-	-	-	-	-	-	-

Source: Murray Catchment Management Authority

- **Table 1-9: Selected Water Level Data for Monitoring Wells within 1km of the alignment**

Well ID	Approximate Chainage	Distance from alignment (boundary) as at 15 May 07	Level						
			10/05/91	04/09/91	17/02/92	03/07/00	02/05/02	02/02/04	06/02/07
MUPLind1	145370	95m	2.35	0.74	1.8	0.96	2.27	1.75	2.4
MUP Lind2	Well destroyed		0.18	0.03	0.65 AGL	0.3 AGL	dry	dry	-
MUPLind3	147580	135m	2.62	2.51	2.42	4.83	5.15	5.77	6.26
MUPLind4	147430	Inside	artesian	0.96 AGL	1.6	0.9*	1.29*	2.0*	dry
MUPLind5	147250	10m	0.15	1.87	0.6 AGL	0.86	1.87	2.36	2.72
MUPLind6	147220	290m	5.55	4.88	4.96	Dry	Dry	Dry	Dry
MUPLind7	147330	325m	3.6	2.23	3.6	Dry	Dry	Dry	Dry
MUPLind8	147500	205m	Dry	Dry	5.4	3.67	Dry	Dry	Dry
MUPLind9a	147600	135m	Dry	8.6	8.6	3.28	4.83	4.42	4.72
MUPLind9b	147650	145m	Dry	Dry	Dry	Dry	Dry	Dry	Dry
MUP55E	136650	185m	-	-	-	-	-	3.25 (1/10/04)	3.71
MUP82E	145050	520m	-	-	-	-	4.43	4.06	4.48
MUP56E	134970	615m	-	-	-	-	-	5.97 (1/10/04)	8.35

* Measurements taken from Ground Level due to snapped pipe.

Source: Murray Catchment Management Authority

2. Legislative & Regulatory Compliance

2.1 Relevant Legislation

Legislation relevant to the management, use and condition of groundwater for the Project is provided through a range of documents. Relevant documentation is listed in the following table with references and content summaries.

- **Table 2-1 Regulatory Requirements related to Groundwater**

Document Name	Summary
Fisheries Management Act 1995	For works likely to impact on fish habitats, such as discharge of contaminated groundwater
Water Act 1912/ Water Management Act 2000	Licence required for works including extraction of groundwater, installation of bores and installation of monitoring wells
Protection of the Environment Operations Act 1997	Setting out requirements for discharges of pollutants into natural water bodies. An Environment Protection Licence is required for this scheduled activity.
ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality	Sets out the guidelines for groundwater quality.

2.2 Ministers Conditions of Approval

MCoA No.	Condition Requirements	Sub-Plan Reference
M2TT 65	A detailed Groundwater Management Plan shall be prepared to meet the requirements of the DLWC and the EPA. The Plan shall cover the complete proposal and shall provide details of groundwater control measures to be undertaken during both the construction and operation stages and include but not be limited to:	
	▪ impacts on nearby structures from potential settlement	Section 1.3.3 & Section 5
	▪ impacts on existing authorised groundwater users;	Section 1.3.3 & Section 5
	▪ impacts on salinity, groundwater inflow control;	Section 1.3.3 & Section 5
	▪ handling; treatment and disposal of contaminated groundwater;	Section 1.3.3 & Section 5
	▪ monitoring;	Section 6
	▪ auditing;	Section 6
	▪ mitigation measures; and	Section 5
	▪ response actions.	Section 5

MCoA No.	Condition Requirements	Sub-Plan Reference
W2M 2.23	Should the final alignment (and associated works) necessitate the decommissioning of bore GW060551 (Mullengandra), the Proponent shall ensure that a replacement bore is commissioned prior to the commencement of any construction works within the vicinity of GW060551 that may impact on the operation of that bore. The location and depth of the replacement bore shall be determined in consultation with DWE and the relevant landowner/ licence holder. The construction and commissioning of the replacement bore shall be at the full cost of the Proponent.	

In addition this plan considers the requirements in the Statement of Commitments from the Environmental Assessment for Woomargama to Mullengandra (Submission Report & Revised Statement of Commitments, June 2007). These are summarised below, with references to where each is addressed in the plan.

OBJECTIVE	REF#	COMMITMENT	REFERENCE
Minimise the impact on groundwater resources and land capability and manage land degradation relating to water logging and salinisation.	G1	Strategies will be developed to manage groundwater issues associated with surrounding land uses, including management of recharge areas in consultation with the relevant government agencies.	Section 5 & Section 6
Minimise the impact of high water table on road construction.	G2	Appropriate subsurface drainage infrastructure (e.g. blind ditches) will be installed in areas identified as having shallow groundwater levels, to divert groundwater away from pavement subgrade.	Section 5

2.3 Guidelines and Standards

The ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality guidelines have been adopted. It is accepted that these guidelines can be applied to groundwater (Box 1.2 of the guidelines). These are the only guidelines in Australia which are currently available for groundwater quality. However, in accordance with the ANZECC/ARMCANZ (2000) guidelines it is recommended to identify guideline values specifically applicable to the area of interest and to not merely accept the general broad regional guideline mentioned above. Given the predominant use of the groundwater in the area for farming occupations, the ANZECC guidelines for (1) irrigation and (2) livestock drinking water quality will be used. A summary of the guideline values is presented in **Table 2-2**.

The pre-construction monitoring of groundwater wells will help to provide information from which to develop a local guideline trigger value for salinity and pH, specifically for groundwater associated with the Project (refer to **Sections 6.1.2** and **Appendix A** for further details). As many of the groundwater systems (particularly shallow groundwater) are connected to surface water in the region, the groundwater quality is also closely linked to surface water quality. Data collected as part of the surface water quality monitoring program will be utilised to establish a baseline/acceptable level for groundwater exposed during the construction process. Any groundwater which needs to be discharged into surface water systems will be compared to applicable surface water data, prior to release. Further details on the surface water monitoring program and surface water data, are presented in the Soil and Water Management Plan and can also be located in associated results from the surface water monitoring program.

However, in the meantime, given the predominant use of the groundwater in the area for farming occupations, the ANZECC guidelines for (1) irrigation and (2) livestock drinking water quality will be used for reference.

Table 2-2: ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality (2000) for Relevant Parameters

Parameter	Unit	Irrigation	Livestock
Routine Parameters			
EC	µS/cm	2900-5200*	
Conductivity/Salinity	mg/L		2000-10000**
pH		>5-6	
Turbidity	NTU		
Sodium	mg/L	460	
Potassium	mg/L		
Calcium	mg/L		1,000
Magnesium	mg/L		
Chloride	mg/L	700	
Bicarbonate	mg/L		
Sulphate	mg/L		1,000
Total Nitrogen	µg/L	5000	
Total Phosphorous	µg/L	50	
Additional Parameters in Contaminated or Potentially contaminated areas			
Aluminium	µg/L	5000	5000
Nickel	µg/L	200	1000
Lead	µg/L	2000	100
Cadmium	µg/L	10	10
Copper	µg/L	200	400-5000

Parameter	Unit	Irrigation	Livestock
Iron	µg/L	200	-

* Source: ANZECC (2000) for tolerant crops (such as cotton)

**Upper Limit for Livestock for long term use (higher salinity levels may be tolerated for short periods)

2.4 Other Documents and Guidelines

This Groundwater Management plan is consistent with the requirements of the following:

- RTA Guide G36 Environmental Protection

2.5 Approvals, Licences & Permits

Licenses are required from the Department of Water and Energy (DWE) for installation of groundwater monitoring wells and groundwater abstraction bores. Use of groundwater for construction use from existing supply bores owned by a third party also requires approval from the Department of Water and Energy. Details of license requirements along the route are presented in **Table 2-3**.

The groundwater aquifers in the area in which the project is located currently fall under the *Water Act 1912*. If a water sharing plan is implemented along any of the groundwater aquifers at a later date, the applicable legislation will change from the *Water Act 1912* to the *Water Management Act 2000* and licensing requirements will change.

- **Table 2-3: Approval and License Requirements for Groundwater**

Legislation	Activity	Requirement	Details	Notes
Water Act 1912 Part 5, Division 5	Installation of groundwater monitoring bores	License	Application and approval from the Department of Natural Resources and takes approximately 2 weeks	
Water Act 1912 Part 5, Division 3	Installation of groundwater abstraction bores	License	Approval from DWE required. Application process takes approximately 3 months. Any new abstraction well subject to native title assessment, hydrogeological assessment and environmental review	Not permitted in Area 014 (Billabong Creek Aquifer) and Area 015 (Upper Murray Aquifer) as they are embargoed

Legislation	Activity	Requirement	Details	Notes
Water Act 1912 Part 5 Section 117J	Use of groundwater from existing abstraction bore owned by a third party (on-supply from third party to Southern Alliance)	Formal Approval	Application to and Approval from DWE required to change the license (specifies that some is for “industrial” use).	Only method of obtaining water supply from groundwater in areas where and embargo is in place.

The exact requirements and details for the project in terms of source wells are still in the process of being finalised. Once this information is finalised, this section will be updated with details on the number of each type of license which will be required.

3. Structure & Responsibilities

In addition to the responsibilities in the Framework CEMP, specific responsibilities relating to groundwater management are detailed below. Detailed responsibilities are also designated in Section 5:

Designers

- Ensure road is designed in a manner that will not impact on groundwater flows.

Construction Manager

- Ensuring construction activities are conducted in a manner to prevent groundwater contamination

Superintendent/ Foreman

- Ensure satisfactory management of groundwater if intercepted during construction activities
- Ensure monitoring conducted prior to discharge of any intercepted groundwater

Project Engineer

- Management of geotechnical and hydrogeology contractors.

Environment Construction Manager

- Consultation with Agencies regarding installation of monitoring bores and initial groundwater sampling of any new bores;
- Liaison with geotechnical and hydrogeology contractors;
- Analysis of results and overseeing the monitoring, auditing and reporting;
- Implementation of monitoring program;
- Retention of records relating to groundwater monitoring;
- Consideration of groundwater impacts during completion of weekly checklists.

4. Environmental Aspects and Impacts

The environmental aspects are those activities that may result in an environmental impact. The relationship of aspects and impacts is one of cause and effect. The process of identifying impacts is one of progressively breaking down each activity into its environmental.

The construction activities with potential to impact on groundwater are:

- significant cuttings
- excavations, drain and sedimentation/wetland basin construction; and
- filling and construction of earth embankments
- construction of new road sections over low lying areas with shallow groundwater levels
- storage of fuel
- disturbance of contaminated land and waste in the vicinity of Mullengandra landfill
- use of groundwater for water supply.

The potential impacts of the above activities could include the following:

- Contamination of groundwater or release of saline or contaminated groundwater onto land and into surface drainage systems eventually reaching waterways with potential consequences such as vegetation die-off, freshwater habitat degradation, fish kills and overall degradation of water quality for human use.
- Contamination of groundwater from runoff or spills associated with construction activities (eg fuel storage, disturbance of contaminated land in landfill area) with potential impact in groundwater quality
- Drawdown of the groundwater table.

It is not anticipated that large groundwater flows will occur in the road cut batters or even from below the road pavement. It is considered that the quantities of groundwater [if saline] are likely to be small and manageable and captured by the road surface drainage system and fed into sediment basins along with other surface water from the cuttings.

The following table provides a risk assessment of the aspects and impacts relevant to the above activities.

The risk assessment Matrix in the CEMP Section 2.4, has been utilised to determine the risk for groundwater management on the proposed road construction project.

	Consequence		
Likelihood	**High**	**Medium**	**Low**
High	HH	HM	HL
Medium	MH	MM	ML
Low	LH	LM	LL

HH = Extreme Risk	Serious, long term environmental impact/ significant prosecution fines
HM = High Risk	Long term impact/ major breach of legislation
MH, MM, HL = Moderate Risk	Short term impact/ investigation or report to regulatory authority
ML, LH, LM, LL = Low Risk	Minor environmental impact

- **Table 4-1: Approval and License Requirements for Groundwater**

Aspect	**Potential impact**	**Risk Analysis**			
		Extreme	High	Moderate	Low
Cutting	• Localised lowering of groundwater tables in road cutting areas			✓ (MM)	
	• Impacts on flora and waterways due to reduced subsurface flow			✓ (MM)	
	• Release of potentially contaminated groundwater into the surface water system (assumption that no cuts into Mullengandra landfill)			✓ (MM)	
	• Release of potentially saline groundwater into the surface water system			✓ (MM)	
Excavations and construction of drains, sedimentation/ wetland basins in contaminated or saline areas	• Release of potentially contaminated groundwater into the environment due to exposure of shallow groundwater table (only expected near Mullengandra landfill)	✓ (HH)			
	• Release of potentially saline groundwater into the environment				✓ (LL)

Aspect	Potential impact	Risk Analysis			
		Extreme	High	Moderate	Low
	• Localised changed to surface topography resulting in change in surface run-off behaviour and subsequently groundwater releases into the environment in the short and long term			✓ (MM)	
	• Pollution of nearby waterways			✓ (MH)	
	• Adverse impacts on aquatic flora and fauna			✓ (MM)	
Filling/ Embankment Construction	• Localised change to the groundwater regime due to change in surface topography				
Fuel Storage	• Leakage of fuel tanks into ground and subsequent contamination of shallow groundwater table			✓ (MM)	
	• Leakage or runoff from refuelling process and migration to the shallow groundwater table			✓ (MM)	
Disturbance of contaminated land and waste in Mullengandra landfill	• Contamination of groundwater table during excavation.	✓ (HH)			
	• Contaminated runoff from temporary stockpiles reaching the groundwater table.	✓ (HH)			
Construction of new road in low lying areas with shallow groundwater table	• Localised change to subsurface water flows drainage beneath the road (Potential to obstruct groundwater flow beneath the new road)			✓ (MM)	
Water Supply for construction use	• Potential localised drawdown and impact on the local groundwater system if groundwater is used as a water source, including impacts on adjoining properties.			✓ (MM)	
	• Potential reduction to surface water flows in alluvium fed creeks			✓ (MM)	

Aspects identified as having an extreme or high risk (a significant impact) may be downgraded if appropriate controls and measures are put in place and maintained.

5. Environmental Control Measures

Objectives	Targets
To implement best practice measures to ensure that construction activities do not negatively impact the quality or levels of groundwater	No impacts on surface water and soils from groundwater release No significant changes to GW levels and quality
Legislation, Guidelines, References	TT2M MCoA 65 W2M MCoA G1 & G2 Fisheries Management Act 1995 Protection of the Environment Operations Act 1997 Water Act 1912/Water Management Act 2000 ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Relevant Procedures and Forms	Environmental Site Inspection Checklist (Framework CEMP) Construction Method Statements ■ Sediment Basin Management ■ Installing permanent culverts ■ Dewatering
Monitoring	Pre-construction and Construction Monitoring. See **Section 6.1,** Appendix A and Appendix B

Control Measures and Safeguards	Responsibility	Timing / Frequency	Source / Reference
Impact on Shallow Aquifers			
Road will be designed in such a way so that the groundwater flow beneath the surface will not be affected by construction of the road. This will include good drainage under the road to prevent groundwater backing up under or adjacent to the road infrastructure and ponding in the culverts from the upgradient direction in the low lying areas.	Drainage Design Manager	Design Phase	Design Statement of Commitments G2

Control Measures and Safeguards	Responsibility	Timing / Frequency	Source / Reference
Erosion and sediment controls will be managed in such as way so that any runoff does not impact the groundwater aquifers. This will be most applicable in areas underlain by alluvium and in low lying areas including the following: ■ Bells Road Interchange, Tabletop Creek and Bowna Creek ■ Yellow Creek ■ Mullengandra Creek ■ Four Mile Creek	Superintendents / EO / SW	During construction	Soil and Water Management Plan Construction Method Statements Statement pf Commitments G2
Fuel and chemical storage will be undertaken in compliance with the Soil and Water Management Plan	Superintendent / Site Engineer / EO / Construction Environmental Manager	During construction	Soil & Water Management Plan Construction Method Statements Statement of Commitments G2
Management of Intercepted Groundwater (except if the water is contaminated)			
During construction of sedimentation basins and drains, all excavations will be checked for exposure of shallow groundwater.	Superintendents / SW / EO	Construction - Ongoing / daily during construction of basins and drains	TT2MMCoA 65 Construction Method Statements
Groundwater exposed in any sedimentation basins or other excavations will be measured for salinity as per the Soil and Water Management Plan.	Superintendents / EO	Construction - Ongoing / daily during construction of basins and drains	Soil & Water Management Plan

Control Measures and Safeguards	Responsibility	Timing / Frequency	Source / Reference
If water table is exposed, the water will be diverted and collected so that it does not enter surface water systems, and then ■ intercepted water re-used in an ecologically sustainable manner, for example for dust suppression and diluted if necessary; and ■ if significant water is being released, it will be tested for salinity and either: - if necessary and agreed with DWE and DECC, strategically released a controlled manner following protocols agreed with DWE and DECC to avoid pollution. Slow release techniques will be applied to dilute hypersaline water - if the salinity of the water exceeds the levels agreed with DWE and DECC as being suitable for re-use or controlled release , the water will be stored in an appropriate location until it is able to be diluted	Superintendents / Construction Manager	Construction –if water table is exposed.	M2TT MCoA 65 Construction Method Statements - Dewatering
Management of Contaminated Runoff and Groundwater from Mullengandra landfill			
Remediation and excavation at the landfill will be performed under a Remediation Action Plan which will include measures to capture contaminated runoff from stockpiles and specify procedures to prevent escape of contaminated groundwater into surrounding areas.	Environment and Sustainability Manager / Douglas Partners	During remediation activities at Mullengandra landfill and during construction in the area	Remediation Action Plan
Any groundwater seeping from near the landfill at Mullengandra will be analysed for contaminants in accordance with DECC waste guidelines (DECC, 1999). If the water is classified as contaminated, the wastewater will be collected and disposed. This management strategy will be included in a Remediation Action Plan and in consultation with DECC.	Construction Environmental Manager or Groundwater Consultant	During Construction	Remediation Action Plan
Ongoing monitoring will determine the success of any remediation. Any contaminated water will be collected from cut seepages, and either remediated onsite or disposed off-site in accordance with DECC guidelines.	Construction Environmental Manager or Groundwater Consultant	During Construction and as specified in RAP	Remediation Action Plan

Control Measures and Safeguards	Responsibility	Timing / Frequency	Source / Reference
Salinity			
No deep water bores will be installed along the proposed highway corridor in areas affected by salinity outbreaks (Mullengandra Creek – between Mullengandra and "The Hermitage" property)	Environment and Sustainability Manager	Prior to construction / during construction	
Impact on Local Groundwater System including Existing Groundwater Users			
Note: ***Details on use of groundwater in existing aquifers (such as Mullengandra Creek) are still under investigation and as such a decision on use of this source has not been finalised. This section will be updated once more information is available and if groundwater extraction from aquifers is proposed.***	Construction Environmental Manager	On completion of investigations	
Groundwater bores for water supply (if installed) will be located away from existing agricultural bores and potential impacts will be investigated/ considered prior to installation. DWE and local stakeholders (if required) will be consulted with regards to any strategies or proposals relating to installation of new groundwater bores.	Environment and Sustainability Manager	Prior to construction/during construction	Section 2.5 Statement of Commitments G1
If any bores are installed, approval would be sought from DWE according to the *Water Act 1912* or *Water Management Act 2000*. In addition, an appropriate management plan would be prepared for each individual bore on its capacity, yield, and proximity to other bores. No bores will be installed in areas which fall under an embargo.	Environment and Sustainability Manager	Prior to construction/during construction	Section 2.5 Statement of Commitments G1
Liaison with stakeholders will be conducted if existing bores will be destroyed by project alignment.	Environment and Sustainability Manager	Prior to construction	

Control Measures and Safeguards	Responsibility	Timing / Frequency	Source / Reference
Monitoring			
A groundwater monitoring program will be implemented covering both prior to and during the construction to track the change in groundwater quality throughout the project (See **Section 6.1** and **Appendix A**)	Construction Environmental Manager	Pre-construction/during construction	
Settlement			
Appropriate condition surveys would be undertaken of potentially affected infrastructure to assess whether there are any impacts from settlement due to groundwater drawdown	RTA	Pre-construction	Project Plan

6. Inspection, Auditing & Monitoring

6.1 Monitoring

In order to pre-empt groundwater problems that may arise during the construction of the Project, groundwater boreholes will be installed to monitor levels and general groundwater chemistry, and more specifically salinity, at key locations along the alignment prior to, and during construction. The information collected will be used to implement, regulate and if necessary further formulate appropriate mitigation measures to manage the identified groundwater risks.

All groundwater sampling will be undertaken in accordance with internationally accepted sampling methods, which will ensure an appropriate level of quality control is achieved in the process of conducting the monitoring identified below. Refer to **Appendix B** for detailed procedures to be employed for sampling. Consideration will also be given with regards to the Guidelines for Assessment and Management of Groundwater Contamination (DECC 2007).

On-going consultation will occur with DWE and DECC to ensure appropriate controls and methods are employed to manage any salinity issues, which arise throughout the construction

6.1.1 Monitoring Locations

Considering the lack of information and the high variability of the aspects of the groundwater over the length of the Project, the Southern Alliance will adopt an approach which utilises both existing bores in the area and installation of new monitoring bores.

The current proposed approach to selection of monitoring locations is presented below. Proposed locations are presented in **Appendix A**. This approach and locations will be subject to consultation and approval from both DWE and DECC and any stakeholders prior to commencement of the monitoring program. In addition, in the event that any additional monitoring is proposed throughout the project after investigation of the Mullengandra landfill or due to unexpected circumstances, these will also be discussed with DWE and DECC.

Existing Bores

There are several bores and unregistered monitoring wells which already exist which are located close to the alignment. Some of these boreholes will be selected for inclusion into the groundwater monitoring program, subject to approval from the well/bore owners.

Installation of New Bores

Installation of new bores will be subject to the following considerations:

- the sites must be accessible for the duration of construction and for the appropriate period during the operation phase of the project
- the most effective location of the bore to encounter the targeted groundwater. Parameters which have further dictated the location of the bore (as per the table below) include:
    - in close proximity to the apex of the cutting where the surface area of cut is the greatest (i.e. where seepage is most likely)
    - in close proximity to any part of a surface drainage system. Where possible the bores have been located in areas close to watercourses.
- There are two significant cuts proposed for the project, which are located in rock formation where the likelihood of encountering significant groundwater is low. However, to monitor any potential impact, it is proposed to install at a groundwater well at the top of at least one of the significant cuts;
- Locations which will benefit the community and stakeholders after the completion of the project. Monitoring boreholes which fall into this category will be discussed with the relevant stakeholders prior to finalising locations. In some cases these may be monitoring wells which will replace existing monitoring piezometers affected by the construction works or the alignment.

6.1.2 Approach to Groundwater Monitoring

The groundwater monitoring program will consist of the following:

- *Pre-construction monitoring*: at least two monitoring events prior to substantial construction commencing (excluding early works). This will include an initial full screen (see below), followed by insitu monitoring.
- *Construction Monitoring:* Monthly groundwater monitoring during construction
    - locations where substantial cuts will be located.
    - other areas of potential impact (areas where groundwater wells are sunk for abstraction purposes to monitor potential impact on the aquifer)
    - Any contaminated areas identified

The monitoring program will include three main types of parameter groups:

- *Insitu monitoring*
- *Characteristic screen:* to measure basic groundwater chemistry and salinity characteristics
- *Contaminant screen:* monitoring of contaminants.

The parameters in each of these groups, and proposed monitoring frequency are outlined in **Table 6-1** below.

Table 6-1: Monitoring Program and Parameters

Monitoring Group	Parameters	Frequency
Insitu Monitoring	Groundwater Level	▪ Pre-construction Monitoring events ▪ All monitoring events during construction (monthly)
	Salinity/Electrical Conductivity	
	pH	
	Dissolved Oxygen	
	Turbidity	
	Temperature	
Characteristic Screen	Total Nitrogen	▪ First Pre-construction monitoring event (prior to substantial construction) ▪ Annually ▪ In locations where salinity is identified as an issue at appropriate frequency
	Chloride	
	Calcium	
	Sodium	
	Total Phosphorous	
	Sulfate	
	Magnesium	
Contaminant Screen	Aluminium	▪ First Pre-construction monitoring event (prior to substantial construction), ▪ Annually during construction ▪ If contaminated material encountered or results suggest regular monitoring is required
	Nickel	
	Lead	
	Cadmium	
	Copper	
	Iron	

Elevated monitoring results will be investigated to try and establish if they are due to natural fluctuations or impacts from construction.

If monitoring indicates that the project is having a significant impact on groundwater quality or levels, DWE would be consulted immediately and a plan to investigate and manage the impacts would be developed. As no significant impacts on groundwater are predicted, it is not appropriate to develop detailed response plans at this stage.

6.2 Inspection & Auditing

Regular inspections regarding groundwater issues will be performed as part of site inspections. This will include the items listed on the Site Inspection checklist (See Framework CEMP), which will be used as a basis for weekly inspections of all construction areas.

Groundwater monitoring and management would be audited as part of the planned internal and external audits detailed in the CEMP.

7. References

NSW Roads and Traffic Authority (2007a), *Hume Highway Duplication: Woomargama to Mullengandra; Environmental Assessment*, February 2007.

NSW Roads and Traffic Authority (2007b), *Hume Highway Upgrade: Yarra Yarra to Holbrook Woomargama to Mullengandra; Groundwater Assessment*, Prepared by Parsons Brinkerhoff, February 2007.

NSW Roads and Traffic Authority/VicRoads (1995), *Albury Wodonga Potential National Highway Routes, Environmental Impact Station/Environmental Effects Statement*, Prepared by Guteridge Haskins and Davey Pty Ltd, October 1995.

RTA Environmental Services (2007), *Hume Highway Upgrade, Tabletop to Mullengandra: Environmental Review*, January 2007

Department of Environment and Conservation (DECC) (1999), *Environmental guidelines: Assessment, classification & management of liquid & non-liquid wastes*, Printed May 1999, Reprinted with updated contact details June 2004.

Douglas Partners (2007); *Assessment of Available Geotechnical Information, Hume Highway Duplication Tabletop to Woomargama near Albury*, Project 44225A, Prepared for Hume Highway Southern Alliance, February 2007.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000); *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, October 2000

Department of Environmental and Conservation in NSW (DECC) (2007); *Guidelines for the Assessment and Management of Groundwater Contamination* February 2007

Appendix A Groundwater Monitoring Locations and Program

GW Well ID	Type	Approximate Location of Well	Details (depth, geology)	Side of Alignment	Distance from Alignment (m)	Comments/ Rationale
Tabletop to Mullengandra						
HHSA MW1	Proposed	Ch: 157 000	In alluvium	South	<500m	To measure any drawdown or change in flow due to road construction Ch: 156 300 to 157 600
MUPLind 3	Existing	Ch: 147580	~9m	South	135m	To measure change in levels and salinity down gradient of new road
MUPLind 1	Existing	Ch: 145370	<10m	South	95m	To measure change in levels and salinity down gradient of new road MUPLind1 preferable
HHSA MW2	Proposed	Ch: 148150	At the top of cut to 2m below cut (~24m deep)	South (near rest area)	At the edge of project boundary	Cuts at Wrights Property 147800-148400, 148420-148750 and 148870-149550. Largest extent of cut is 22m at Chainage 148150

GW Well ID	Type	Approximate Location of Well	Details (depth, geology)	Side of Alignment	Distance from Alignment (m)	Comments/ Rationale
Mullengandra to Woomargarma						
HHSA MW3	Proposed	Ch: 145150	24m deep	West	At the edge of project boundary	Up gradient background GW levels and quality
HHSA MW4	Existing	CH: 143500	9m	East	At the edge of project boundary	To measure change in levels and salinity down gradient of new road
HHSA MW5	Proposed	Ch: 141000	In alluvium	East	At the edge of project boundary	To measure change in levels and salinity down gradient of tentative potential source well in vicinity of Sweetwater creek.
HHSA MW6	Proposed	Ch:137900	In alluvium	East	At the edge of project boundary	To measure change in levels and salinity down gradient of new road. Place south east so downgradient of MUP55E and MUP56E
HHSA MW7	Proposed	Ch: 134400	In alluvium	West (near rest area)	At the edge of project boundary	To measure change in levels and salinity down gradient of new road

Note: Based on 100 day design

Appendix B Groundwater Sampling Methods

Installation of bores

1.	The bores must be installed in accordance with DWE requirements (licensed contractor and relevant permits)
2.	It will be necessary to have bore information in the form of drillers logs, lithological logs and construction details.
3.	PVC materials will be used to construct the monitoring well

Planning and Preparation Steps

1.	Ensure access to the properties (where the well is located) is permitted if the land is privately owned
2.	Coordinate with the chosen laboratory that sampling is programmed to take place
3.	Plan the transportation method of getting the samples from the site to the lab
4.	Ensure the monitoring equipment is calibrated and in working order
5.	Obtain relevant sample bottles, maps, forms, buckets, contaminant-free water (e.g. town water supply) etc
6.	Prepare decontamination solution – this requires the use of biodegradable Phosphorous-free detergent. This solution should be concentrated into a container (20L) approximately 4 hours prior to use to kill any existing bacteria. For the initial screen of contaminants and the quarterly sampling of parameters familiar to saline water, sodium hypochlorite bleach should be used as the sterilising agent.

Sampling Method

One of two methods will be employed to extract the groundwater, either extraction by (a). pumping or (b). bailing. This will be dependent upon the possibility of encountering problems associated with access to the well and depth at which the groundwater is located.

(a)	Pumping involves the submersion of a mechanical extraction device at/below the groundwater level and purging the well via a pump and sampling accordingly
(b)	Bailing involves the lowering of a ‘bailer’ at/below the groundwater level to physically retrieve a water sample

Decontamination

The equipment used to implement this program will be decontaminated in the following fashion.

1.	Ensure decontamination occurs away from sampling site
2.	Wear clean sterile gloves when conducting the initial screen for contaminants and the quarterly sampling for parameters familiar to saline waters. Monitoring of in-situ parameters need not require sterile gloves
3.	Decontaminate pump/bailer by placing the instrument into the sterilising solution. Run pump to flush system, or otherwise rinse bailer several times in the solution. Ensure the outside and inside of the hose (of the pump) or bailer is cleaned thoroughly
4.	Pump contaminant free water through the pump, or rinse the bailer
5.	For the initial screen of contaminants and the quarterly sampling, the equipment should be allowed to dry before being used to extract samples
6.	The equipment is ready for use

Bore Purging

The purpose of bore purging is to remove any stagnant water in the well prior to the extraction of the sample to be analysed.

1.	Measure the Static Water Level (SWL) of the bore using a sterilized floating device (distance from ground surface to water level). Record the measurement. This measurement will allow the calculation of the volume of the casing as per below:- Volume = IIr ^{2} h Where r = radius of the well h = height of the water (depth of bore minus SWL)
2.	Three times the volume of the well casing should be removed prior to taking a sample of water to be analysed. If using a bailer, ensure it is calibrated to a specific volume. If pumping is used to extract a sample, extracted water should be quantified and measured to ensure the correct volume is removed from the well. If in the process of purging the well it becomes dry and does not recharge immediately, this should be recorded. In-situ parameters as identified in the Groundwater Management Plan can be sampled. If this occurs (dry well) during the initial screen monitoring or during the quarterly monitoring for parameters familiar to saline waters and the well does not recharge within two hours the sample should be extracted and the earliest convenience.

3.	Chemical stability of the discharged water is necessary prior to extracting the true water sample. Measurements of pH, temperature and EC, taken at intervals of 5 minutes or more should differ by less than the following: pH 0.1 unit Temperature 0.2 degrees Celsius EC 5% If stability is not achieved in four volumes of discharge, that should be noted, and a sample taken for analysis
4.	If using a pump to extract a sample for use, it is best that the pump is set at the lowest rate of extraction
5.	All purging equipment should be decontaminated in accordance with those requirements outlined above
6.	If the water appears contaminated, it will be poured into a sealed drum. An appropriately licensed liquid waste contractor would then dispose of the sealed drum.

Field Measurements

1.	All grabs samples should be undertaken in compliance with the attached table titled ‘Sampling Containers, Preservation and Holding Times’ [Extract from Murray-Darling Basin Groundwater Quality Sampling Guidelines]
2.	When taking the in-situ readings of the water to be sampled, it is best to use a container with the discharge pipe at the base of the container, to avoid exposure of the water to the atmosphere
3.	Rinse the probes of the multi-probe unit upon completion of the sampling
4.	The following information should be recorded when undertaking in-situ monitoring and taking grab samples:-Site no, date/time, SWL, necessary calculations to determine volume of purging, confirmation of successful purging process, relevant values of parameters recorded in-situ, name and signature of sampler, method of transport if necessary, number of grab samples retrieved if necessary and any comments

Transportation and storage of samples

1.	Approved containers are to be sought from the lab to undertake the analysis
2.	Samples are to be transported in cool environs to the lab (such as an ice cooler or esky etc)
3.	The temporary storage of any grab samples should be undertaken ensuring tampering cannot take place.
4.	The date/time of the samples leaving site for the lab are to be recorded where necessary