Glenelg Dolomite Quarry

Hydrogeological Assessment

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EXECUTIVE SUMMARY

Sibelco Australia Limited currently produce dolomite from the Tantanoola Quarry 30kms north west of Mt Gambier. The dolomite is used for industrial, construction and agricultural purposes. A new quarry is proposed on Mineral Claim MC4371 which will supply these markets as Reserves at Tantanoola are depleted.

This report documents an assessment of the threat that proposed mining on the Glenelg Dolomite Minerals Claim has on the Piccaninnie Pond Karst Wetlands RAMSAR site and outlines a monitoring program for ensuring that groundwater in this Conservation Area is not impacted by mining.

The northern boundary of the Piccaninnie Pond Karst Wetlands RAMSAR site is located 1.3 kms form the southern boundary of Mineral Claim MC4371 and the planned pit is approximately 2.2 kms north of the karstic sinkholes in the Conservation Area. Sibelco Australia currently produce limestone from the Caroline Quarry which has operated since 1979 and is located adjacent to Minerals Claim 4370, being approximately 2.2 kms north of the Piccaninnie Pond Karst Wetlands RAMSAR site.

The Glenelg Dolomite Mineral Claims lies within the Donovans Management Area of the Lower Limestone Coast (LLC) Prescribed Wells Area (PWA). The LLC PWA Water Allocation Plan sets out the rules for managing and taking prescribed water in the LLC PWA. These include the ability for commercial foresting and groundwater abstraction by other industries at a setback distance greater than 1.2 kms north of the Piccaninne Ponds.

Groundwater in the Donovans Management Area shows positive trends observed over the past five years with most monitoring wells showing rising or stable groundwater levels and decreasing or stable salinities (DEWNR, 2016). Groundwater levels and salinity have effectively been stable or improving in the Donovans Management Area since 2000.

The hydrostratigraphy and groundwater chemistry of dolomite at MC4371 is distinct from that of shallow limestone at Picaninnie Ponds with dolomite in MC4371 being in a recharge zone whereas the Picaninnie Ponds are in a regional groundwater discharge zone.

The Piccaninnie Ponds are an integrated surface water and groundwater dependent ecosystem with ponds fed by deep groundwater discharge from karstic caves and with the ponds discharging to the coast via a drain. The salinity of the Ponds range seasonally from approx. 1760EC in summer to 4000EC in winter. Seasonal peaks in sea level appear to enhance sea water intrusion which influences the chemistry of groundwater discharging in a deep karst spring. The seasonal sea level peak at Piccaninnie Ponds in winter correlates with higher salinity and the timing of this peak overrides the influence of seasonal recharge in freshening the near coastal aquifer. The Piccaninnie Ponds are resilient to land use change because of this hydrology and so the ecology has adapted to this environment. The ponds are seasonally flushed which exports salt and regulates the system and are therefore very robust in respect to groundwater quality change.

Potential salinity change with land use change is considered not to be a threat because of the natural flushing of saline water at Piccaninnie Ponds to the sea and shallow groundwater levels are stable within the coastal discharge zone.

Following mining approval Sibelco plans to install additional shallow piezometers up and downgradient of the approved pit as to monitor for potential hydrocarbon contamination. Sibelco will mine above the shallow watertable and there will be no groundwater abstraction so local hydrology will not be altered.

Mining does not pose a threat to the hydrology of Piccaninnie Ponds.

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1 Introduction

1.1 Report objectives

The aim of this report is to document a Hydrogeological Assessment of the Glenelg Dolomite Mineral Claims to assist with approval for mining.

1.2 Hydrogeological Assessment objectives

The primary objective is to provide an assessment of the threat that proposed mining on the Glenelg Dolomite Minerals Claim has on the Piccaninnie Ponds Conservation Area and to outline a monitoring program for ensuring that groundwater in the Conservation Area is not impacted by mining.

1.3 Work undertaken

In November 2016 Sibelco initiated this Hydrogeological Assessment with a desktop review. Hydrogeological data was obtained from the SA Government Water Connect website and this data with technical reports forms the basis of the assessment. In January 2017 Sibelco contacted DEWNR, who are the DPC internal referral agency on groundwater issues, for assistance. DEWNR provided advice, permission and a key to monitor the State Government Observation (OBSWELL) bores. Monitoring was initiated in February 2017, as part of a planned six-monthly monitoring program with approval, and the results were provided to DEWNR.

2 Background Information

2.1 Glenelg Dolomite Mineral Claims

Sibelco Australia Limited currently produce dolomite from the Tantanoola Quarry 30kms north west of Mt Gambier. The dolomite is used for industrial, construction and agricultural purposes. Sibelco is seeking approval for the establishment of a new quarry at the Glenelg Dolomite Mineral Claims, which will supply these markets as Reserves at Tantanoola are depleted. Approval is determined by the Mining Regulations Branch of the Department of the Premier and the Cabinet (DPC). The proposed Glenelg Dolomite Quarry is located 24kms south-east of Mt. Gambier and is covered by Mineral Claims MC4370 and MC4371. See Figure 1.

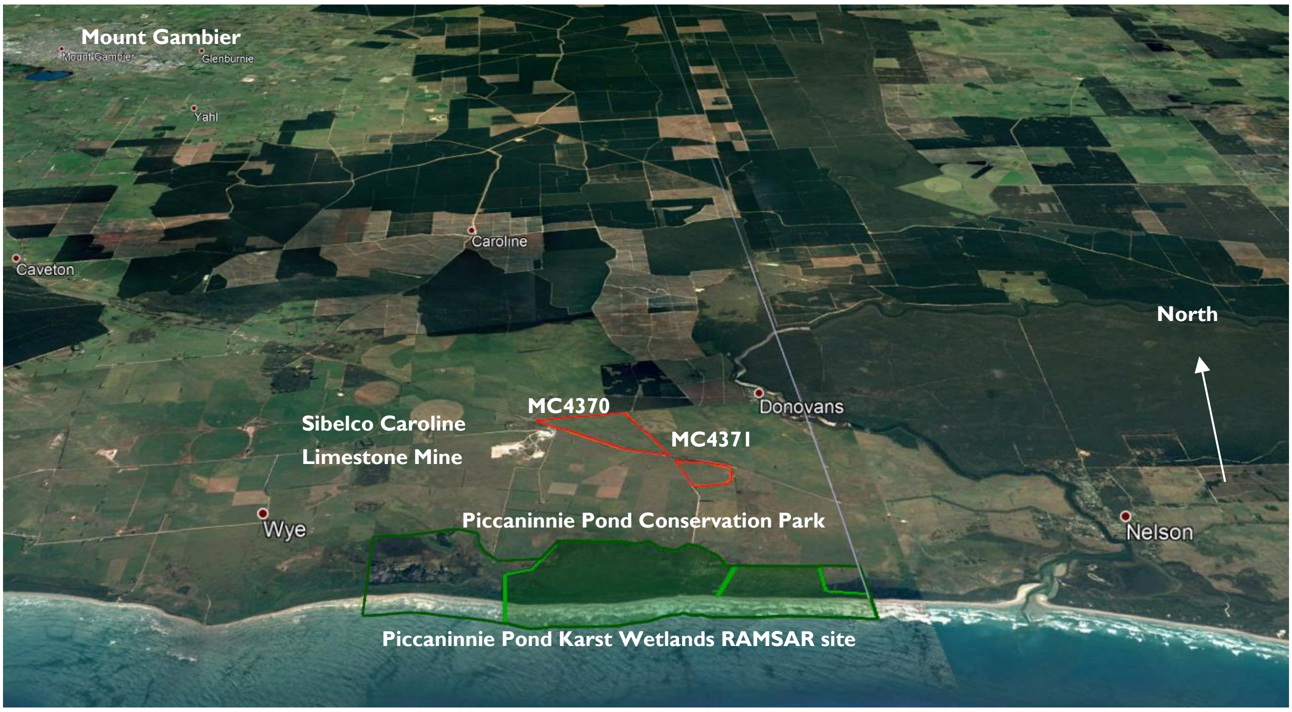

Figure 1: Location Map

2.2 Piccaninnie Ponds Karst Wetlands RAMSAR site

The Piccaninnie Pond Karst Wetlands RAMSAR site, which includes the Piccaninnie Ponds Conservation Park, is located to the south of the proposed Mining Lease as shown in Figure 1. The Piccaninnie Ponds are of high environmental value and are managed by the South Australian Department of Environment and Natural Resources (DEWNR).

2.3 Caroline Limestone Mine

Sibelco Australia currently produce limestone from the Caroline Quarry which is located adjacent to Minerals Claim 4370, being approximately 2.2 kilometres north of the Piccaninnie Pond Karst Wetlands RAMSAR site. The limestone quarry has operated since 1979 and is mined by elevating scrapers, crushed and milled on site before being dispatched by road (DPC website). Mining is permitted to the water table and there has been no impact from mining on the Piccaninnie Pond Karst Wetlands RAMSAR site.

3 Groundwater Monitoring Network

Sibelco has established a groundwater monitoring network at Glenelg consisting of Sibelco, Government and privately owned bores. See Figure 2.

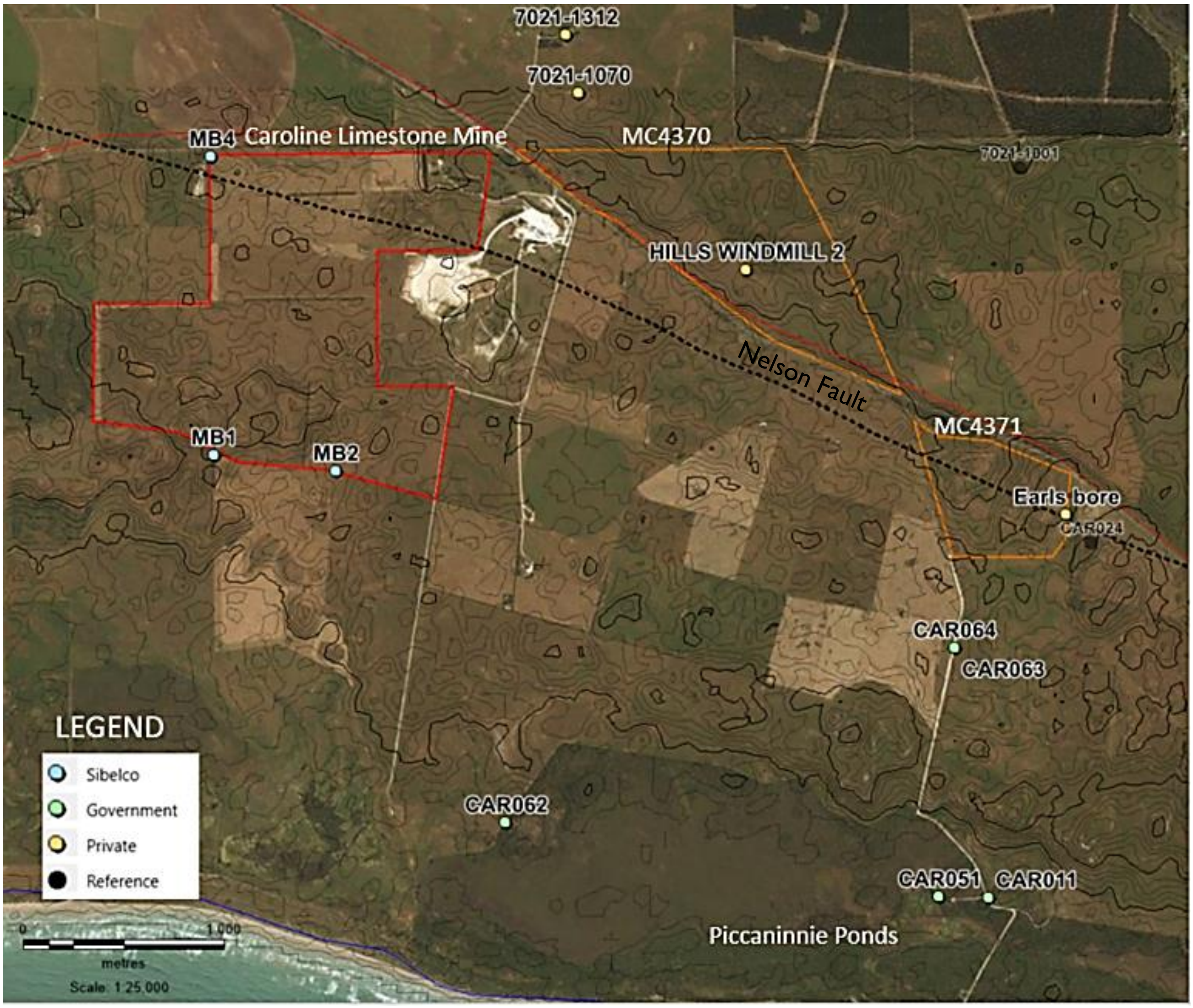

Figure 2: Groundwater Monitoring Network

Pre-mining six monthly monitoring was initiated in February 2017 to provide data for this assessment and to further "benchmark" groundwater data prior to mining. The management of threat that land use changes pose to groundwater level and salinity is outlined in Lower Limestone Coast (LLC) Prescribed Wells Area (PWA) Water Allocation Plan as discussed in Section 5. Sibelco will mine above the waytertable and there will be no groundwater abstraction. Salinity is considered not to be a threat because of the natural flushing of saline water at Piccaninnie Ponds to the sea, as discussed in Section 6. The hydrology of Piccaninnie Ponds will not be altered or impacted by mining. Sibelco plans to install additional shallow piezometers up and downgradient of the approved mining pit primarily for hydrocarbon monitoring purposes but will also provide further information on the local hydrology.

4 Geology

4.1 Stratigraphy

The Gambier Embayment forms the western margin of the Otway Basin and lies mainly in South Australia. During the Middle Oligocene to Early Miocene (38–15 Ma) period marine transgressions with continued subsidence of the Gambier Embayment produced extensive coral development and sedimentation. Uplift and erosion in the mid-Miocene terminated Gambier limestone deposition. The Gambier Limestone is a bryozoan-rich, cool water carbonate, which was subdivided by McGowran (1973) into three units and was further sub-divided by Li et al (2000) into seven distinct units. Based on this work and that of Mustafa and Lawson (2002), the stratigraphy is summarised below:

STRATIGRAPHY				DESCRIPTION
Loxton-Parilla Sand				Sand
Gambier Limestone	**Green Point Member**	UPPER	1	Off white to cream bryozoal Limestone with and without marl and chert (flint) inclusions
			2	Grey Marl with abundant chert (flint) inclusions
		MIDDLE	3	Cream to light grey bryozoal Limestone, with or without chert. May be partially dolomitised.
		LOWER	4	Grey Limestone with abundant Marl
			5	Cream to off-white limestone
	Camelback Member *		6	Grey to pink Dolomite
	Greenways Member		7	Grey Marl with coarse bioclastic, frequent chert and often glauconitic at base
Narrawateruk Marl				Glauconitic Marl
Mepunga Formation				Sand, silt, mud
Dilwyn Formation				Interbedded sequence of clay, sand and gravel

* Geoscience Australia has the dolomitic Camelback Member at the top of the Gambier Limestone sequence

Table 1 Regional Stratigraphy

Dolomite has formed by metasomatic replacement of bryozoal limestone in close proximity to faults such as Sibelco's Tantanoola Dolomite Quarry adjacent to the Tartwaup Fault (DPC website). Dolomite similar in type and composition occurs between Burnda and Compton near Mount Gambier, and a number of irregular lenses arranged en echelon within Gambier Limestone, 30 km southeast of Mount Gambier (Glenelg Deposit) mark the trace of the Nelson Fault over a distance of 2 km (DPC website).

Petrographic and isotopic analysis of dolomites in the Gambier Embayment indicate that the bulk of dolomite is compatible with precipitation from seawater and that crystal growth must have been during periods of marine transgression (Kyser et al, 2002). Dolomitisation of the Mount Gambier Limestone occurred in the Early to mid-Miocene prior to uplift and erosion associated with a late Miocene marine regression. Dolomitisation in saline environments is currently occurring in the Coorong and inland saline lakes.

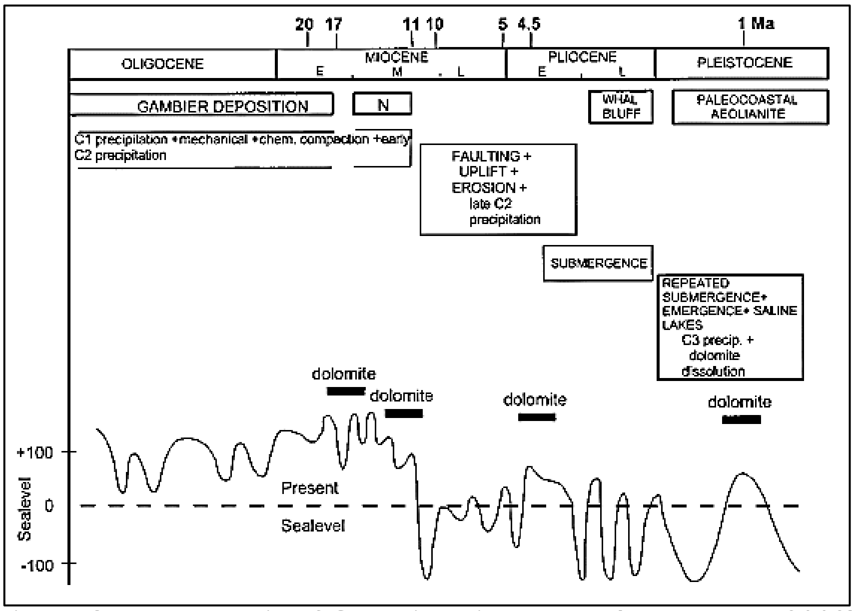

Figure 3: Paragenesis of Gambier Limestone (Kyser et al, 2002)

4.2 Structure

The Gambier Embayment is strongly modified by faulting. See Figure 4.

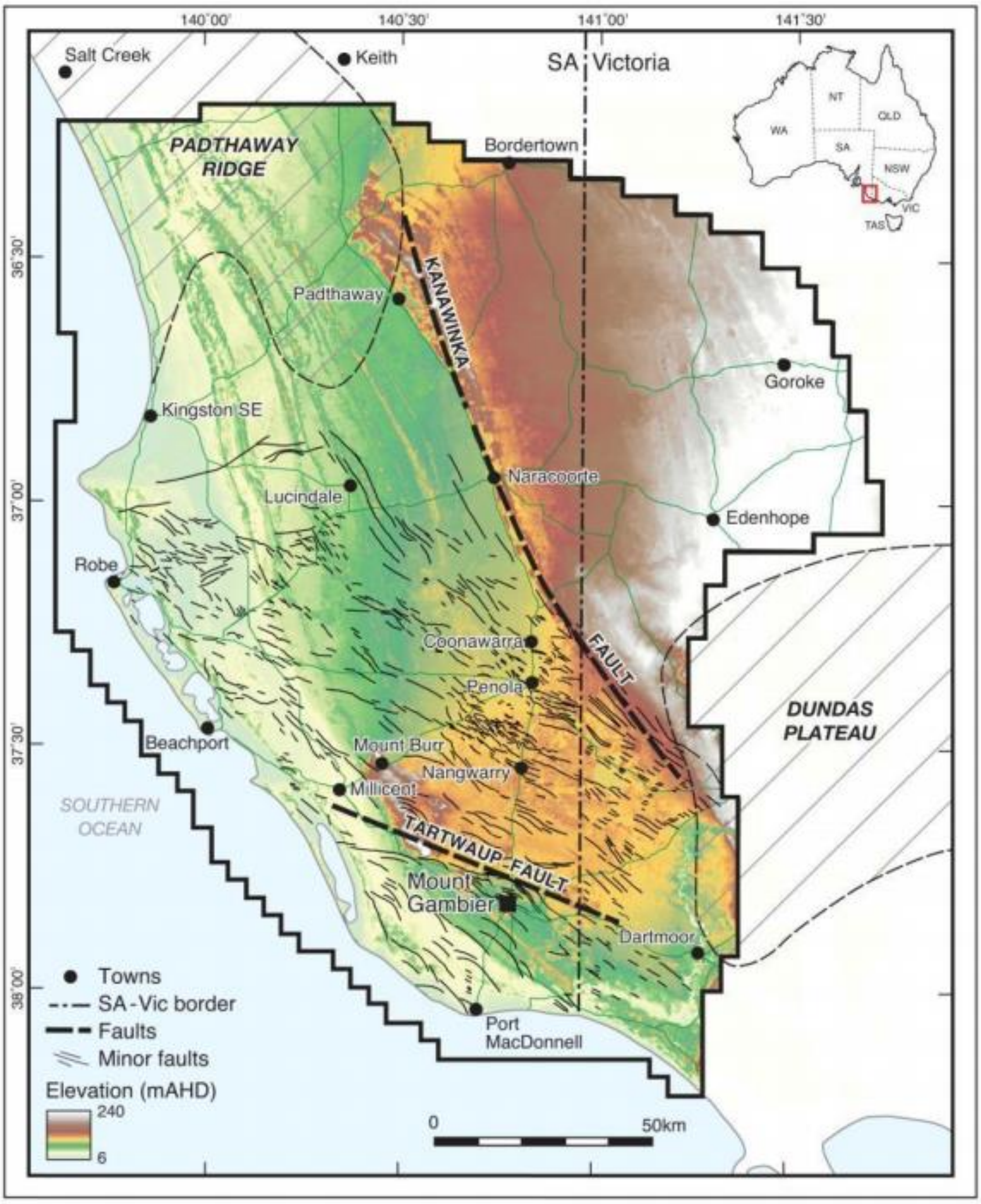

Figure 4: Regional Faulting (from Barnett, Lawson et al, 2015)

The Kanawinka, Tartwaup and Nelson Faults all have southerly block down displacements with parts of the stratigraphy absent due to erosion.

The Kanawinka Fault was studied by Gorey (2008) near Coonawarra, being approximately 80km north of the Glenelg Deposit. Gorey (2008) found that the Gambier Limestone is only exposed in the uplifted section, east of the Kanawinka Fault. The Greenways Member is not present in this area and the Gambier Limestone is generally of the Camelback Member. To the west of the Kanawinka Fault the Dilwyn Formation is 150 metres thicker than to the east of the fault due to erosion with fault movement. NW-SE faulting is prominent in the Dilwyn Formation not only in South Australia but also through-out south-western Victoria with regional southern block down displacements and local horsts. See Figure 5.

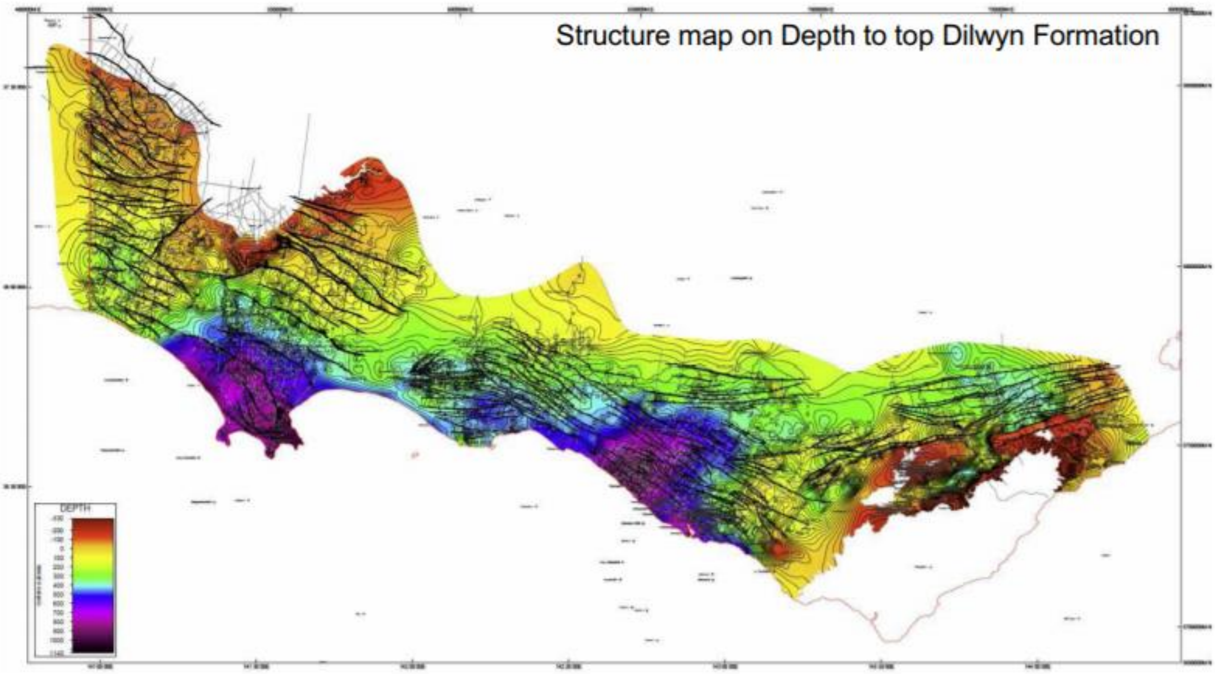

Figure 5: Dilwyn Formation Aquifer Faulting (Southern Rural Water, 2011)

The Tartwaup Fault is a NW-SE trending fault within a regional NW-SE faulting package. At Mount Gambier, south of the Tartwaup Fault, there is extensive faulting with stratigraphic offset, creation of horsts and volcanic extrusion through these crustal weaknesses. See Figure 6.

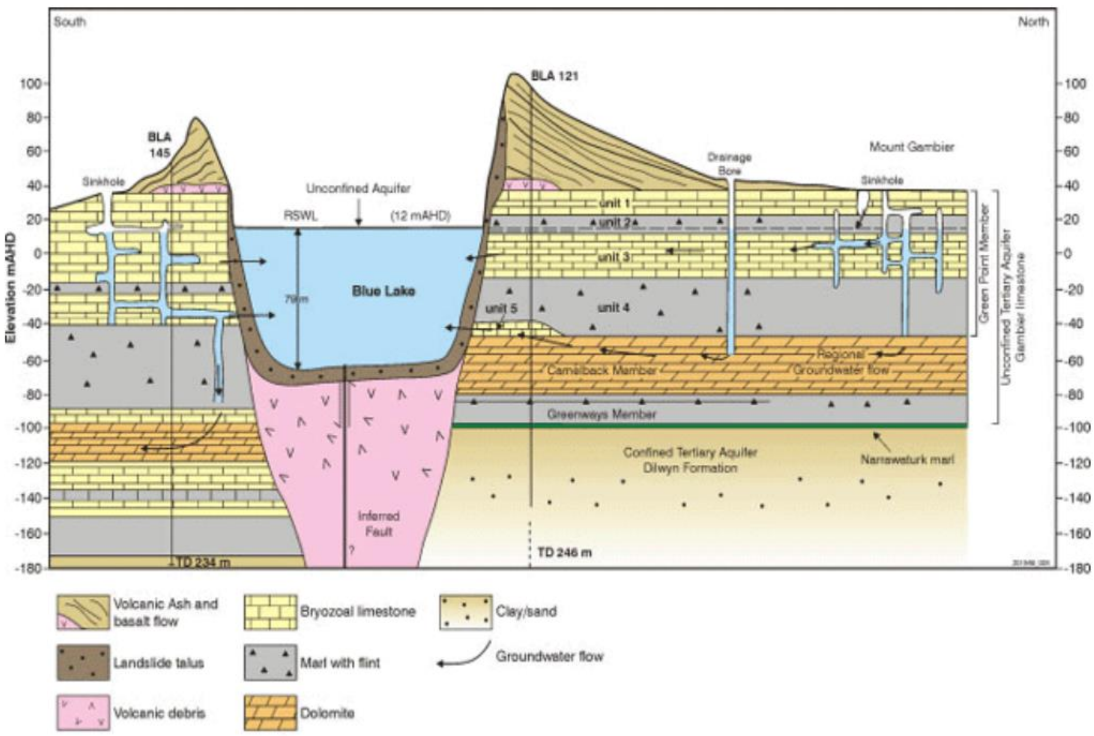

Figure 6: N-S section of the Blue Lake (from DEWNR Fact Sheet, July 2014)

The Nelson Fault is NW-SE trending fault which lies to the south of the Glenelg River Road and North of State Observation Bores CAR063 and CAR064 as shown on the DEWNR (2012) regional fault map below.

Figure 7: Nelson Fault surface expression (from DEWNR, 2012)

The Nelson Fault has an approx. 70-80m south block down throw based on OBSWELL stratigraphic drilling logs and forms a local horst. See Figure 7.

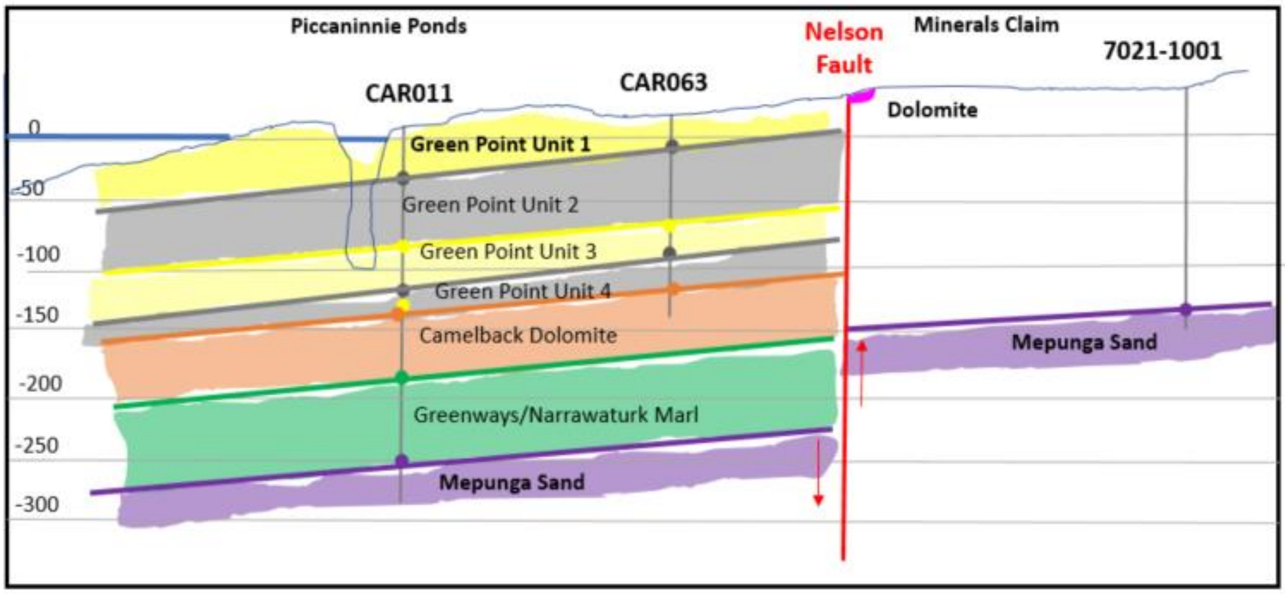

Figure 7: West facing section of Mineral Claim and Piccaninnie Ponds showing Nelson Fault influence on stratigraphy

Erosion with faulting has exposed a dolomitic portion of the Green Member on the Minerals Claim, which based on regional stratigraphy indicates that this is Green Point Member Unit 3.

5 Hydrogeology

5.1 Groundwater Management of the Lower Limestone Coast Prescribed Wells Area

Groundwater Management of South East of South Australia is in accordance with the rules and plans developed for the Lower Limestone Coast (LLC) Prescribed Wells Area (PWA). The LLC PWA was gazetted on 2 December 2004. The groundwater resources across the LLC PWA are administered using 61 Management Areas (MA). These MA have been defined more for administrative convenience rather than on any hydrogeological or hydrological characteristics.

The Glenelg Dolomite Mineral Claims lies within the Donovans Management Area of the LLC PWA and Zone 1A of the Border Agreement Zone. The prescribed water resources of the LLC PWA consist of two distinct underground water systems, being the upper unconfined Tertiary Limestone Aquifer and the lower Tertiary Confined Sand Aquifer. Within the Gambier Limestone Aquifer system there are lithological aquifers of limestone, marl and dolomite of variable permeability, water quality and connectivity.

The LLC PWA Water Allocation Plan sets out the rules for managing and taking prescribed water in the LLC PWA. Groundwater in the LLC PWA is used for many purposes including farming, forestry and public water supply. The dominant land use types in the Lower South East are dryland grazing of modified pastures; softwood and hardwood plantation and irrigated sown grasses (DEWNR, 2011). Environmental values of water include industries, drinking water and ecosystems.

The value of the groundwater resource to ecology is determined by its dependence on groundwater for existence or health. Five types of ecosystems dependent upon groundwater are identified in the LLC PWA being karst; streams/watercourses; wetlands; phreatophytic vegetation and marine environment. Karst features in the coastal region south of Mount Gambier fall into two categories - caves and sinkholes, which lie inland, and rising springs along the coast. Rising springs are karstic cavities along the coast which provide discharge points for the water table.

Groundwater dependence ranges from none to total. Ewens Ponds, Piccaninnie Ponds, Crescent Pond and Hammerhead Pond are found within Conservation Parks and provide well preserved examples of an integrated surface and subsurface underground water dependent ecosystem (South East Natural Resources Board, 2015).

The LLC PWA has identified 13 priority wetland complexes for protection and have specified setback distances from these priority wetland complexes to protect these wetlands. The setback distance protects underground water availability by requiring that any new wells, increases in extraction, or first rotation commercial forests must be located at a distance from the wetland that will not cause a reduction in the relevant watertable. The aim of this is to maintain the available underground water conditions for the wetland. See Table 2.

	Priority Wetland Complex	Management Area	Setback distance for commercial forests (metres)
1	Hog Lake Complex	Mount Benson	1,751
2	Robe to Beachport Coastal Lakes Complex	Waterhouse and Lake George	1,410
3	Lake Hawdon Complex	Bray, Waterhouse, Ross	1,410
4a	Mary Seymour Complex	Moyhall	2,330
4b	Bool Lagoon Wetland Complex	Bool	1,977
5	Deadmans Swamp Complex	Joanna	1,961
6	Green Swamp Complex	Monbulla	1,853
7	Topperwein and Trail Waterhole Complex	Zone 2A	1,640
8	Whennan Complex	Riddoch	1,098
9a	Overland Track Complex	Riddoch	1,098
9b	The Marshes Complex	Hindmarsh	1,684
10	Honan and Kangaroo Flat Complex	Young	1,439
11	Lower SE Rising Springs West Complex (Winterfield Creek, Middle Point Swamp)	MacDonnell, Kongorong	1,211
12	Lower SE Rising Springs Central Complex (Cress Creek Spring, Jerusalem Creek Spring, The Woolwash, Ewens Ponds Complex, Stratman Pond)	Donovans	1,169
13	Lower SE Rising Springs East Complex (Piccaninnie Ponds, Green Point, Pic Swamp)	Donovans	1,169

Table 2: Priority Wetland Setback distances (South East Natural Resources Board, 2015)

Commercial foresting and groundwater abstraction by other industries is permissible 1.2 kilometres north of the Piccaninne Ponds. The northern boundary of the Piccaninnie Pond Karst Wetlands RAMSAR site is located 1.3 kilometers form the southern boundary of Mineral Claim MC4371 and the planned pit is approximately 2.2 kilometers north of the karstic sinkholes. Even though Sibelco could extract groundwater on the Mineral Claims in accordance with the conditions of the LLC PWA Water Allocation Plan, Sibelco will mine above the shallow watertable and there will be no groundwater abstraction.

5.2 Aquifer properties

The aquifer properties of the Gambier Limestone are dictated by stratigraphy. A description of the aquifers based on stratigraphy is presented as Table 3.

STRATIGRAPHY				**AQUIFER DESCRIPTION**
Loxton-Parilla Sand				Unconfined Aquifer
Gambier Limestone	**Green Point Member**	UPPER	1	Unconfined Aquifer, high T, high k
			2	Semi-confined Aquifer, lower T, low k
		MIDDLE	3	Unconfined (?) Aquifer, high T, high k
		LOWER	4	Semi-confined Aquifer, may act as an aquitard, low T, low k
			5	Unconfined (?) Aquifer, high T, high k
	Camelback Member *		6	Semi-confined Aquifer: Dual porosity, extensive fracturing, extremely high porosity, T and k
	Greenways Member		7	Semi-confined Aquifer to Aquitard, very low T, low k
Narrawateruk Marl				Aquitard: Glauconitic Marl, very low T, very low k
Mepunga Formation				Confined Aquifer, variable T and k
Dilwyn Formation				Confined Aquifer, variable T and k

Table 3 Regional Hydro-stratigraphy

5.3 Regional groundwater level and chemistry

Recharge to the Gambier Limestone aquifer occurs regionally through diffuse infiltration of rainfall and is heavily dependent on land use, soil type and annual rainfall. Groundwater flow is southerly to the sea. Groundwater level contours constructed from June 2000 and June 2010 water-level records by DEWNR (2012) are shown in Figure 8.

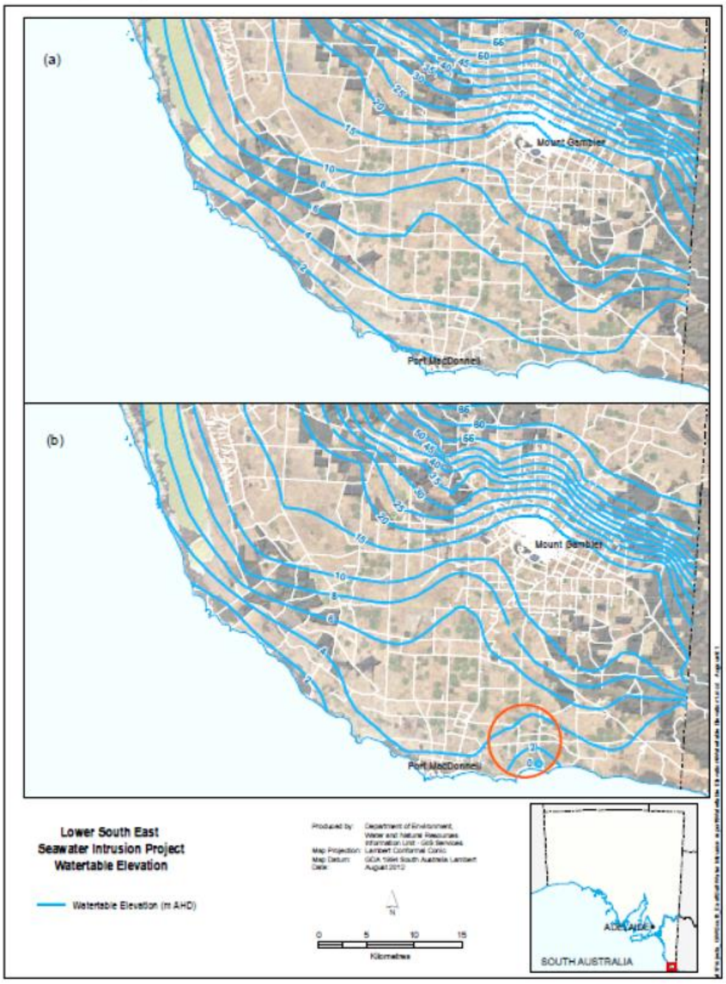

Figure 8: Groundwater level contours (from DEWNR 2012)

The June 2000 groundwater level contours were derived by DEWNR (2012) because the Donovan Management Area at that time was fully allocated but not fully developed. There was no significant change in groundwater levels at Piccaninnie Ponds from June 2000 to June 2010 (DEWNR, 2012). Salinity was generally stable or decreasing. In 2016 the coastal plain and Donovans Management Area has been assigned a green status in the LLC PWA. Groundwater shows positive trends observed over the past five years with most monitoring wells showing rising or stable groundwater levels and decreasing or stable salinities (DEWNR, 2016). Groundwater levels and salinity have effectively been stable or improving in the Donovans Management Area since 2000.

Although the Donovans Management Area has been assigned a green status by DEWNR, there is some risk of seawater intrusion in the future and this risk is being actively managed through ongoing monitoring and groundwater assessments (DEWNR, 2016).

Seawater intrusion and the position of the freshwater -saltwater interface adjacent to the coast has been investigated in the Mount Gambier region since the problem was identified in the 1970's. DEWNR has conducted detailed investigations with extensive sampling since 2008. Regional groundwater chemistry is dominated by Ca-HCO3 type. The influence of seawater can be identified by the addition of NaCl which changes groundwater composition. The origin of water salinity and influence of seawater can also be identified in a number of ways including Na-Cl molar ratio of 0.75-0.86; Br-Cl correlation and can be characterised as an anvil shape in a major ion Stiff diagram as shown in Figure 9.

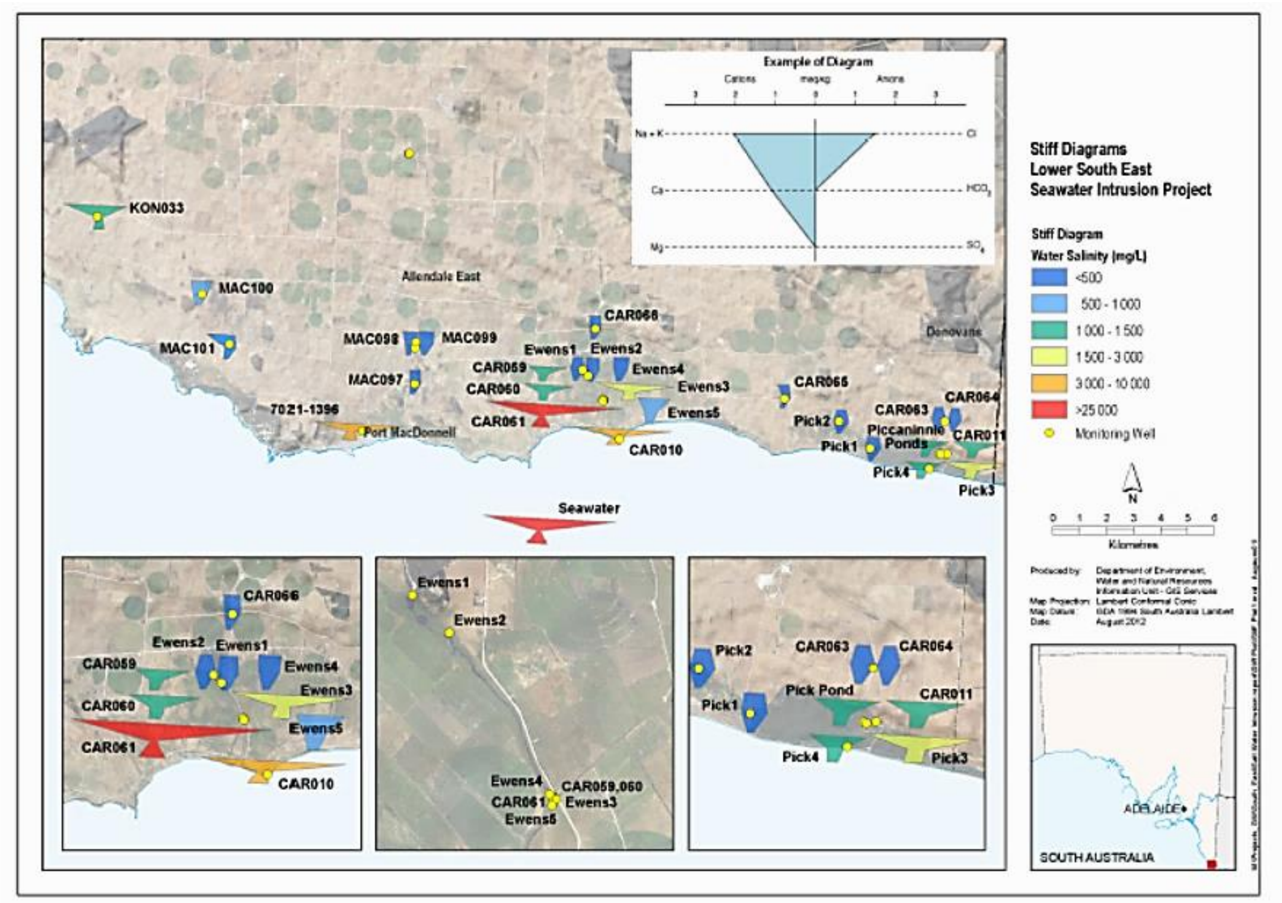

Figure 9: Stiff Diagrams of Seawater Intrusion (from DEWNR 2012)

The percentage of seawater in a sample can be calculated using chloride mass balance assuming that chloride is a conservative ion. The seawater mixing ratio in the Piccaninnie Ponds complex ranges from 3-6% (DEWNR, 2012). Seawater intrusion at Piccaninnie Ponds is discussed further in Section 6.

5.4 Local groundwater level and chemistry

Groundwater flow is westerly to southerly to the sea. The groundwater elevation at MC4371 is estimated to be 4m AHD based on longer term groundwater monitoring of CAR064 and recent monitoring of Sibelco and privately owned bores. See Figure 10.

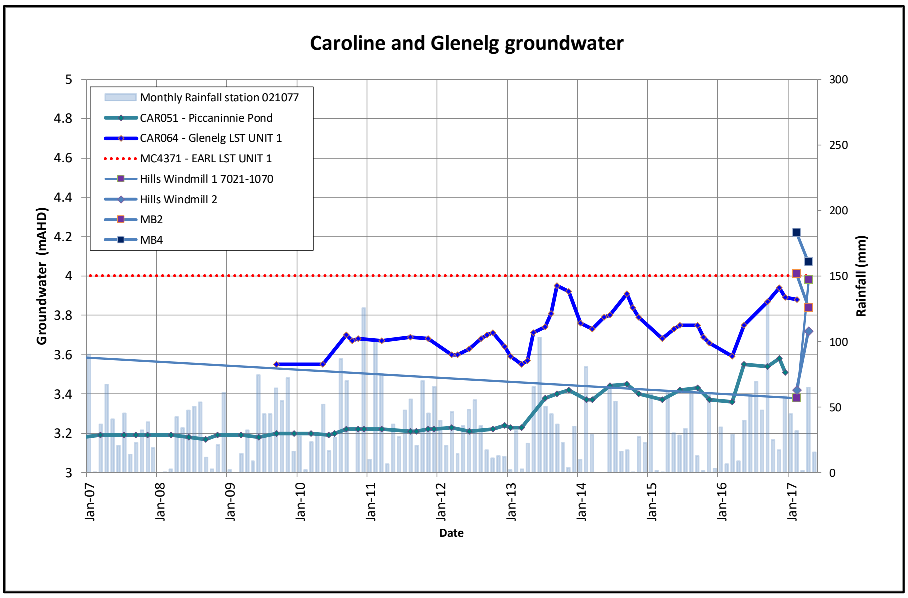

Figure 10: Mineral Calim 4371 groundwater level

CAR064 is nested with CAR063 between Mineral Claim 4371 and Piccaninnie Ponds as shown in Figure 2. A hydrograph of CAR064 and CAR063 is shown in Figure 11.

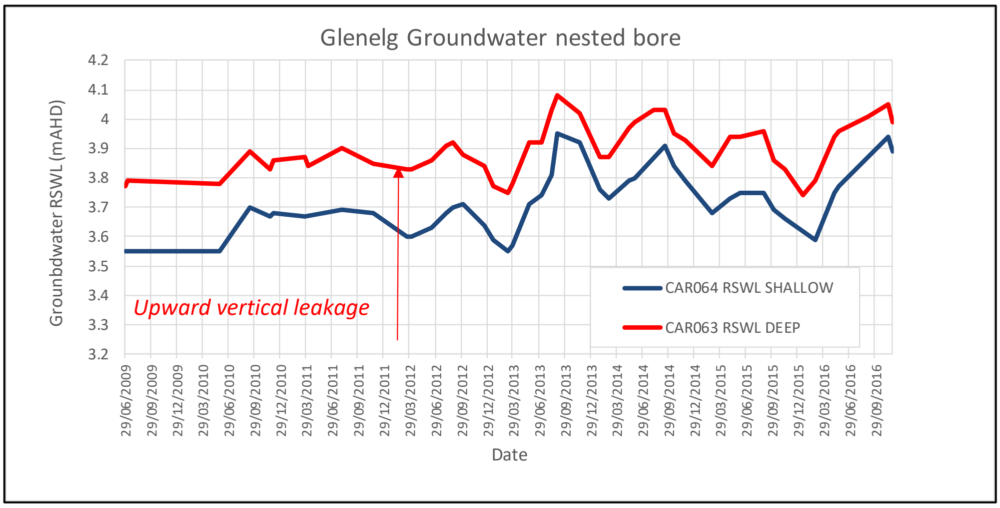

Figure 10: CAR064 and CAR063 hydrograph

The deeper, Camelback Member screened CAR063 has a pressure head more elevated than the shallow Green Point Member No.1 screened CAR064 indicating upward vertical and a groundwater discharge zone south from Mineral Claim 4371.

Groundwater chemistry reveals that shallow groundwater in the Mineral Claims dolomite has elevated Mg as Ca-Mg-HCO3 groundwater and is chemically and hydro-stratigraphically distinct from shallow limestone to the south at Piccaninnie Ponds being Ca-HC03 groundwater. Groundwater in the Picaninnie Pond chasm has elevated Na, Cl and Mg due to seawater intrusion. A summary of local chemistry is presented as Table 4 with an accompanying map on groundwater types as Figure 11.

Bore	Aquifer screened	Date	Water level mAHD	EC	Ca	Mg	Mg: Ca molar ratio	Groundwater type	Na	Cl	Br	Cl:Br molar ratio	Na:Cl molar ratio	Seawater Cl mixing ratio	Seawater Br mixing ratio
7021-1312	Greens Point Unit 3	Feb-17		763	73	21	11.5	Dolomite	50	84			0.92	0.4%	
7021-1070	Greens Point Unit 3	Feb-17	**3.38**	995	84	13	6.2		98	143			1.06	0.7%	
Hills Windmill 2	Greens Point Unit 3	Feb-17	**3.42**	745	58	14	9.7		68	90			1.17	0.5%	
MB4	Greens Point Unit 3	Feb-17	**4.22**	692	71	19	10.7		38	55			1.07	0.3%	
Earls bore		Nov-16	**3.24**					Unknown							
MB2	Greens Point Unit 1	Feb-17	**4.01**	626	69	6	3.5	Limestone	38	68			0.86	0.4%	
MB1	Greens Point Unit 1	Feb-17	**4.29**	736	67	8	4.8		77	91			1.30	0.5%	
CAR024	Greens Point Unit 1	Jan-72			94	8	3.4		47	86			0.84	0.4%	
CAR064	Greens Point Unit 1	Aug-09		755	78	19	9.8	Limestone - CAR063 upward vertical lekage	46.3	78	0.26	676	0.92	0.4%	0.4%
CAR064	Greens Point Unit 1	May-10		700	73	19	10.5		39.8	80	0.26	693	0.77	0.4%	0.4%
CAR064	Greens Point Unit 1	Feb-17	**3.88**	624	68	10	5.9		36	66			0.84	0.3%	
CAR063	Camelback Member	Aug-09		805	79	22	11.4	Dolomite	52.1	84	0.31	611	0.96	0.4%	0.5%
CAR063	Camelback Member	May-10		745	75	22	11.6		43.5	82	0.27	684	0.82	0.4%	0.4%
CAR062	Greens Point Unit 1	Feb-17		681	66	9	5.5	Limestone	54	110			0.76	0.6%	
chasm 10m	Greens Point Unit 1	Oct-09		2524	88	53	24.0	Limestone - sea water inflluenced	336	650	2	732	0.80	3.4%	3.2%
chasm 10m	Greens Point Unit 1	Feb-17		1280	77	31	16.1		130	282			0.71	1.5%	
chasm 65m	Greens Point Unit 3	Oct-09		2561	87	53	24.4		332	680	2.2	697	0.75	3.5%	3.5%
CAR011	Green Point Unit - Camelback Member	Oct-09		2680	88	59	26.8		357	670	1.9	795	0.82	3.5%	3.0%
CAR011	Green Point Unit 1- Camelback Member	May-10		3275	103	61	23.5		424	910	3	684	0.72	4.7%	4.8%
seawater	n/a	Nov-10			356	1250	140.7	n/a	9650	19900	65	690	0.75	103.5%	103.0%

Table 4: Local water chemistry

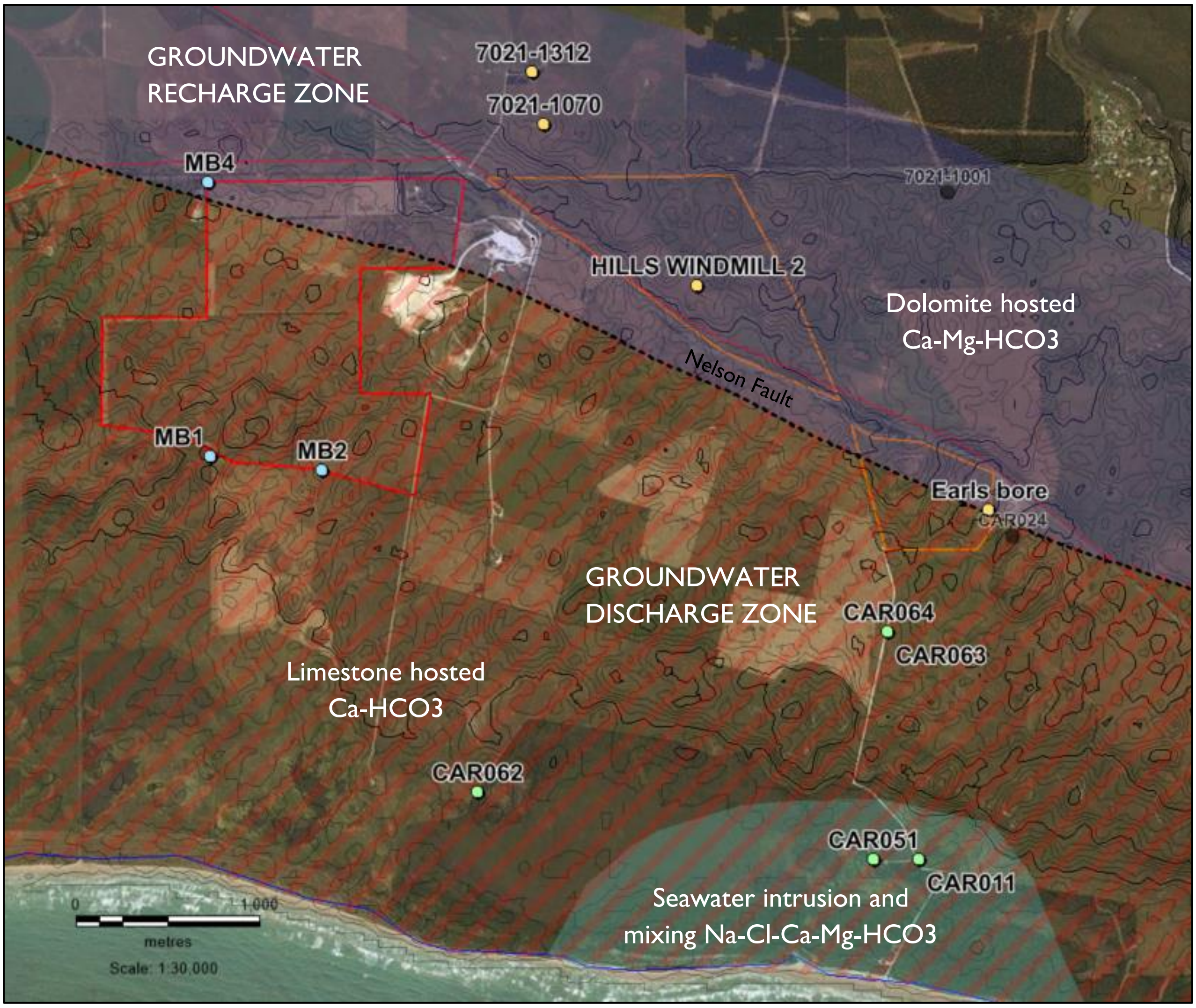

Figure 11: Local groundwater types

6 Piccaninnie Ponds

6.1 Environmental value

The Piccaninnie Pond Karst Wetlands RAMSAR site conserves a wetland fed by freshwater springs in a karst landscape. It contains three main features of interest to cave divers being the 'First Pond', the 'Chasm' and the 'Cathedral'. Freshwater rising to the surface under pressure has eroded a weakness in the limestone to form The Chasm. This same process has formed the large underwater cavern known as The Cathedral creating its majestic white walls of sculptured and scalloped limestone. Freshwater springs bubble up into sand on the beach (National Parks South Australia website).

6.2 Hydrogeology

The Piccaninnie Ponds are an integrated surface water and groundwater dependent ecosystem (South East Natural Resources Board, 2015) with ponds fed by groundwater discharge See Figure 12.

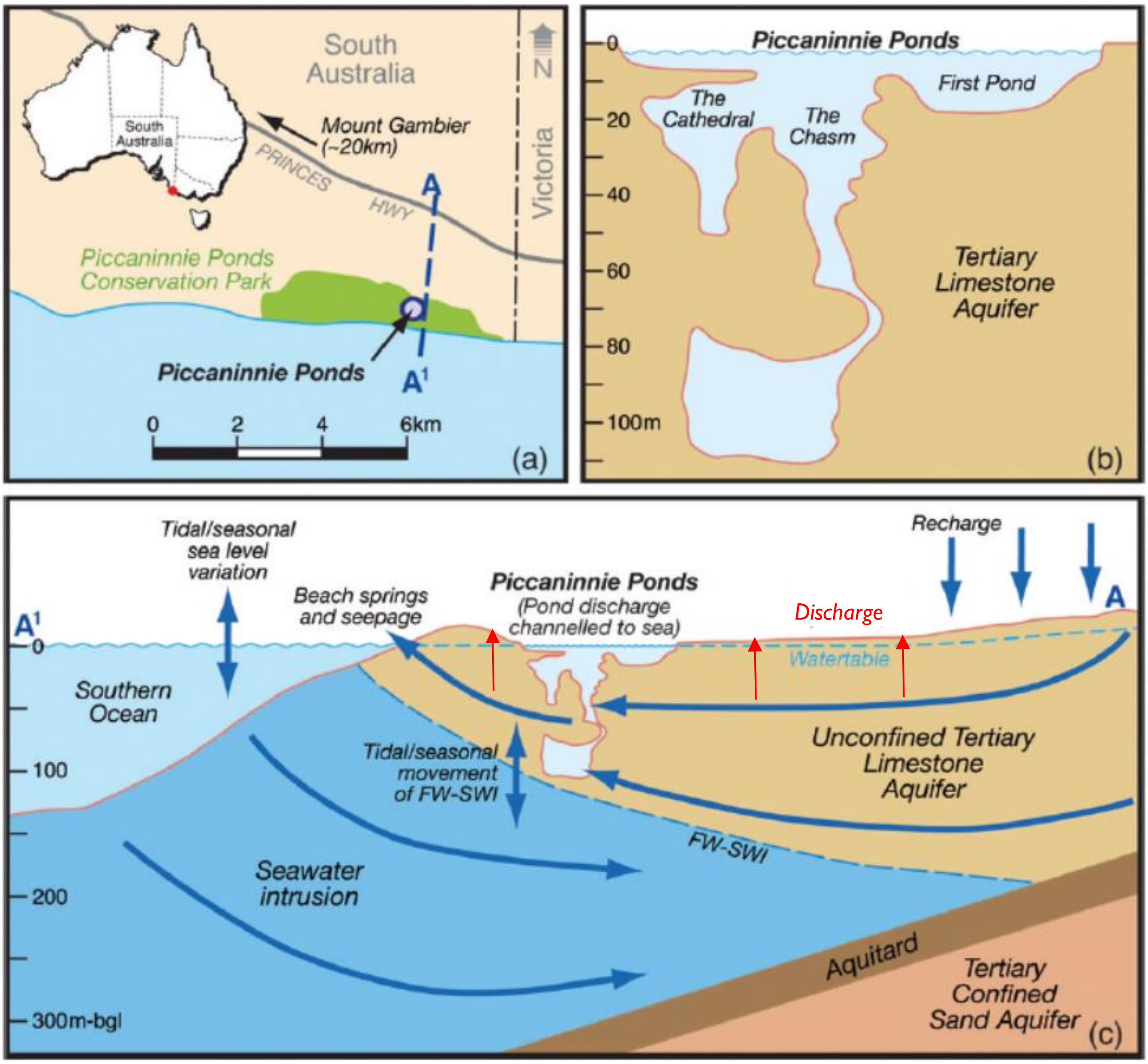

Figure 12: Conceptual Model (modified from Wood and Harrington 2015)

The ponds discharge to the coast via a drain 300 south-west of the Main Ponds complex.

Groundwater discharge is thought to occur along the whole section of the pond chasm with the greatest discharge in a highly-fractured zone at 36 metres at the base of the Green Point Unit Member No 1 (Wood et al, 2011).

The chemistry of water in the ponds is dominated by Na-Ca-Cl type whereas the regional groundwater chemistry is dominated by Ca-HCO3 type, which is attributed to the presence of a saline-freshwater interface within the aquifer discharging into the ponds. Groundwater salinity profile of CAR011 ranges between 2000-4000EC to a depth of 80 metres and then sharply increase. See Figure 13.

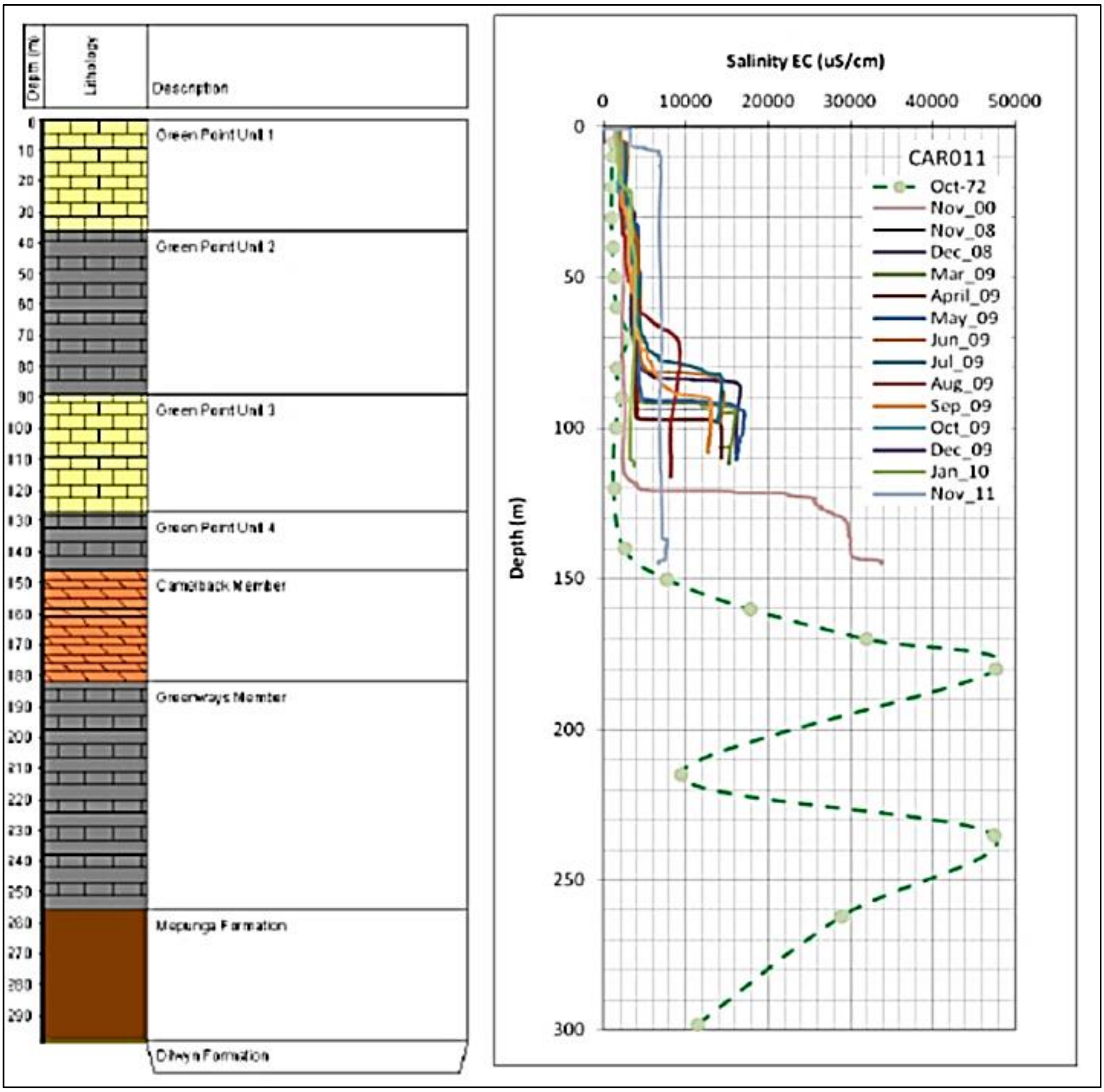

Figure 13: CAR011 geology and salinity (combined from DEWNR 2011 and 2012)

The salinity increase may represent a transitional zone between the seawater and freshwater front or alternatively the area at the site could be subject to seasonal intrusion and regression of seawater which results in this water type mixing and cation exchange processes (DEWNR, 2012).

The salinity of the Ponds range seasonally from approx. 1760EC in summer to 4000EC in winter. Wood and Harrington (2015) investigated this seasonally trend and concluded that seasonal peaks in sea level appear to enhance sea water intrusion which influences the chemistry of groundwater discharging in a deep karst spring. See Figure 12.

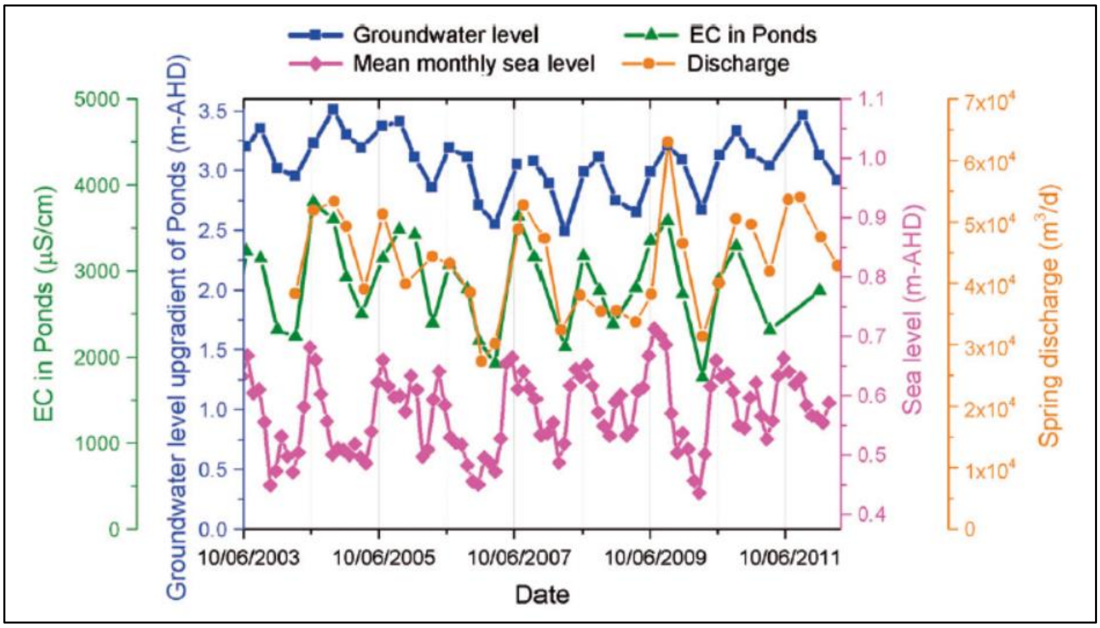

Figure 12: Seasonal variation in level and salinity (from Wood and Harrington 2012)

The seasonal sea level peak at Piccaninnie Ponds is in winter which correlates with higher salinity. and the timing of this peak overrides the influence of seasonal recharge in freshening the near coastal aquifer (Wood and Harrington, 2015).

6.3 Resilience to land use change

The Piccaninnie Ponds are resilient to land use change because the salinity of the ponds seasonally varies naturally by up to 2000EC and so the ecology has adapted to this environment. In addition, the ponds are seasonally flushed which exports salt and regulates the system. The Piccaninnie Ponds are therefore very robust in respect to groundwater quality change.

Groundwater levels in the Donovans Management Area are stable under the current management regime and the groundwater response of bore CAR051 in the last few years indicates that groundwater management by the LLC WAP provides adequate protection of Piccaninnie Pond Karst Wetlands RAMSAR site under the current climatic conditions.

The hydrostratigraphy and groundwater chemistry of dolomite at MC4371 is distinct from that of shallow limestone at Picaninnie Ponds with dolomite in MC4371 being in a recharge zone whereas the Picaninnie Ponds are in a regional groundwater discharge zone.

New groundwater abstraction is permitted at a distance greater than 1.2 kilometres from Piccaninnie Ponds as specified in the LLC PWA Water Allocation Plan. Sibelco will not be abstracting groundwater and therefore will not change the hydrology and mining does not pose a threat to the hydrology of Piccaninnie Ponds.

7 References

Barnett, S, Lawson J, Li C, Morgan L, Wright S, Skewes M, Harrington N, Woods J, Werner A and Plush B, 2015. A Hydrostratigraphic Model for the Shallow Aquifer Systems of the Gambier Basin and South Western Murray Basin. Goyder Institute for Water Research. Published Technical Report Series No. 15.15.

Department of Environment, Water and Natural Resources (DEWNR) website
http://www.environment.sa.gov.au/Home

DEWNR, 2011. Measurement and Evaluation of Key Groundwater Discharge sites on the Lower South East of South Australia. Published Technical Report 2011/14.

DEWNR, 2012. Preliminary investigation of seawater intrusion into a fresh water coastal aquifer – Lower South East. Published Technical Report 2012/01.

DEWNR, 2014. Everything you ever wanted to know about the Blue Lake A comprehensive resource. Fact Sheet July 2014.

DEWNR, 2016. Lower Limestone Coast PWA Unconfined aquifer. 2016 Groundwater level and salinity status report.

Department of the Premier and Cabinet website
http://minerals.statedevelopment.sa.gov.au/geoscience/mineral_commodities/limestone

Gorey, P, 2008. Monitoring and modelling natural and anthropogenic inputs of nitrogen into an unconfined aquifer in the South East of South Australia. Flinders University thesis.

Kyser T.K, James, N.P and Bonne, Y, 2002. Shallow burial dolomitization and dedolommitization of Cenozoic cool-water limestones, Southern Australia: geochemistry and origin. Journal of Sedimentary Research Vol 72, No 1, January 2002

Li, Q, McGowran Band White M.R, 2000. Sequences and biofacies packages in the mod Cainozoic Gambier Limestone, South Australia: reappraisal of foraminiferal evidence. Australian Journal of Earth Sciences 47: 955-970.

McGowran, B 1973. Observation bore no 2. Gambier Embayment of the Otway Basin: Tertiary micropalaeontology and stratigraphy. Mineral Resources Review, South Australia, 135:43-55.

Mustafa, S and Lawson J for the Department of Water Land and Biodiversity Conservation, 2002. Review of Tertiary Gambier Limestone aquifer properties, lower South-East, South Australia. Published Technical Report 2002/24.

National Parks South Australia website
https://www.environment.sa.gov.au/parks/Find_a_Park/Browse_by_region/Limestone_Coast/piccaninnie-ponds-conservation-park

South East Natural Resources Management Board, 2015. Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area. Published report.

Southern Rural Water, 2011. Dilwyn Formation Aquifer Study. Published Report.

Wood C and Harrington G.A, 2015. Influence of Seasonal Variations in Sea Level on the Salinity regime of a Coastal Groundwater-Fed wetland. Groundwater Vol 43, No 1.