Environment Protection Authority

Groundwater Prohibition Area (GPA) – Tonsley and portions of Clovelly Park, Mitchell Park and Marion

EPA Determination Report for consultation, November 2020

South Australia

Groundwater Prohibition Area (GPA) – Tonsley and portions of Clovelly Park, Tonsley, Mitchell Park and MarionEPA Determination Report for consultation

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ISBN 978-1-876562-62-5

November 2020

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Abbreviations

auditor	site contamination auditor or site auditor
ASC NEPM	*The National Environmental Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013)*
BTEX	benzene, toluene, ethylbenzene and xylene (aromatic hydrocarbons)
consultant	site contamination consultant
DCE	cis-1,2-dichloroethene
DEW	Department of Environment and Water (formerly Department for Environment, Water and Natural Resources)
DNAPL	dense non-aqueous phase liquid
EP Act	*Environment Protection Act 1993* (South Australia)
EPA	South Australian Environment Protection Authority
GPA	groundwater prohibition area
groundwater plume	groundwater contaminant plume
IARC	International Agency for Research on Cancer
LNAPL	light non-aqueous phase liquid
NATA	National Association of Testing Authorities
PCE	tetrachloroethene, perchloroethene, perchloroethylene or tetrachloroethylene
PFAS	per- and poly-fluoroalkyl Substances
SA Health	Department for Health and Wellbeing (South Australia)
S83A	reference to section 83A of the *Environment Protection Act 1993* Notification of site contamination that affects or threatens groundwater
TCE	trichloroethene or trichloroethylene
TDS	total dissolved solids
VC	vinyl chloride
US EPA	United States Environmental Protection Agency
WHO	World Health Organization
WQ Policy	*Environment Protection (Water Quality) Policy 2015*

Summary

In South Australia, section 103S of the *Environmental Protection Act 1993* (EP Act) establishes the legislative framework for the prohibition and/or restriction on taking water affected by site contamination. In establishing a groundwater prohibition area (GPA), the Environment Protection Authority (EPA) must be satisfied that there is site contamination that affects or threatens water, and action is necessary to prevent actual or potential harm to human health or safety. To this end, the EPA applies the 'precautionary principle[1]' to the assessment of risk of site contamination.

The EPA is considering the establishment of a GPA in Tonsley and portions of Clovelly Park, Mitchell Park and Marion (Figure 1). The proposed GPA will encompass the shallow unconfined aquifer at the base of the Pooraka Formation and the upper Hindmarsh Clay Quaternary aged aquifer. The GPA is proposed to extend to a total depth of 25 m below ground level (including a vertical and lateral buffer zone).

This report provides a comprehensive summary of the technical information reviewed by the EPA for the consideration of establishing a GPA. This report provides concise information on the requirements for supporting a GPA and describes the roles of SA Health and the EPA, and outlines the legislative framework applied in establishing a GPA. This report provides a summary of determinations into the nature and extent of contamination in the groundwater throughout the localised aquifer system. This iterative process is achieved through reviews of supporting evidence documenting site contamination in soil and groundwater in the Tonsley area and portions of Clovelly Park, Mitchell Park and Marion, supporting the GPA determination.

The description of the review process in this report is intended to assist local residents, businesses, community groups, local schools, kindergartens, childcare centres, local Aboriginal groups and council (City of Marion) in understanding why the EPA considers a prohibition on the taking of groundwater to be necessary.

This report provides a description of:

- the legislative framework relevant in establishing a GPA
- the determined groundwater prohibition area
- the role of the EPA and site contamination professionals
- the role of SA Health
- the aquifers affected by site contamination
- specific details relating to the source sites
- the historical and ongoing assessment and remediation of these sites
- justification for a buffer zone and its purpose
- community engagement
- public access to information.

A GPA is established by notice in the Government Gazette and details placed in the EPA Public Register[2].

Where a GPA is established, future purchasers of properties will be made aware of the prohibition and/or restriction on taking of groundwater via the Form 1 statement according to section 7 of the *Land and Business (Sale and Conveyancing) Act 1994.*

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[1] Where there are threats or serious irreversible damage to human health and or the environment, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation or human exposure.

[2] Pursuant to section 109 of the EP Act

A person must not contravene the prohibition or restriction[3]. A maximum penalty of $8,000[4] applies (Division 5 fine).

It is important to note that SA Water mains water and rainwater are not affected by the GPA.

For further information on site contamination please contact:

Site Contamination Branch	Telephone:	(08) 8204 2004
Environment Protection Authority	Free call (country):	1800 729 175
GPO Box 2607	Website:	https://www.epa.sa.gov.au/
Adelaide SA 5001	Email:	EPASiteContam@sa.gov.au

For health-related information on site contamination please contact:

Scientific Services Branch	Telephone:	(08) 8226 7100
Public Health Services	SA Health website:	www.sahealth.sa.gov.au
PO Box 287	Email:	public.health@health.sa.gov.au
Rundle Mall SA 5000		

[3] Pursuant to section 103S(3) of the EP Act

[4] At the time of publication of this report

1 Introduction

1.1 Background

In South Australia, groundwater is widely regarded as an important supplementary resource to mains and rainwater. In recent times variable seasonal weather conditions, including dry hot summers, have placed an increased demand on groundwater use for domestic and irrigation purposes. Groundwater contamination arising from point sources and diffuse sources can threaten the health of the whole aquifer system, potential groundwater users and groundwater dependent ecosystems[5]. The use of groundwater could result in an increased risk of human exposure to chemical substances that exist in the groundwater.

When the Environment Protection Authority (EPA) receives information regarding site contamination the potential for widespread groundwater contamination exists. When this is evident, primarily in residential areas, the process for determining whether a groundwater prohibition area (GPA) is necessary. Through the determination process, the EPA considers sources of groundwater contamination, the nature and extent of groundwater plume, the groundwater exposure pathways and human receptors. The protection of human health and safety is the primary objective of the EPA when considering establishing a GPA and the EPA aims to apply the precautionary approach to ensure that site contamination does not impact on human health or safety.

The establishment of a GPA can eliminate the pathway between the contaminated groundwater and human contact, and prevent or eliminate human exposure to the contaminants of concern. A GPA provides a long-term regulatory solution in which the use of groundwater may be prohibited for any purpose or restricted in the uses post abstraction (extraction). There may be exemptions for environmental monitoring or industrial uses.

1.2 Legislative framework

Part 5B of the *Environment Protection Act 1993*[6] (EP Act) defines site contamination and section 103S (Table 1) establishes the legislative framework for the prohibition and/or restriction on taking water affected by site contamination. In establishing a groundwater prohibition area (GPA), the EPA must be satisfied there is site contamination that affects or threatens water, and action is necessary to prevent actual or potential harm to human health or safety.

Part 10 of the EP Act sets out the Objectives of the Act, including the ability to apply the precautionary approach and Part 10A establishes a legislative framework for managing site contamination in South Australia, including provisions[7] which enable the EPA to prohibit or restrict the use of groundwater (Table 1).

If groundwater is affected by site contamination[8] and there is a likelihood it may be used for domestic or irrigation purposes then the establishment of a GPA may be warranted for the protection of human health.

A GPA may be necessary in circumstances where remediation approaches have not yet addressed risks to human health associated with groundwater contamination. Where pervasive or persistent contaminants have been identified in the groundwater, possibly extending into residential or sensitive areas, the EPA will make a regulatory determination to establish a GPA.

5 Ecological habitats established in groundwater fed surface water expressions.

6 www.legislation.sa.gov.au/index.aspx

7 Pursuant to section 103S of the EP Act

8 Pursuant to Part 5B of the EP Act

Table 1 Section 103S of the *Environment Protection Act 1993*

Section 103S – Prohibition or restriction on taking water affected by site contamination
(1) If the Authority is satisfied that – (a) there is site contamination that affects or threatens water; and (b) action is necessary under this section to prevent actual or potential harm to human health or safety, the Authority may, by notice in the Gazette, prohibit or restrict the taking of the water. (2) A notice under this section must – (a) specify the water to which it relates; and (b) give particulars of the site contamination affecting the water. (3) A person must not contravene a notice under this section. Penalty: Division 5 fine. (4) The Authority may, by notice in the Gazette, vary or revoke a notice under this section.

A maximum penalty of $8,000[9] applies for the contravention of a notice under section 103S of the EP Act (Appendix 1).

1.3 Groundwater prohibition area

The EPA is considers that it necessary to establish a GPA in Tonsley and portions of Clovelly Park, Mitchell Park and Marion. Figure 1 identifies the proposed area currently under consideration.

Groundwater from the upper Quaternary aged aquifer (8–23 m below ground level) are known to be contaminated. The underlying deeper Quaternary aged aquifers (greater than 25 m below ground level), and the Neogene and Paleogene aged aquifers or Tertiary aquifers (greater than 140 m below ground level) are not known to be affected by site contamination arising from the known contamination sources in the area.

Information gathered during the assessment of site contamination at various (current and former) industrial and manufacturing sites (Figure 2) informs the broad conceptual site model developed in this report for the proposed GPA (section 2). The development of the conceptual site model assists in the understanding of groundwater contamination within the greater Clovelly Park, Tonsley, Mitchell Park and Marion area. Audited sites, historically assessed sites and sites where a notification of site contamination of underground water has been made to the EPA, have also been considered. A summary of comprehensive site contamination assessments and remediation where contamination has been assessed and found to be contributing to groundwater contamination is presented in Appendix 2.

1.4 Role of EPA, SA Health and site contamination professionals

Contamination of groundwater is largely historic in nature and generally caused by past industrial and infrastructure management practices. The EP Act establishes a legislative process to regulate site contamination caused by these historical practices. The EPA regulates the assessment and remediation of site contamination across South Australia in accordance with relevant legislation[10], EPA policies[11] and guidelines[12] [13]and where necessary, implements controls to protect human health and safety or the environment.

9 At the time of publication of this report

10 EP Act

11 Water Quality Policy

12 *Guidelines for the assessment and remediation of site contamination* (EPA 2019)

13 *Regulatory and orphan site management framework* (EPA 2017)

The EPA relies on reports produced by site contamination consultants and audit reports to assist in the effective regulation of site contamination. A consultant is suitably qualified in the assessment and remediation of site contamination. An auditor is an experienced site contamination professional, accredited by the EPA to independently examine and review the work undertaken by a consultant and provide written opinions and determinations in the form of a site contamination audit report. Where an auditor may consider it warranted, a GPA recommendation may be included in the site contamination audit report, where a risk to human health and safety from groundwater contamination has been determined to exist[14].

The decision for determining the requirement for a GPA is developed through an iterative review process of technical information held in the EPA Public Register and presented in this groundwater prohibition report. In order to meet the legislative requirement to establish a GPA, the EPA requires information that documents the existence of site contamination and the nature of groundwater contamination. The EPA will also consider the lateral and vertical extent of site contamination for the protection of human health and safety.

The responsibility for site contamination is assigned to the original polluter who is liable for any assessment and remediation of contamination on and off site, regardless of when it was caused. As site contamination is generally historical in nature and in some cases the original polluter no longer exists, the liability for on-site assessment remediation is passed onto the current site owner. Where the site contamination has moved off site and the original polluter no longer exists, the EPA has an established framework to assess offsite contamination through a process which commences or continues assessment and/ or remediation with the intention to protect human health and safety[15]. The establishment of a GPA is an institutional control to manage site contamination of groundwater but is, however not a form of remediation.

Where site contamination exists the determination will be made if 'action is necessary to prevent actual or potential harm to human health or safety'. SA Health recommends that it is reasonable to lower the direct community exposure to groundwater contaminants in affected suburbs and, more generally where groundwater exceeds relevant health-based guidelines, through groundwater prohibition.

1.5 Documentation review and information in the EPA Public Register

In compiling this determination report, the EPA has examined information from multiple sites in the suburbs of Clovelly Park, Tonsley and Mitchell Park. The documents reviewed are recorded in the EPA Public Register. A list of these reports, including peripheral sites in Marion, is presented in Appendix 2.

To view or obtain reports in the public register, please contact the EPA by telephone (08) 8204 2004 or 1800 623 445 (for country users), https://www.epa.sa.gov.au or email: epa.publicregister@sa.gov.au

Additional information for sites within the GPA may be recorded in the public register following the completion of the determination report for any future associated works at sites previously assessed for the consideration of a GPA.

14 Guidelines for the site contamination audit system (EPA 2019)

15 Regulatory and orphan site management framework (EPA 2017)

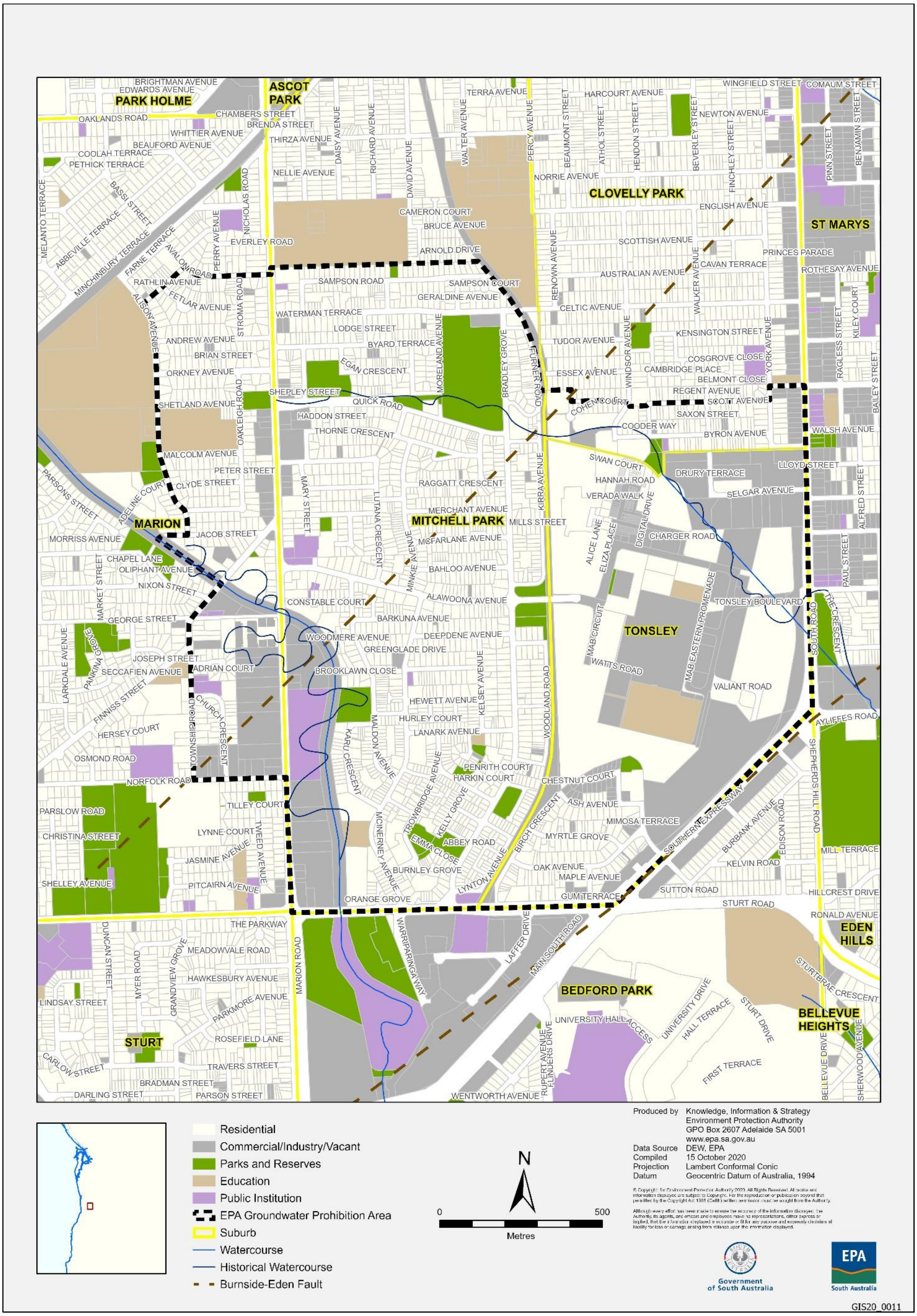

Figure 1 Map of proposed groundwater prohibition area (GPA)

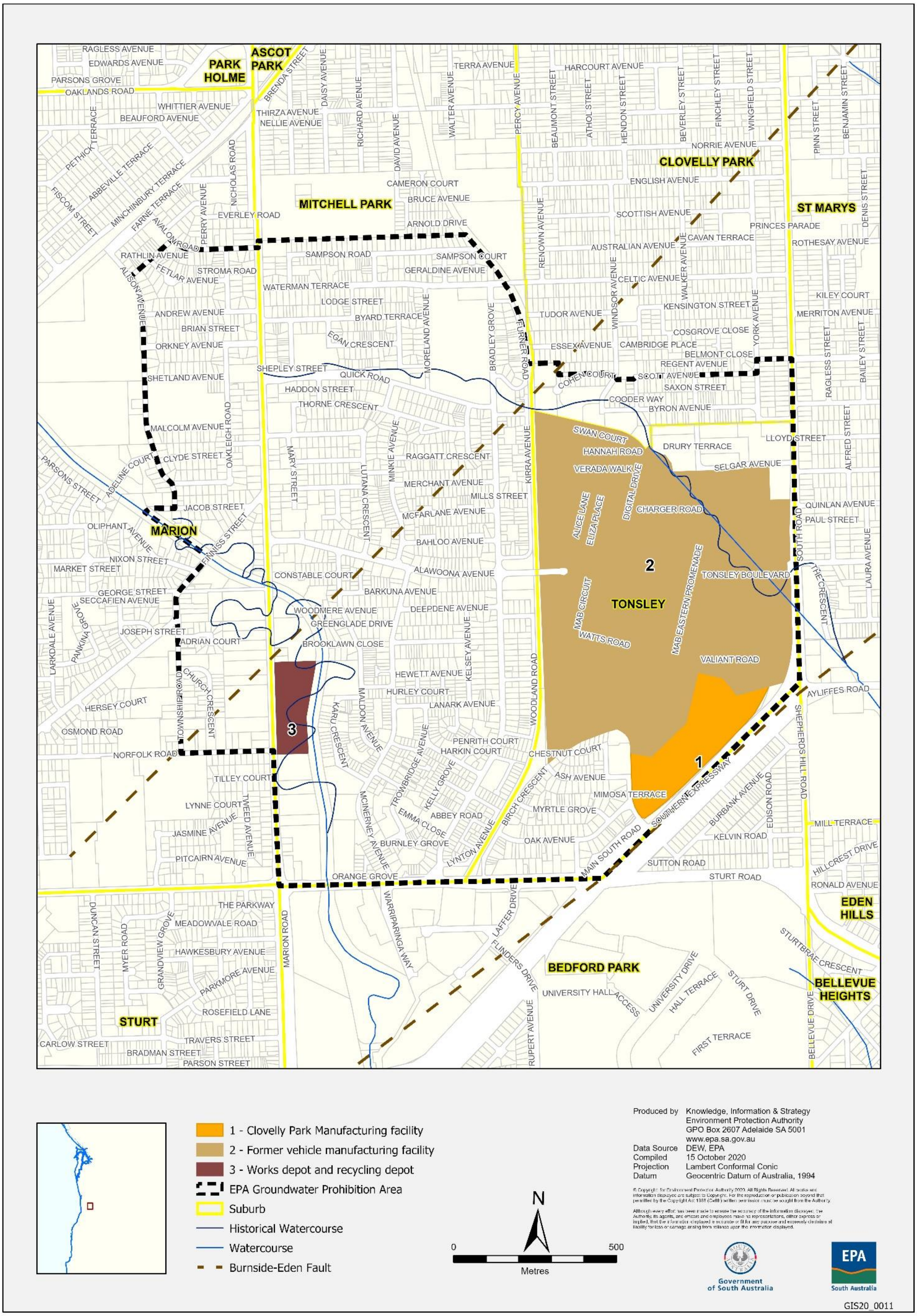

Figure 2 Sites identified to have contributed to groundwater contamination within the GPA

2 Site contamination

2.1 Assessment of site contamination

Assessment of site contamination is essential to ensure adequate protection of human health and safety and should always be undertaken in accordance with the framework provided in the *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013)* or ASC NEPM. The ASC NEPM has been developed as a nationally consistent approach to the assessment of site contamination. The EPA provides guidelines to assist consultants and auditors in interpreting relevant EPA legislation[16], policies[17], and national and international guidelines[18 19 20] which provides that assessment and remediation of site contamination can be conducted to an appropriate standard.

In accordance with the *Guidelines for the assessment and remediation of site contamination* (EPA 2019), where site contamination exists that is not trivial, implementation of soil and groundwater assessment and remediation may be necessary. To provide the highest level of protection for human health and safety, when making a determination of site contamination, the EPA considers it appropriate to use the precautionary principle as described in the Objects[21] of the Act. In determining whether to implement a GPA, the EPA takes the Objects into consideration.

Assessments will generally comprise a site history investigation, geological and hydrogeological site characterisation, investigation of the site contamination including contaminants of concern (Appendix 3), and human health and environmental risk assessments. Remediation generally commences following the development of a remediation options assessment. In South Australia, remediation includes treatment, containment, removal or management of chemical substances on or below the surface of the site[22]. Due to the physical and hydrogeological characteristics of an aquifer system, the removal of the source of contamination will not remove the contamination from the groundwater. However, a process of natural attenuation of contaminants in the groundwater exists where the speed of contaminant depletion is dependent on the nature of the aquifer[23].

Assessment of site contamination requires that contamination be well characterised. Initially this may include iterative investigations within all media (soil, soil vapour surface water and groundwater) at the site (on site) where potentially contaminating activities have been identified. This would be followed by a broader assessment in the vicinity of the site (off site) where the contamination has been assessed to have impacted groundwater.

The EPA's determination of a GPA includes the review of information relating to the source of contamination, the nature and extent of any contaminated groundwater and the potential users of that groundwater. This is interpreted as the source (chemicals in the groundwater), pathway (exposure to groundwater through a well) and receptor (human health and safety) relationship. By understanding this relationship and striving to remove the pathway, direct human exposure to contaminated groundwater can be reduced.

16 EP Act

17 Water Quality Policy

18 National Environmental Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013)

19 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018)

20 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

21 In relation to the Objects of the Act, refer to section 10 of the *Environmental Protection Act 1993*

22 Pursuant to section 3 of the EP Act

23 Wiedemeier TH, Rifai HS, Newell CH and Wilson JT 1999, *Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface,* John Wiley & Sons, New York, USA.

2.2 Characterisation of the nature and extent of groundwater contamination

As part of the assessment of site contamination at specific sites, groundwater assessments have been undertaken in the area of Tonsley, Clovelly Park, Marion and Mitchell Park (Figure 2). Specifically to determine the nature and extent of groundwater contamination affecting the quality of the local aquifers and the risk to potential users.

The environmental assessment reports, prepared in relation to the sites in the GPA, documents the potentially contaminating activities that were undertaken at the sites, and the known soil and groundwater contamination (Appendix 2). This information has been used to inform a broad conceptual site model for the GPA.

2.3 Conceptual site model

A conceptual site model is developed to understand sources, pathways and receptors with respect to site contamination. The development of the conceptual site model includes the identification of all sources, modes of migration, potential receptors of concern, and how exposure may occur (ie exposure route) [24] [25]. A model may include diagrams to assist in describing the various exposure pathways and their relevance. However, a written model, such as this report, is an alternative interpretation or accompaniment to a diagrammatic model.

For the purposes of determining a GPA, the EPA has developed a broad conceptual site model which focuses on the source, pathway and receptor relationship with regards to the potential human exposure to groundwater. This has been developed as an amalgamation of site-specific conceptual site models created through each site-specific investigation.

This section describes a broad conceptual site model for the identified source sites, summarised in sections 1.3, 2.2 to 2.4 (Figures 2 and 3) and section 4 (Table 2).

The development of a broad conceptual site model comprising the following, assisted in the consideration of the GPA:

- Site history and surrounding uses.
- Summary of regional and local hydrogeology.
- Characterisation of the nature and extent of soil and groundwater contamination.
- Groundwater users.
- Factors considered in the determination of a GPA.
- Exposure pathways and human health risk assessment.

All the information presented in this determination report represents the development of the broad conceptual site model through observational and intrusive investigations at the sites and surrounding areas, within the vicinity considered for a GPA.

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[24] *National Environmental Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013)*

[25] *Guidelines for the assessment and remediation of site contamination* (EPA 2019)

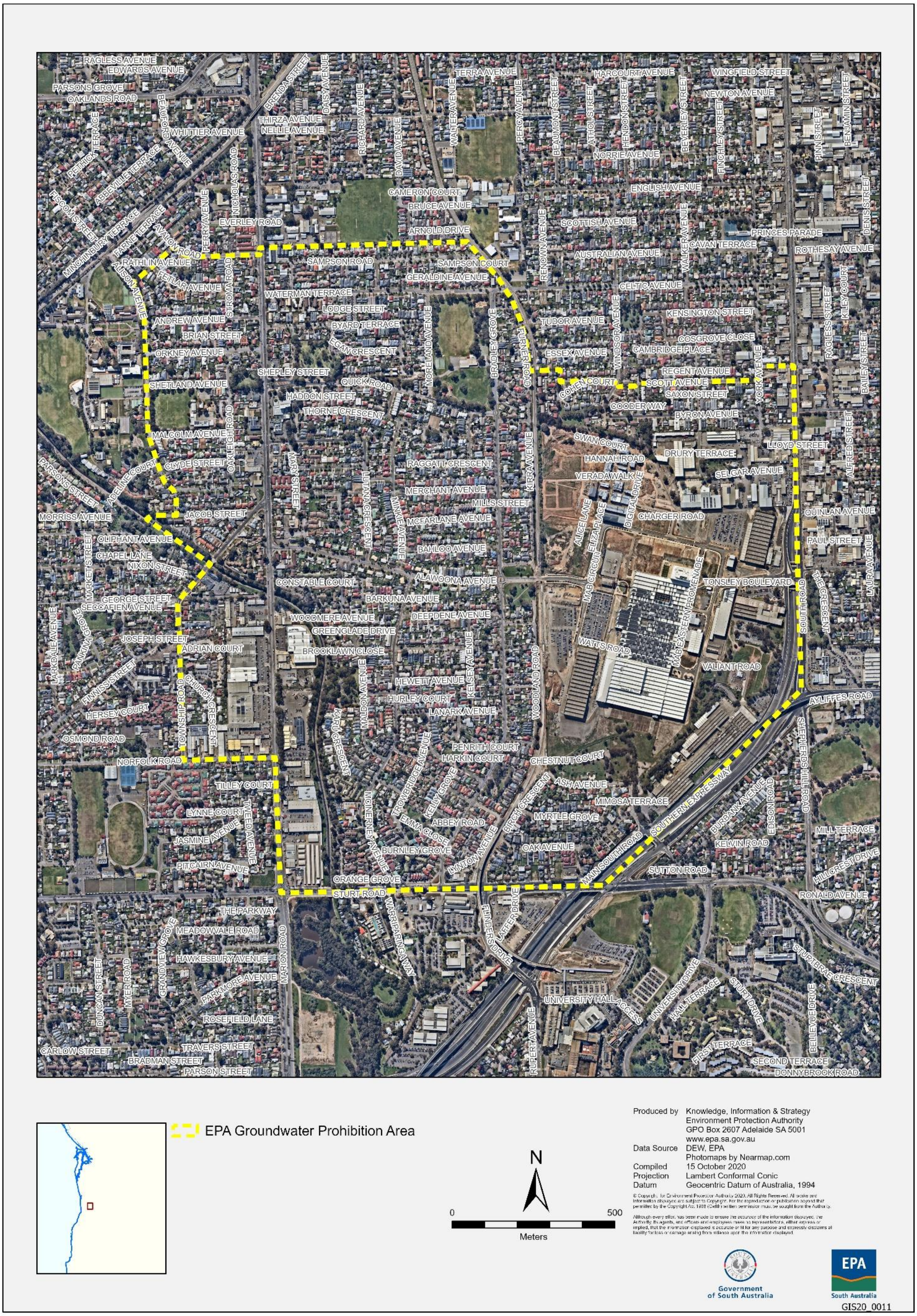

Figure 3 Aerial photo of Tonsley and portions of Clovelly Park, Mitchell Park and Marion within the proposed GPA

3 Geology and hydrogeology

3.1 Site history and surrounding land uses

The suburbs of Clovelly Park, Tonsley, Mitchell Park and Marion and surrounding suburbs are within the traditional lands of the Kaurna people.

The suburbs were historically used for the production of fruit and vegetables. In 1838 extensive vineyards, dryland crops and orchards were planted upon the fertile alluvial soils on the eastern banks of the Sturt River. This area became a significant wine region in Adelaide's history of wine making in the mid to late 19th century[26]. With the commencement of the 20th century, market gardening on smaller holdings of land contributed to the provision of commercial fruit and vegetables through the early 1900s and First World War. By the 1950s, smaller allotment residential housing were evident along with the development of industrial precincts in the area and by the end of the 1960s, flood mitigation of the Sturt River completed the area's transition from primary food production to medium to low density residential between zones of commercial and industrial facilities.

Currently land use within the proposed GPA is mixed commercial and residential properties, including public recreational facilities.

3.2 Summary of regional and local geology and hydrogeology

Geographically, the proposed GPA is situated on the Adelaide Plains (Metropolitan Adelaide) within the Tonsley, Clovelly Park, Mitchell Park and Marion area, approximately 6 km southwest of the Adelaide central business district and directly east of the Sturt River.

Geologically, the area is situated on the central alluvial flood plains of the Adelaide Plains of the Sturt River outwash alluvial fan, within the Golden Grove–Adelaide Embayment. The groundwater system (aquifers) exist within inter-bedded Quaternary aged sands, gravels, silts and clays that are deposited along the river channels and across the alluvial plains, and the deeper Tertiary (Paleogene and Neogene aged) sediments (Figures 4 and 5). Deep exploratory drilling has identified the Quaternary terrestrial sediments of the Pooraka Formation and Keswick Clay overlying the massive Hindmarsh Clay, which in turn overlies the older Tertiary (Paleogene and Neogene) sediments.

It is generally recognised that six Quaternary aged aquifers are supported within the sediments of the Hindmarsh Clay, which underlies the semi-confining Pooraka Formation[27]. Within these aquifers there are higher transmissive zones of sandy clays, sands and gravel beds, generally separated by lower permeable silts and clays[28]. Various gradings[29] of sandy silts to silty clays have been observed through intrusive drilling investigations in the lower permeable beds.

The sediments of the Pooraka Formation unconfined aquifer are observed at 5–6 m below ground, where sandy clayey lenses have been identified[30] [31]. The first semi-confined Quaternary aquifer is observed approximately 15–17 m below ground level within the Hindmarsh Clay[32].

26 www.marion.sa.gov.au/services-we-offer/history-and-heritage/stories-of-the-sturt-river, accessed 22 September 2020

27 Martin R and Hodgkin T 2005, *State and Condition of the Adelaide Plains Sub-Aquifers*, Report DWLBC 2005/32, Government of South Australian, Department of Water Land, Biodiversity and Conservation.

28 Webber A 2018, *Site Contamination Audit Report, Waste Derived Fill, PEET Limited, Stages 2 + 2A of Tonsley Village*, July 2018.

29 Change in grain size from coarse to fine within an upwards deposited sedimentary sequence

30 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010

31 AECOM 2016, *Groundwater Monitoring Event, March 2016, Monroe Clovelly Park*, August 2016.

32 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 2, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, December 2016.

Through the various assessments in the area, the geologic stratum has been observed to dip towards to northwest away from the Adelaide Hills escarpment. Similarly groundwater has been inferred to flow generally in a north-northwest to northwesterly direction, congruent with the geological profile and the natural flow direction of the Sturt River. Local exceptions to this groundwater flow regime, however, have been observed at various sites (specific details in section 4.1). Due to the variable sediment types observed it is inferred that preferential groundwater flow pathways are present on the area.

Underlying the Quaternary sediments are the Tertiary sandstone and limestone sedimentary sequence. The Tertiary aquifers, within this sequence, are confined beneath the thick overlying (up to 100 metres) Hindmarsh Clay unit. The first Tertiary aquifer comprises the Hallett Cove Sandstone and the second Tertiary aquifer comprises the Port Willunga Formation, separated by the Munno Para Clay (Table 2). Two deeper Tertiary aquifers are anticipated to underlie the first and second Tertiary aquifers, however, they have not been developed as a groundwater resource due to drilling depth constraints (greater than 400 m depth from ground level).

Extensive structural mapping of the Adelaide Plains, undertaken in the 1960s, further defined a major fault system within the Adelaide region associated with the Mount Lofty and Flinders Ranges Delamerian Orogeny[33 34]. Of these the Eden–Burnside Fault, observed to trend from the Little Para Reservoir in the north to Seacliff in the south, centrally passes through the Clovelly Park area (Figure 2). Historical movement within this fault zone has resulted in southerly to southeasterly tilting along the uplifted Eden–Burnside block and while generally concealed by overlying sediments, the Eden–Burnside fault marks the Adelaide Hills Face Zone (Figure 6)[35]. Due to the multiple associated fracturing along and in the vicinity of the faulted zone, a complex interaction of groundwater movement has been observed across the fault, which structurally impedes or enhances the flow of groundwater from the east to the west[36].

Groundwater generally flows through the aquifers of the Adelaide Plains from the Mount Lofty Ranges in the east to the Gulf St Vincent in the west where groundwater discharge occurs. Figure 7 shows a general cross-sectional model of the groundwater movement across the Adelaide Plains. The geology and hydrogeology of South Australia is described in more detail in Appendix 4. The southeastern corner of the proposed GPA overlies the Eden–Burnside Fault and the central portion of the GPA overlies a parallel en echelon fault mapped approximately 1 km to the northwest of the main Eden–Burnside Fault (Figure 8). Groundwater chemistry analysis has inferred that groundwater may be flowing directly across the main fault line from the older fractured rock aquifer unit[37].

33 Mountain building structural activity.

34 Priess WV 1987, 'The Adelaide Geosyncline, late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics', *Bulletin of Geological Survey*, South Australia.

35 Talbot JL and Nesbitt RW 1968, *Geological excursions in the Mount Lofty Ranges and the Fleurieu Peninsula*, McGraw-Hill, Sydney, NSW.

36 Green G, Watt E, Alcoe D, Costar A and Mortimer L 2010, *Groundwater flow across regional scale faults.* Technical Report DFW 2010/15, Government of South Australian, Science, Monitoring and Information Division, Department for Water.

37 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 2, Tonsley Development, Former MMAAL Site, Clovelly Park, SA*, December 2016.

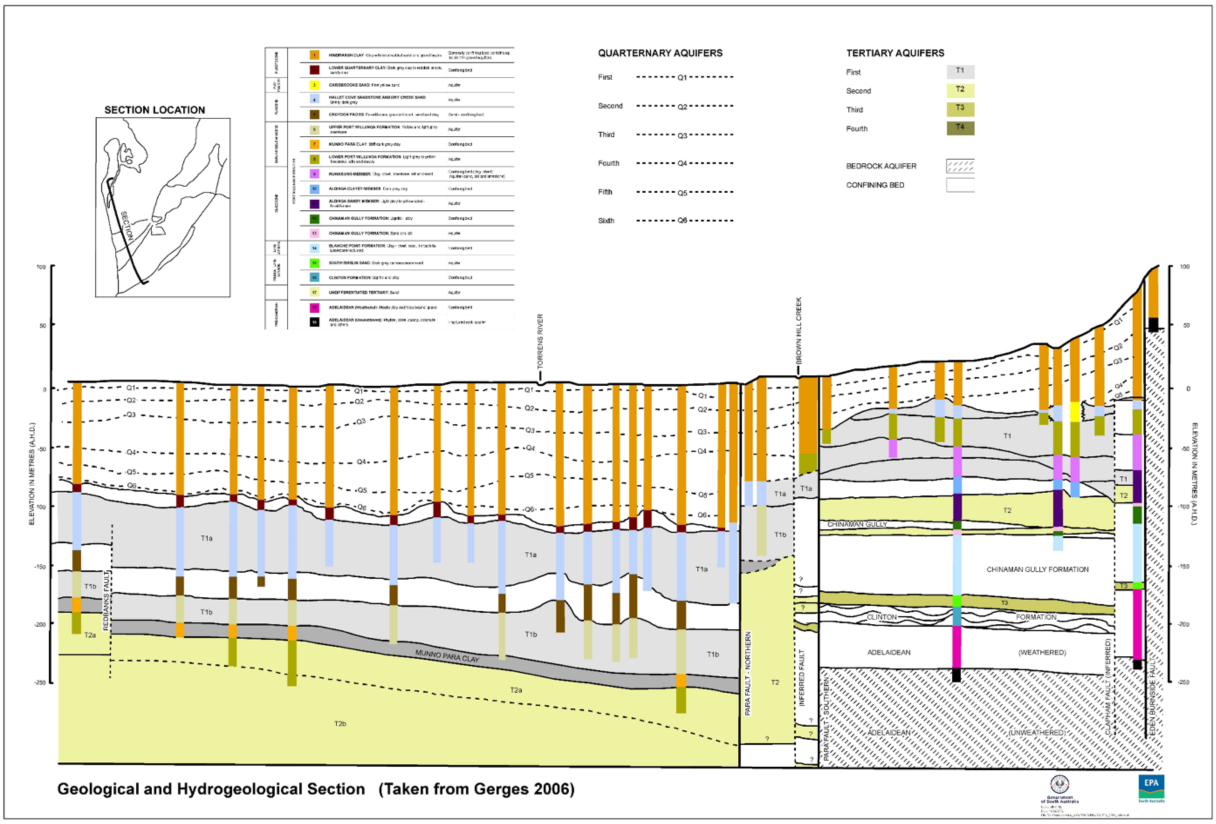

Figure 4 Geological and hydrogeological cross-section[38]

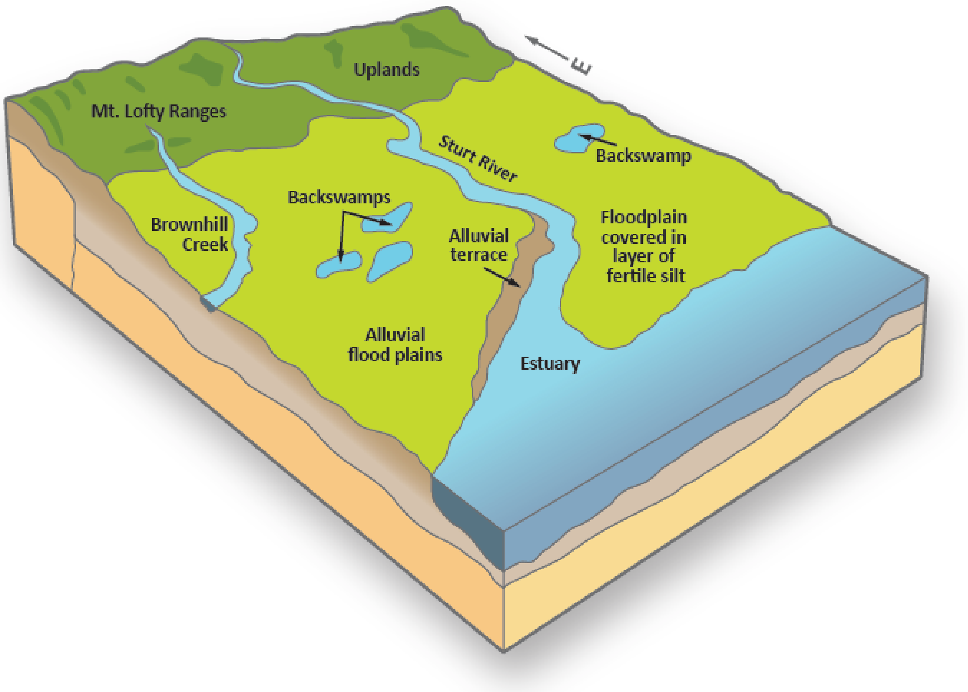

Figure 5 Conceptualised model of the Sturt River prior to European settlement

38 Gerges N 2006, *Overview of the hydrogeology of the Adelaide metropolitan area,* Report DWLBC 2006/10, Department of Water, Land and Biodiversity Conservation, Government of South Australia.

Table 2 Stratigraphic sequence of sediments of the Adelaide Plains[39]

Age	Willunga		Adelaide Plains	
Quaternary	Numerous units	Quaternary Aquifer	Pooraka Formation	
			Hindmarsh Clay	Q1–Q6
			Carisbrooke Sand	
Tertiary	Port Willunga Formation	Port Willunga Formation Aquifer	Hallet Cove Sandstone	T1
			Port Willunga Formation	
			Munno Para Clay	Aquitard
			Port Willunga Formation	T2
	Chinaman Gully Formation	Aquitard	Chinaman Gully Formation	T3
	Blanche Point Formation	Aquitard	Blanche Point Formation	Aquitard
	South Maslin Sand	Maslin Sands Aquifer	South Maslin Sand	T4
	North Maslin Sand		Clinton Formation	Aquitard
			North Maslin Sand	T4

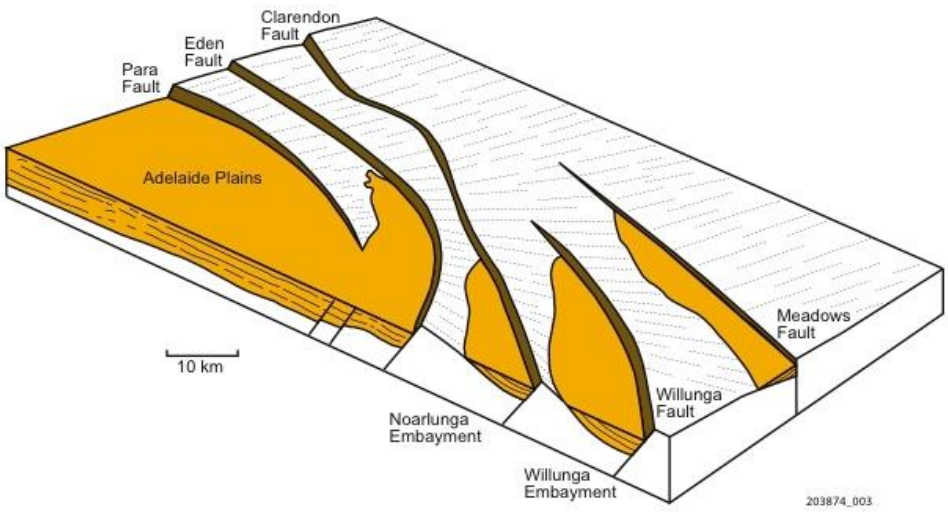

Figure 6 Interpretive cross-sectional plan of the major faults in the Adelaide region[40]

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39 Cook P 2014, *Adelaide's Groundwater: What We Don't Know,* NCGRT, Flinders University and CSIRO.

40 Talbot JL and Nesbitt RW 1968, *Geological excursions in the Mount Lofty Ranges and the Fleurieu Peninsula*, Sydney NSW.

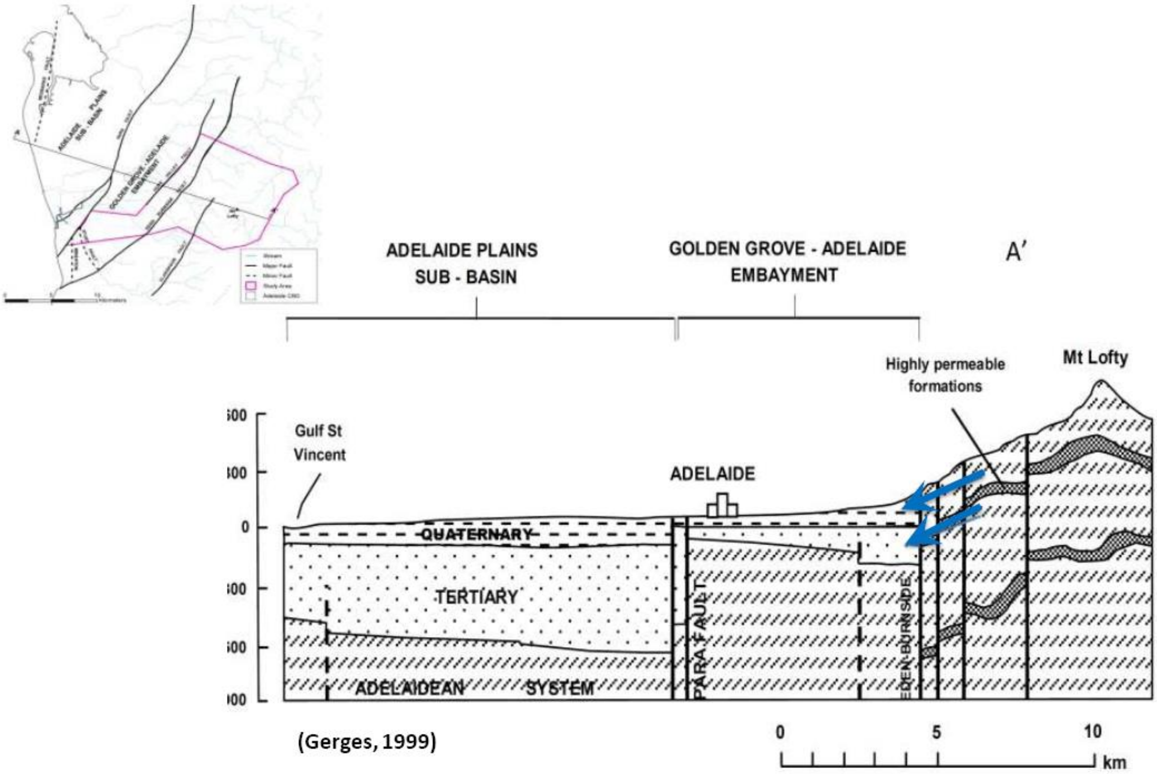

Figure 7 General flow of groundwater from the Mount Lofty Ranges across the Adelaide Plains[41]

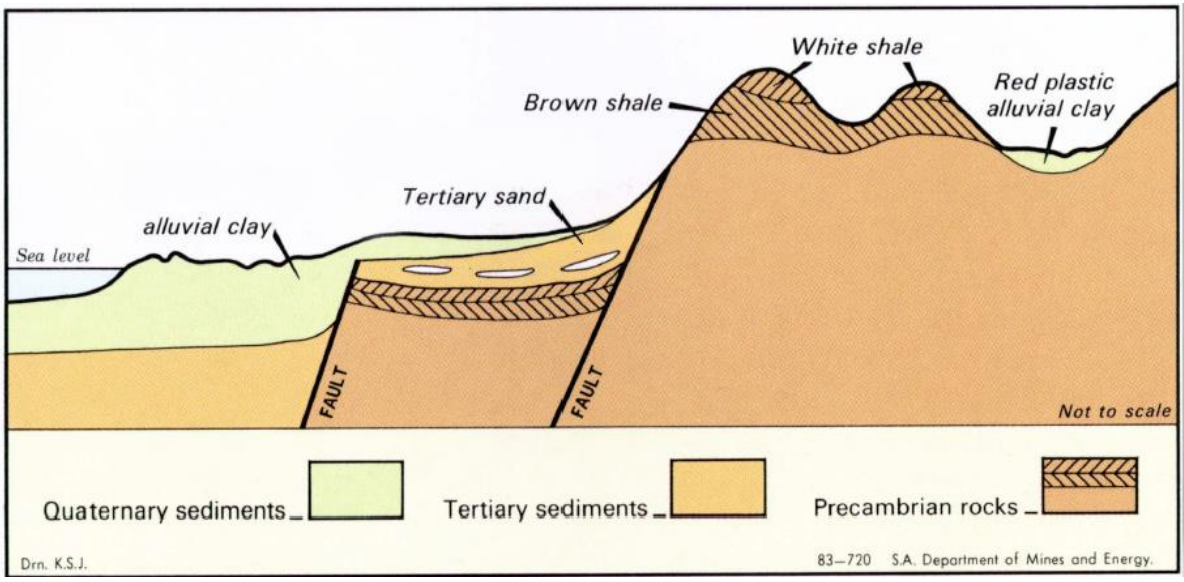

Figure 8 Interpretive cross section of major faulting in the Adelaide region[42]

3.2.1 Specific aquifer and lithological conditions, the Quaternary aquifers

In addition to reviewing the findings and outcomes of the site contamination assessment reports and the audit reports it held (Appendix 2), the EPA, the EPA completed a desktop review of additional information on hydrogeological conditions and groundwater contamination in the vicinity of Clovelly Park, Tonsley, Mitchell Park and Marion.

41 Gerges NZ 1999, *The Geology and Hydrogeology of the Adelaide Metropolitan Area,* PhD Thesis, Flinders University, South Australia.

42 Selby J 1984, *Geology and the Adelaide Environment.* Handbook No. 8, Department of Mines and Energy, South Australia.

These reports have identified a shallow unconfined aquifer at the base of the Pooraka Formation, approximately 5–8 m below ground level and the first Quaternary aquifer of the Hindmarsh Clay, approximately 10–15 m below ground level. The first Quaternary Hindmarsh Clay aquifer comprising fine to medium grained silty sandy clay with inter-bedding of gravels in a semi-confined aquifer. Perched groundwater has been identified onsite at shallow depths within fill material[43]. Groundwater is generally flowing in a northwest to westerly direction towards the lower reaches of the Sturt River near the coast and the Gulf St Vincent with a groundwater flow velocity of up to 20 m per year. Historical groundwater wells in the area indicate that three deeper Quaternary aquifers are present at approximately 30–45 m below ground level, 45–60 m below ground level and 65–80 m below ground level.

In general, lithological investigations in the Tonsley, Clovelly Park, Mitchell Park and Marion area have identified variable sandy, silty and gravel sediments with semi-confining clays within the Pooraka Formation and the underlying Hindmarsh Clay. Sand and clay forms an inter-fingering nature with discrete gravel lenses which can provide a mechanism where leached chemicals can adsorb on the clay fraction and the dissolved material can migrate along the sandier material of the aquifer[44].

Observations around the sympathetic offset zones along the margins of the main Eden–Burnside Fault have noted higher groundwater permeabilities[45]. This has the potential to affect contaminant transport in proximity to fault zones[46].

3.2.2 Specific aquifer conditions, the Tertiary aquifers

Underlying the Quaternary aquifers, there are two well-defined Tertiary aquifers within the proposed GPA. The Tertiary sediments are separated from the Quaternary aquifers by a massive clay layer which confines the Tertiary aquifers and creates an upward hydraulic gradient. This is widely supported by a hydrogeological study undertaken by Dr Nabil Gerges[47] and was presented in a Department of Water, Land and Biodiversity Conservation[48] report in 2006.

3.2.3 Groundwater quality

The Quaternary hydrogeology in the area of Clovelly Park, Tonsley, Mitchell Park and Marion, is largely defined by the terrestrial alluvial deposits of clays, sands and gravels.

Field observations of groundwater salinity during on-site investigations and salinities tested in a National Association of Testing Authorities (NATA) accredited laboratory range between 300 mg/L to 2,000 mg/L total dissolved solids[49] indicating that groundwater is considered marginal as a potable water source. Salinity measurements observed are highly variable throughout the area and this is generally associated with the variability in lithology of the Keswick and Hindmarsh Clay aquifers.

3.2.4 Surface water influences

The natural drainage system in the area comprise the Sturt River (Warri-Pari), Viaduct Creek (Wattiparinga), the Warriparinga Wetlands and Oalkands Park Wetlands. This area and its waterways hold cultural significance for the

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43 URS 2009, *Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment.*

44 URS 2009, *Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment*.

45 Gudmundsson A 2000, *Active fault zones and groundwater flow,* Geophysical Research Letters, Vol 27, pg 2993–2996

46 Green G, Watt E, Alcoe D, Costar A and Mortimer L 2010, *Groundwater flow across regional scale faults,* Technical Report DFW 2010/15, Government of South Australia, Science, Monitoring and Information Division, Department for Water.

47 Gerges N 2006, *Overview of the hydrogeology of the Adelaide metropolitan area,* Report DWLBC 2006/10, Department of Water, Land and Biodiversity Conservation, Government of South Australia.

48 The South Australian Government Department of Water, Land and Biodiversity is now known as the Department for Environment and Water

49 Seawater is 35,000 mg/L

Kaurna people as a transport route from Aboriginal clans and special meeting place for celebrations and rituals. The Warriparinga Wetlands are significant for the Tjilbruke dreaming story[50].

The Sturt River is situated within the western edge of the proposed GPA. Prior to 1965, the Sturt River channel meandered through this lower portion of the Adelaide Plains to the Patawalonga River and estuary, until flood mitigation works were completed in 1971, resulting in a straightened and concrete lined river channel. At that time the Warriparinga Wetlands were also altered for flood mitigation purposes. Viaduct Creek (Wattiparinga Creek), another meandering channel, was also flood mitigated in the late 1960s and travels through the central northeastern portion of the proposed GPA as a box culvert.

Assessments have been undertaken based on major ion chemistry analysis of the groundwater to determine the influence of rainfall and reticulated mains water have on aquifer recharge and flow direction in the Tonsley and Mitchell Park area. During periods of high rainfall, when the Sturt River, Viaduct Creek and open and closed drains are flowing, there is evidence of groundwater and surface water interaction in the vicinity north of the Warriparinga Wetlands and east of the Sturt River. This interaction is identified through the installation of groundwater well level logging equipment in the vicinity of the Sturt River and north of the Warriparinga Wetlands. The surface to groundwater interaction is suggested to be retarded in low permeable regions of the aquifer[51].

Through the flood mitigation works undertaken in the 1970s, the natural alignment of the Sturt River was altered prior to concrete lining. The natural river bed was backfilled with material excavated from the current river channel. Groundwater flow direction in the vicinity of the Sturt River has been gauged in a westerly direction towards these natural and current river channels [52]. Groundwater fate and transport modelling indicates that groundwater contamination arising from the automotive parts and automotive manufacturing sites east of the Sturt River may impact the river in approximately 15 years and potentially limit groundwater plume migration may. This is, however, largely dependent on the interaction between the river and the uppermost aquifers[53] . The 2020 site contamination audit report concluded that straightening and concrete lining of the Sturt River created an unlikely connection between the upper water table aquifer and the Sturt River[54].

The City of Marion operates a deep managed aquifer recharge system at the Oaklands Park Wetlands. Investigations to assess the risk of contaminated groundwater impacting the Warriparinga and Oaklands Park Wetlands were undertaken in 2016 and 2017. It was determined that the likelihood of contaminated groundwater impacting the wetlands is negligible due to the separation distances from the groundwater plume and the wetlands themselves[55].

Historical investigations of surface water features in the area identified multiple open and closed stormwater drains, predominantly in the southeast of the area considered for a GPA, discharging to the Sturt River. A creek utilised for stormwater capture and a natural creek running along the western and northern boundary respectively, of the former vehicle manufacturing facility were identified[56] [57]. Two large diameter stormwater drains historically thought to be a former

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[50] Government of South Australia 2012, *Cultural History Report, Tonsley,* prepared by Martins Integrated.

[51] BlueSphere Environmental 2016, *Conceptual Site Mode (CSM): Tonsley VSCAP Investigation – Revision 02, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2016.

[52] Hall A 2000, *Site Audit Report, City of Marion Operations Depot, 935 Marion Road, Mitchell Park, SA*.

[53] Fyfe 2014, *Clovelly Park/Mitchell Park Environmental Assessment, Volume 1 & 2 Report*.

[54] Lane 2020, *Site Contamination Audit Report (Restricted Scope) EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, South Australia*, 18 June 2020.

[55] BlueSphere Environmental 2018, *Conceptual Site Mode (CSM): Tonsley VSCAP Investigation – Revision 04, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2018.

[56] Rust PPK 1995, *Environmental Audit of MMAL Tonsley Park Plant, September 1995*.

[57] Webber A 2017, *Site Contamination Audit Report, Residential Audit Area – Suburban Activity Node Zone, Portions of Former Mitsubishi Motors Australia Limited Site Tonsley*, December 2017.

northern creek is located along the northern site boundary. These stormwater drains were assessed in 2010 to be corroded and thought to act as a conduit for surface water leakage to groundwater[58], potentially creating a preferential pathway for contaminated surface water infiltration to groundwater. Additional investigations were undertaken in 2012 and 2013 to identify underground stormwater infrastructure and preferential pathways for the migration of contaminants derived from the manufacturing facilities in Clovelly Park. At that time contaminants of concern were thought to be moving off site through stormwater drains, however no detection of contaminants of concern were identified in the surface water within the drains[59]. In 2015 an abandoned private sewer line was identified in the southern part of Clovelly Park. Further investigations, including visual inspection, in 2016, indicated that the vitrified clay sewer may have acted as a preferential pathway for discharge of trade wastes derived from the automotive parts manufacturing facility site[60].

58 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

59 URS 2013, *Monroe Clovelly Park Facility Environmental Investigations May 2012 to March 2013*.

60 BlueSphere Environmental 2016, *Conceptual Site Mode (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL, Site Clovelly Park, SA*, February 2019.

4 Characterisation of nature and extent of site contamination

4.1 Site contamination in the Tonsley, Clovelly Park and Mitchell Park area

The EPA holds reports and associated information relating to site contamination on various sites or parcels of land within the Tonsley, Clovelly Park, Mitchell Park and Marion area. The site details and certificates of titles of the identified source sites which contributed to groundwater contamination, are listed in the table below and a map showing information held by the EPA in the determined GPA area and aerial photo is illustrated in Figures 2 and 3, respectively. The source site details and certificates of title are listed in Appendix 2 and a map showing information held by the EPA in the proposed GPA and satellite photo is illustrated in Figures 2 and 3, respectively.

Through a detailed review of reports held by the EPA as listed in Appendix 2, groundwater contamination was identified or inferred to have migrated off site from known sources. As a result of on and off-site assessment, it was determined that the most pervasive known source of contamination occurs from the former vehicle component manufacturing facility and the former vehicle manufacturing facility on South Road, Tonsley, in the form of volatile chlorinated hydrocarbons.

Table 3 Sources of groundwater contamination identified in the proposed GPA area

Source of groundwater contamination (section 4.1)	Address	Council	Contaminants identified relevant to drinking water guidelines[61] [62]or health investigation levels[63]	Certificates of title
1 – Automotive parts manufacturing facility	1326–1378 Main South Road, Tonsley	City Marion	Chlorinated hydrocarbons, metals and petroleum hydrocarbons above relevant drinking water guidelines.	CT5245/380
2 – Former vehicle manufacturing facility	1284–1324 Main South Road, Tonsley	City Marion	Chlorinated hydrocarbons, PFAS, metals and petroleum hydrocarbons above relevant drinking water guidelines.	CT6201/875; CT6201/875; CT6149/30; CT6149/31; CT6149/32; CT6197/567; CT6145/982; CT6145/984; CT6145/985; CT6145/986; CT6159/712; CT6159/713; CT6159/714; CT6176/975 & CT6157/497 (as of February 2020)
3 – Works depot and recycling depot	935 Marion Road, Mitchell Park	City of Marion	Petroleum-based products above drinking water guidelines.	CT 5494/674

61 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

62 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

63 *National Environmental Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)*

4.1.1 Automotive parts manufacturing facility (Figure 9)

1236–1378 Main South Road, Tonsley (formerly Clovelly Park)

Site history

The automotive parts manufacturing facility commenced operations in 1949 producing a range of goods including tools, metal pressings, precision machine components, household items and vehicle parts including shock absorbers, tail shafts and jacks[64]. Significant infrastructure development and redevelopment occurred on the site up until 1990. Solvent use remained constant during plant operations up until the early 1990s. Additionally, by 1990 the manufacturing activities on site were predominantly in support of producing suspension components[65] for the automotive manufacturing industry.

Summary of environmental assessments

A limited initial site assessment commenced in 1995 after suspected soil contamination was identified at the rear of the automotive parts manufacturing facility during earthworks excavation[66]. The investigation work at the site included the installation of seven soil bores and one groundwater monitoring well. Results of the sampling program indicated metals and petroleum hydrocarbon contamination in both soil and groundwater and chlorinated hydrocarbon contamination in groundwater[67]. It was understood that the petroleum hydrocarbon contamination occurred through containment failure of an underground storage tank. However the source of the chlorinated hydrocarbons was not identified during this initial assessment stage. In 1996 further assessment was undertaken to characterise the shallow groundwater and to determine the nature and extent of groundwater contamination identified in 1995.

In 2009 assessment recommenced at the site as a result of investigations at the adjacent former vehicle manufacturing facility (section 4.1.2) which identified chlorinated hydrocarbons in groundwater at the southern portion of the site. The investigation focused solely on chlorinated hydrocarbons, due to their significance as a contaminant of concern for both persistency and mobility.

The scope of the assessment was to develop a better understanding, through a historical review, of potentially contaminating activities undertaken at the site, groundwater monitoring[68] and a developed understanding of potential source zones at the site. Through this phase of investigation a site-based conceptual site model was further improved, indicating gradational variations in concentration of the contaminants of concern within structural and lithological variability across the site.

In September 2009 an auditor was engaged by the site owners to determine the nature and extent of site contamination and necessary remediation[69]. The continuing scope of works included the installation and development an additional 20 groundwater monitoring wells in both the shallow aquifer at the base of the Pooraka Formation and the deeper Quaternary aquifer of the Hindmarsh Clay.

Further assessment undertaken in 2010 included the geology, hydrogeology and contaminant impact at the site to further develop the conceptual site model[70]. The process of developing the model enabled the understanding of potential contaminant migration mechanisms and pathways to determine the fate and transport of contaminants in the

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64 URS 2009, *Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment*.

65 URS 2009, *Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment.*

66 Rust PPK 1995, *Site Contamination Assessment, Clovelly Park*.

67 Rust PPK 1995, *Site Contamination Assessment, Clovelly Park*.

68 URS 2009, *Monroe Clovelly Park Facility Groundwater Monitoring*, January 2009.

69 Kirsanovs S 2009, *Notification by auditor after commencement of audit, 1326–1378 South Rd, Clovelly Park, SA*, September 2009.

70 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

groundwater. This iterative process of on and off-site knowledge capture continued until 2019. In 2010 the commencement of off-site drilling identified chlorinated hydrocarbons within the groundwater of both the shallow and deep aquifers. Due to the high concentrations of these chlorinated hydrocarbons, the suspected presence of a dense non-aqueous phase separation of these contaminants was likely[71]. The investigations identified two significant on-site source area to the northwest and southwest of the main building. These source areas were thought to be associated with TCE wash areas and chemical waste disposal areas, giving rise to two chlorinated hydrocarbon groundwater plumes[72].

In 2012 and 2013 further improvement of delineation of the groundwater plumes were undertaken by the installation of additional groundwater monitoring wells on site and on the adjacent property. Groundwater samples analyses in the southwestern area of the site resulted in concentrations of chlorinated hydrocarbons above the 1% solubility limit. This indicates that a dense non-aqueous phase liquid is present, which has the potential to act as a secondary contamination source of chlorinated hydrocarbons impacting groundwater[73].

On and off-site investigations were undertaken in 2012 at two former housing trust properties, west of the automotive parts manufacturing facility (Figure 10). A single groundwater monitoring well was successfully installed northwest of the properties to gauge water level of 22 m to the upper Hindmarsh Clay aquifer and sampled, identifying chlorinated hydrocarbons and petroleum hydrocarbons[74].

In May 2015, the EPA agreed to a voluntary site contamination assessment proposal (VSCAP) with the owners of the automotive parts manufacturing facility to complete the assessment of the nature and extent of off-site contamination. This stage of assessment included biannual groundwater monitoring to provide seasonally updated information to assist in contaminant fate and transport trend analysis (Figure 12 [75] [76] [77] [78]).

Investigations from the VSCAP, completed in 2018, enabled further understanding of the localised geology and hydrogeology of the area. These investigations, which include processes, such as the installation, stratigraphy logging and gauging of over 70 groundwater monitoring wells, assisted in the collation of both a site-specific conceptual site model and a broad conceptually modelled utilised in the determination of the proposed GPA.

Local geology and hydrogeology

The Eden–Burnside Fault is thought to be a significant geological feature impacting the understanding of chemical contaminant fate and transport within the groundwater[79]. Developing a robust conceptual site model of groundwater movement is important for the determination of fate and transport for contaminants of concern arising from the site and adjacent sites.

During the assessment program it was identified that up to 4 m of fill material had been progressively distributed on the site for surface levelling. Perched groundwater was identified in some areas within this fill material and at varying depths. Given the free draining sandy geomorphology of the fill material and a measured low salinity, it has been inferred that the perched groundwater is rainwater derived. Drilling identified a shallow unconfined aquifer at the base of the Pooraka

71 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

72 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

73 URS 2013, *Monroe Clovelly Park Facility Environmental Investigations May 2012 to March 2013*.

74 Golder Associates 2012, *Preliminary Environmental Investigation Report, 22A and 22B Ash Avenue, Clovelly Park, South Australia*.

75 URS 2015, *Monroe, Clovelly Park Facility, Groundwater Monitoring Event (GME) Summer Factual Report*, August 2015.

76 AECOM 2015, *Groundwater Monitoring Event, October 2015*.

77 AECOM 2016, *Groundwater Monitoring Event, March 2016*, Monroe Clovelly Park.

78 AECOM 2017, *Groundwater Monitoring Event, September 2016*, Monroe Clovelly Park.

79 URS 2009, *Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment*, June 2009.

Formation, approximately 5–8 m below ground level and the first Quaternary aquifer of the Hindmarsh Clay, approximately 10–17 m below ground level[80].

In 2014 a comprehensive groundwater monitoring event occurred targeting all on and off-site wells in the investigation area[81] (Figure 11). This investigation enabled a complete point-in-time representation of the groundwater levels and contaminant concentrations for the known chlorinated compounds previously identified. Additionally, hydraulic conductivities were assessed throughout the monitoring well networks to identify the average seepage velocity of the groundwater and any preferential pathways for contaminant movement[82]. Generally, the groundwater is moving in a northwesterly to westerly direction over the majority of the sites, which is consistent with regional groundwater flow in the area.

To date investigations indicated perched groundwater identified in central and western portions of the site within predominantly fill material utilised to levels the site during initial construction phase of the site. A water bearing gravelly horizon was identified at approximately 3–5 m below ground level, potentially at the base of the Pooraka Formation and east of the Eden–Burnside Fault, where this stratigraphy has been observed through drilling at other eastern sites. A shallow, sandy, water bearing zone, and a deeper gravelly water bearing zones of the Hindmarsh Clay exist between 10–22 m below ground level were identified west of the Eden–Burnside Fault. Early cross-sections identifying the shallow aquifer were developed in 2010 to conceptually understand the aquifer (Figure 13)[83]. To the southwest of the site, sediments were observed to contain a higher clay and silt content, giving rise to a notably lower permeability. Several monitoring wells locations contained no water in this area and monitoring wells were unable to be developed[84] or remained dry after development[85].

Sandy, gravelly water bearing zones within the central to western portion of the site lend towards higher permeability aquifers, faster seepage velocity and preferential pathways for groundwater and contaminant plume movement. With a higher clay and silt content and lower permeability observed in the south, groundwater movement is impaired by a lack of pore space connectivity and groundwater movement or seepage velocity is slow.

Stormwater drainage lines, and current and former sewer lines extending from the site have been identified. It is inferred that these drainage lines may act as potential preferential pathways for the rapid movement of chlorinated hydrocarbons and PFAS offsite (Figure 14)[86] [87].

Nature and extent of site contamination

During the assessment phase, predominantly from 2000 to 2018, petroleum hydrocarbons and chlorinated hydrocarbons – predominantly tetrachloroethene, trichloroethene, dichloroethene and vinyl chloride – in groundwater were identified to

80 URS 2009, *Monroe Clovelly Park Facility Stage 2 Environmental Site Assessment*, December 2009.

81 URS 2014, *Monroe, Clovelly Park Facility, Groundwater Monitoring Event – July 2014*.

82 URS 2014, *Monroe, Clovelly Park Facility, Groundwater Monitoring Event – July 2014*.

83 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

84 Golder Associates 2012, *Preliminary Environmental Investigation Report, 22A and 22B Ash Avenue, Clovelly Park, South Australia*.

85 URS 2009, *Monroe Clovelly Park Facility Stage 2 Environmental Site Assessment*, December 2009.

86 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2016.

87 Lane A, *Site Contamination Audit Report (Restricted Scope) EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, South Australia*, 18 June 2020.

be above drinking water guideline values[88]. This phase of assessment was unable to determine the extent of the groundwater contamination and recommendations for further assessment was proposed[89]

Assessments undertaken at the site the site have determined that site contamination exists with contaminants of concern, including chlorinated hydrocarbons, petroleum hydrocarbons, heavy metals and cyanide, in soil and groundwater, above relevant human health guideline guidelines (Table 2)[90] [91].

Investigations off site have determined that site contamination exists in groundwater with contaminants of concern, chlorinated hydrocarbons, above relevant human health guidelines[92] (Table 2). Through the installation and monitoring of an extensive groundwater well network, it has been identified that the groundwater plume derived from the automotive parts manufacturing facility has extended approximately 600 m off site before co-mingling with groundwater plumes associated with the former vehicle manufacturing facility north of the site boundary (Figure 15).

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88 National Health and Medical Research Council and National Resource Management Ministerial Council, 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

89 Rust PPK 1996, *Stage II Site Contamination Assessment, Clovelly Park*.

90 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

91 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

92 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

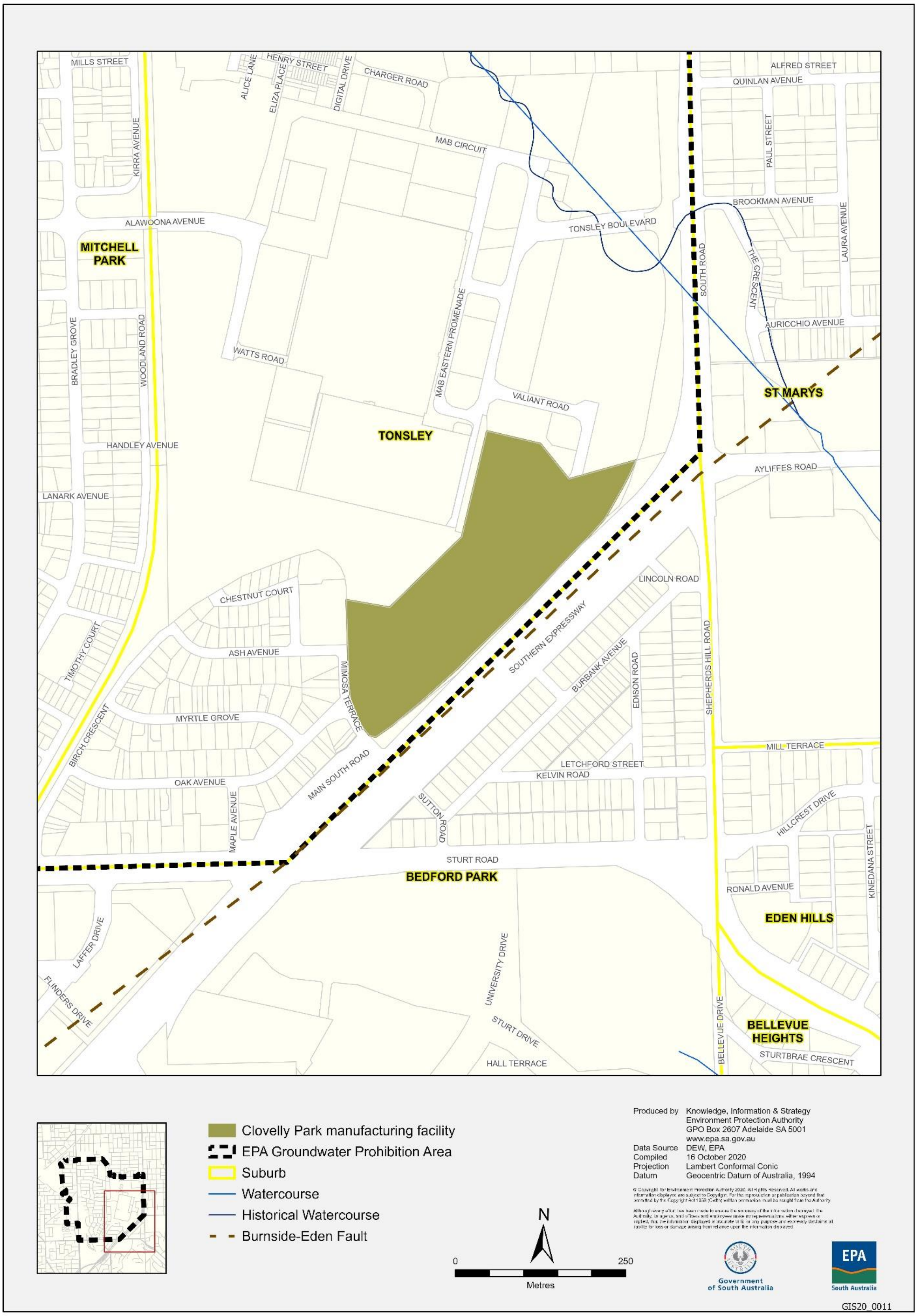

Figure 9 Site 1 – Automotive parts manufacturing facility

Figure 10 Investigation of two former housing trust properties west of the automotive parts manufacturing facility[93]

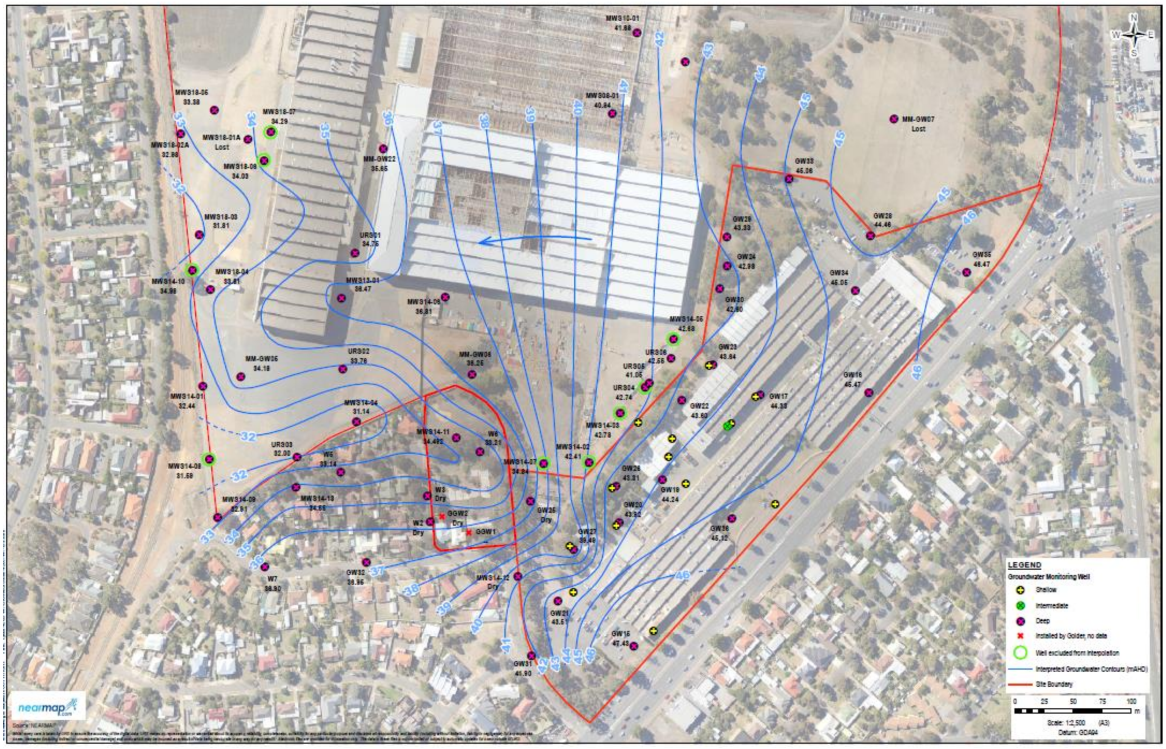

Figure 11 Monitoring well network and groundwater flow direction at the Clovelly Park manufacturing facility and southern part of the former vehicle manufacturing facility[94]

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93 Golder Associates 2012, *Preliminary Environmental Investigation Report, 22A and 22B Ash Avenue, Clovelly Park, South Australia.*

94 URS 2014, *Monroe, Clovelly Park Facility, Groundwater Monitoring Event*, July 2014.

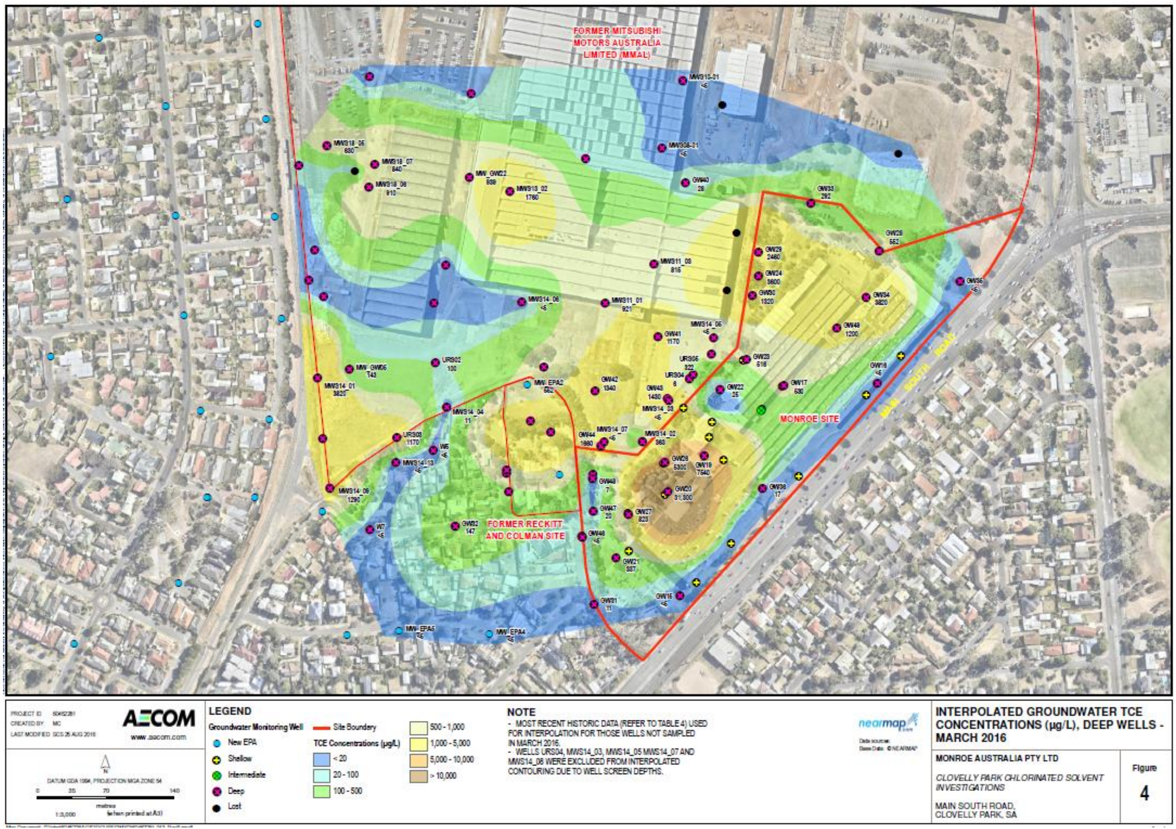

Figure 12 **TCE groundwater contamination plume in August 2016 at the automotive parts manufacturing facility**[95]

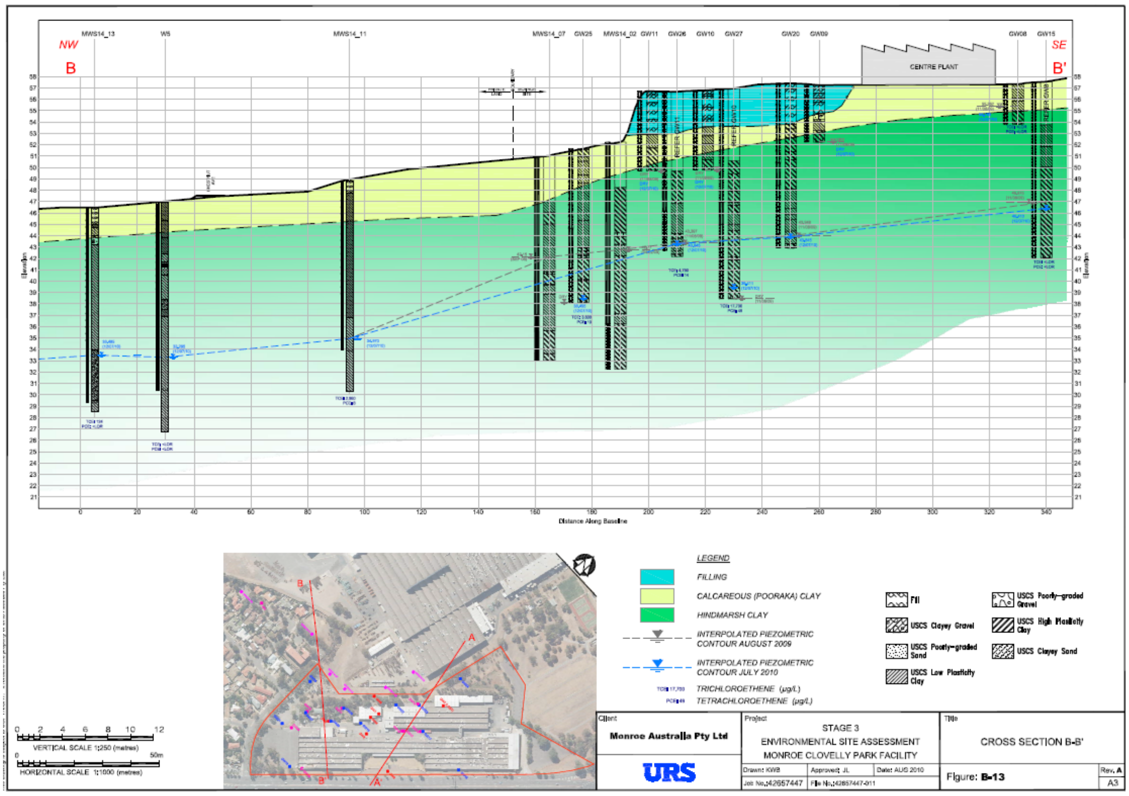

Figure 13 **Northwestern cross-section of sandy aquifer within the Hindmarsh Clay**[96]

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95 AECOM 2016, *Groundwater Monitoring Event, Monroe Clovelly Park*, March 2016.

96 URS 2010, *Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment*, October 2010.

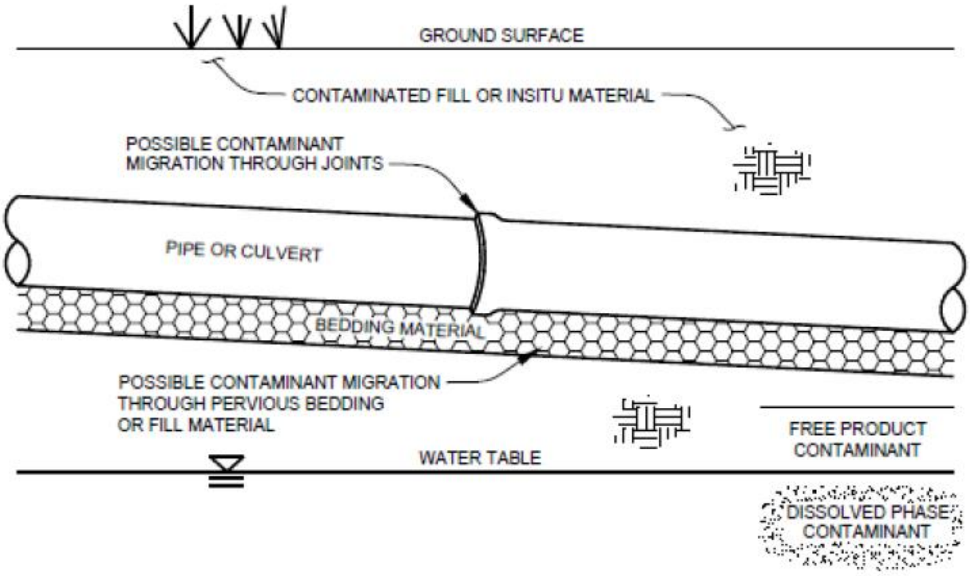

Figure 14 Example of preferential pathway movement of contaminants through an enclosed drain[97]

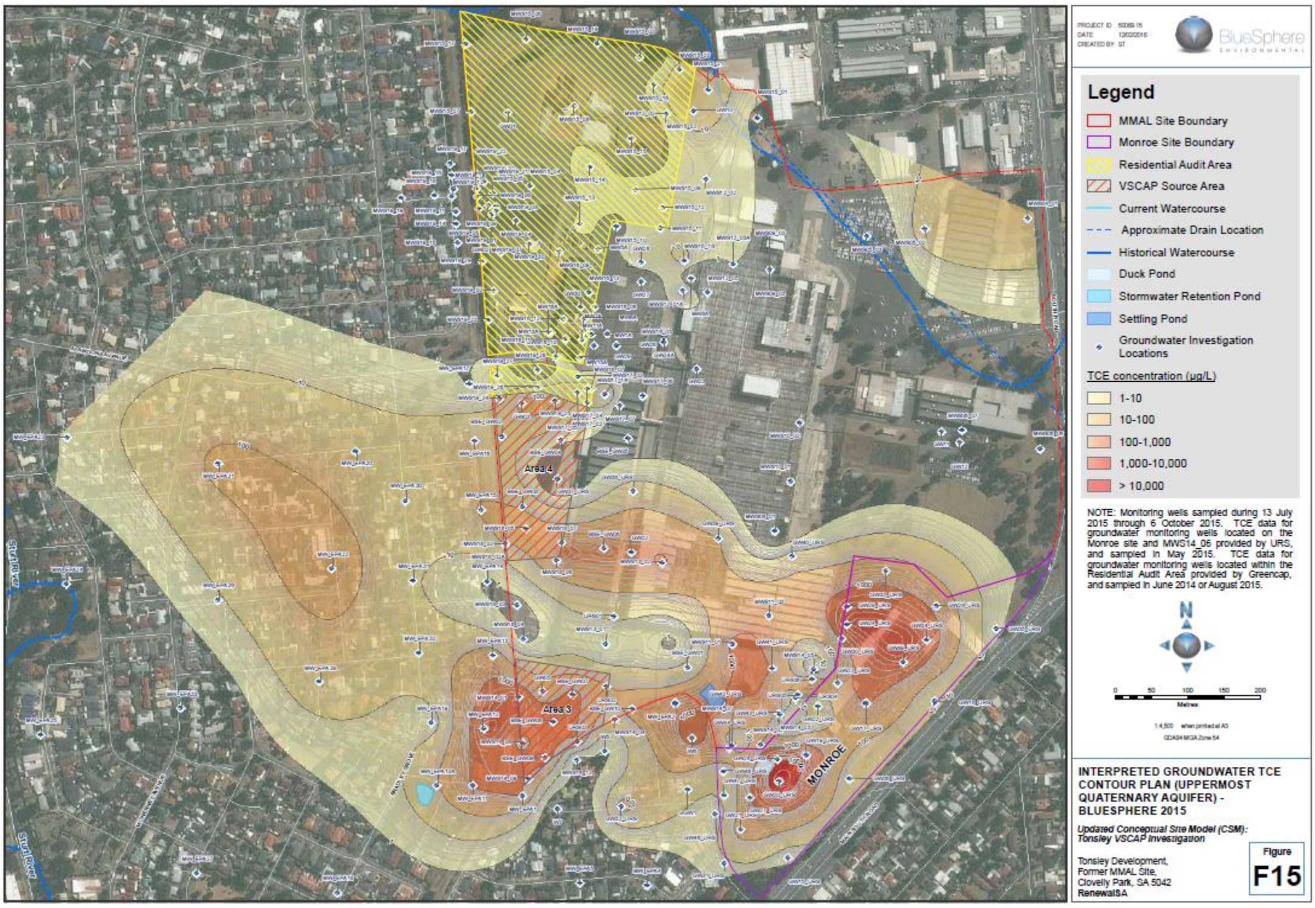

Figure 15 Interpreted groundwater TCE contour plan for Hindmarsh Clay aquifer[98]

97 LWC 2016, *Passive Vapour Migration, Migration – Proposed APA Pipelines, Volume 1: Main Report*, October 2016.

98 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2016.

4.1.2 Former vehicle manufacturing facility (Figure 16)

1284–1324 South Road, Clovelly Park

Site history

In 1955 Chrysler Australia Limited acquired the 71-hectare Tonsley Park Stud Farm in Clovelly Park, utilising the site for warehouse storage of spare automobile parts and the construction of an engine plant in 1957. By 1964 Chrysler Australia completely relocated the vehicle assembly plant from Anzac Highway in Forestville to the Clovelly Park site[99]. The engine plant was later relocated to Lonsdale in 1966, however vehicle assembly operations continued and expanded under joint, then full ownership, with Mitsubishi Motors Australia Limited until 2008 when the site was divested for redevelopment as residential, community, education and commercial properties. The facility at Clovelly Park, now Tonsley, became the main office and assembly plant of cars and trucks for Mitsubishi Motors Australia Limited. The site also included warehouses for vehicle components and accessories, a completed vehicle parking area and storage areas for hazardous wastes and materials for recycling. The storage areas were unsealed.

Summary of environmental assessments

Assessment commenced at the site in 1995 with initial investigation into site history and chemical use audit[100]. During this initial assessment, underground and above ground storage tanks containing fuel, solvents, lubricating and hydraulic oil, ethylene glycol, acid and alkali, were thought to be the primary risk to groundwater contamination[101]. Groundwater monitoring well installation commenced in 1997 with the development of two initial wells. During the initial groundwater monitoring events, petroleum hydrocarbons were identified impacting groundwater at approximately 8.5 m below ground level[102], with the presence of phase separated hydrocarbons, light non-aqueous phase liquid was detected in several monitoring wells[103]. Continued management of the groundwater contamination through monitoring and numerical modelling was undertaken over the next five years, primarily to monitor natural attenuation of identified petroleum hydrocarbons within the upper Hindmarsh Clay aquifer.

In 2004 chlorinated hydrocarbons were identified in the groundwater as a result of investigations into the solvent storage area on site. During that time, a temporary soil vapour extraction system was installed to remove light non-aqueous phase liquid from petroleum hydrocarbons groundwater contamination[104]. Comprehensive staged investigations were undertaken by the site owners from 2008 to 2010 prior to divestment of the site in 2010[105] [106] and during the subsequent staged redevelopment of the site for ongoing uses. Assessment and remediation priorities over the years generally targeted identified source areas, including a former underground storage tank farm area, chemical drum storage areas and treatment shops. A 2011 groundwater monitoring event targeted the southern area of the site, where the majority of the chlorinated hydrocarbon groundwater contamination was previously identified. The groundwater contamination at the

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99 Rust PPK 1995, *Environmental Audit of MMAL Tonsley Park Plant*, September 1995.

100 Rust PPK 1995, *Environmental Audit of MMAL Tonsley Park Plant*, September 1995.

101 PPK Environment & Infrastructure 2001, *Environmental Audit of Mitsubishi Motors Australia Limited, Tonsley Park Plant,* September 2001.

102 Fluor Daniel GTI 1997, *Environmental Site Assessment Report, Underground Storage Tanks, Mitsubishi Motors Australia Limited, South Road, Clovelly Park, SA*, November 1997.

103 Golder Associates 2012, *Groundwater Monitoring Report, Former Mitsubishi Manufacturing Australia Limited Plant, Tonsley Park, South Australia*, May 2012.

104 IT Environmental 2004, *Draft Groundwater Monitoring Event 2004, MMAL Solvent Storage Area, South Road, Clovelly Park, SA*, October 2004.

105 Parsons Brinckerhoff Australia 2008, *Stage 1 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA*, May 2008.

106 Parsons Brinckerhoff Australia 2008, *Stage 2 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA*, August 2008.

former vehicle manufacturing facility and off site from the automotive parts manufacturing facility is co-mingled in this southern area[107].

Three stages of groundwater well drilling programs and further investigation were implemented in 2016 to 2018 to further define the extent of the chlorinated hydrocarbon groundwater plume migrating from the western boundary of the site. At this time, full delineation of the groundwater plume to above the laboratory limit of reporting was achieved defining the extent of the chlorinated hydrocarbons in groundwater in the residential areas of Clovelly Park, Mitchell Park and Marion[108] [109]. An update of the conceptual site model indicated that the chlorinated hydrocarbon groundwater contamination was unlikely to impact on the Oaklands Park Wetlands due to;

- the wetlands' distance from the leading edge of the groundwater plume
- the shallow depth of the wetlands
- the low permeable base material utilised in the construction of the wetlands
- the primary surface water sources understood to recharge the wetlands[110].

During the assessments from 2014 to 2017, among the previously identified contaminants in soil and groundwater, per- and poly-fluroalkyl substances (PFAS) in groundwater were also identified. Further investigations regarding the nature and extent of PFAS contamination was updated in 2020[111].

Site contamination audits[112] [113] [114] [115] [116] have been completed for various portions of land within the site during the assessment period for the purposes of determining the nature and extent of site contamination, determining the suitability of the site and/or for proposed residential and mixed commercial purposes and what further remediation may be required.

Several source removal remediation programs have been implemented in various areas across the site resulting in significant reduction of petroleum hydrocarbon impacts in groundwater[117].

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107 AEC Environmental 2011, *Groundwater Monitoring Event, Tonsley Park Sections 11 & 13, Clovelly Park, SA*, July 2011

108 BlueSphere 2016, *Tonsley VSCAP Investigations Mitchell Park Delineation Drilling.*

109 BlueSphere 2016, *Tonsley VSCAP Investigations: Stage 2 Delineation Drilling, Mitchell Park and Marion*, August/September 2016, November 2016.

110 BlueSphere Environmental 2017, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 03, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2017.

111 Lane A 2020, *Site Contamination Audit Report (Restricted Scope), EPA Identified Source Areas 3 & 4 1284 South Road, Tonsley, South Australia*, June 2020.

112 Hitchcock P 2015, *Site Contamination Audit Report, Section 11 & Portion of Section 13, Tonsley Park Redevelopment, Tonsley Park, SA*, November 2015.

113 Htichcock P 2017, *Site Contamination Audit Report, Lot 331 South Road, Tonsley, SA*, November 2017.

114 Webber A 2017, *Site Contamination Audit Report, Residential Audit Area – Suburban Activity Node Zone, Portions of Former Mitsubishi Motors Australia Limited Site, Tonsley*, December 2017.

115 Webber A 2018, *Site Contamination Audit Report, Waste Derived Fill, PEET Limited, Stages 2 + 2A of Tonsley Village,* July 2018.

116 Lane A 2020, *Site Contamination Audit Report (Restricted Scope), EPA Identified Source Areas 3 & 4, 1284 South Road, Tonsley, South Australia*, June 2020.

117 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, February 2016.

Local geology and hydrogeology

In 2016 an updated conceptual site model[118] was compiled to combine all geology, hydrogeology and groundwater contaminant data together to provide a better understanding of contaminant fate in the environment (Figure 19). Additionally, the development of the conceptual site model was used to determine where additional assessment is required to continue this understanding.

A site-specific understanding of the geology and hydrogeology at the site greatly assisted in this process. A geological bore log summary for the former vehicle manufacturing facility indicates approximately 4 m of fill material, with the absence of the Pooraka Formation. Prior to construction, the land surface was cut and fill material used to level the site. The fill material comprised rework clay, containing bricks, asphalt, ash and charcoal. Underlying the fill material the alluvial clays, sands and gravels of the Hindmarsh Clay Formation were mapped, with groundwater identified over various horizons as opposed to one distinct aquifer (Figure 20). The average water depth below the site is 8.9 m, however groundwater monitoring wells have been screened at varying depths. This indicates a series of groundwater horizons within the first 20 m of the Hindmarsh Clay with varying levels of aquifer confinement[119].

Nature and extent of site contamination

Assessments and site contamination audits determined that groundwater contamination at the site predominantly comprises petroleum hydrocarbons and chlorinated hydrocarbons. During the various staged assessments, soil, soil vapour and groundwater investigations targeted sections of the site where known potentially contaminating activities were understood to have occurred (Figure 16), followed by remediation where necessary. On-site groundwater assessment also identified benzene, metals and arsenic as chemicals of concern[120] [121]. One dimensional fate and transport numerical models were developed to determine the groundwater plume movement off site.

The models predicted that off-site impacts were likely, however the range of prediction scenarios were considered to require further calibration with future monitored data to reduce any degree of uncertainty[122] [123] [124]. Regular groundwater monitoring events, comprising groundwater level gauging and sampling, have been undertaken at the site and in the vicinity to determine the full extent of groundwater contamination and to assist in conceptual and numerical model calibration.

Generally, groundwater flows in a westerly direction across the site with variations to the northwest and to the southwest in the central portion of the site[125] (Figures 17 and 18). However, a 2013 investigation in the northern central part of the site, where petroleum hydrocarbons were the primary focus, identified groundwater mounding within the Hindmarsh Clay aquifer (8–10 m below ground level in this area). This mounding inferred a limiting movement of groundwater down

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[118] BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*.

[119] BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*.

[120] Parsons Brinckerhoff Australia 2008, *Stage 1 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA*, May 2008.

[121] Parsons Brinckerhoff Australia 2008, *Stage 2 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA*, August 2008.

[122] Parsons Brinckerhoff Australia 2009, *One-dimensional Groundwater Model Assessment – Section 6 Mitsubishi Motors Production Plant, Tonsley Park, SA*, January 2010.

[123] Parsons Brinckerhoff Australia 2009, *One-dimensional Groundwater Model Assessment – Section 9 Mitsubishi Motors Production Plant, Tonsley Park, SA*, January 2010.

[124] Parsons Brinckerhoff Australia 2009, *One-dimensional Groundwater Model Assessment – Section 12 Mitsubishi Motors Production Plant, Tonsley Park, SA*, January 2010.

[125] Greencap 2017, *Detailed Site Investigation – Tonsley SANZ, Suburban Activity Node Zone –Tonsley*, October 2017.

hydraulic gradient, indicating a reduced migration of contaminated groundwater off site. With the subsequent tank removal, soil remediation and redevelopment of the site it was considered that the groundwater mounding had dissipated and groundwater flow resumed in a westerly direction, congruent to the regional groundwater flow direction[126].

Where assessment was undertaken on portions of the site for proposed residential development, the auditor made recommendations and conditions for ongoing use as a residential area[127]. To understand the current and predicted extent of groundwater plumes statistical trend analysis and numerical modelling was undertaken. The statistical trend analysis of chlorinated hydrocarbon concentration data indicates that the groundwater plumes are continuing to migrate within the upper Hindmarsh Clay aquifer and contamination is likely to extend a further 590 m northwest of the current groundwater plume footprint[128].

Conceptual site modelling undertaken at the site and in the vicinity of the site has determined that the extent of chlorinated hydrocarbon contamination can be divided into three main plumes arising from a southern, central and northern areas on the former vehicle manufacturing facility and the automotive parts manufacturing facility (Figures 21 and 22) as described in section 4.1.1[129]. The contaminant distributions between the groundwater plumes are understood to be influenced by varying degrees on interconnectivity between low and higher permeable sediments creating preferential pathways. In addition anthropogenic connectivity seems to have been created by a complex network of drains, sewer lines and the locally modified creek system. Large diameter stormwater drains on site are understood to discharge into Viaduct Creek and then to the Sturt River west of the site[130].

The auditor also recommended that the EPA consider a groundwater prohibition for the area[131].

The comprehensive assessment undertaken at the site and in the vicinity of the site have determined that contaminants of concern are above relevant human health guidelines[132] [133].

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126 Land and Water Consulting 2013, *Groundwater assessment, former Mitsubishi Manufacturing Australia Limited Plant, Section 9, Flinders University (Kinetica) Site, Tonsley Park Development*, September 2013.

127 Webber A 2017, *Site Contamination Audit Report, Residential Audit Area – Suburban Activity Node Zone, Portions of Former Mitsubishi Motors Australia Limited Site Tonsley*, December 2017.

128 Lane A, *Site Contamination Audit Report (Restricted Scope) EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, South Australia*, 18 June 2020.

129 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*, March 2016.

130 Lane A, *Site Contamination Audit Report (Restricted Scope) EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, South Australia*, 18 June 2020.

131 Lane A, *Site Contamination Audit Report (Restricted Scope) EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, South Australia*, 18 June 2020.

132 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

133 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

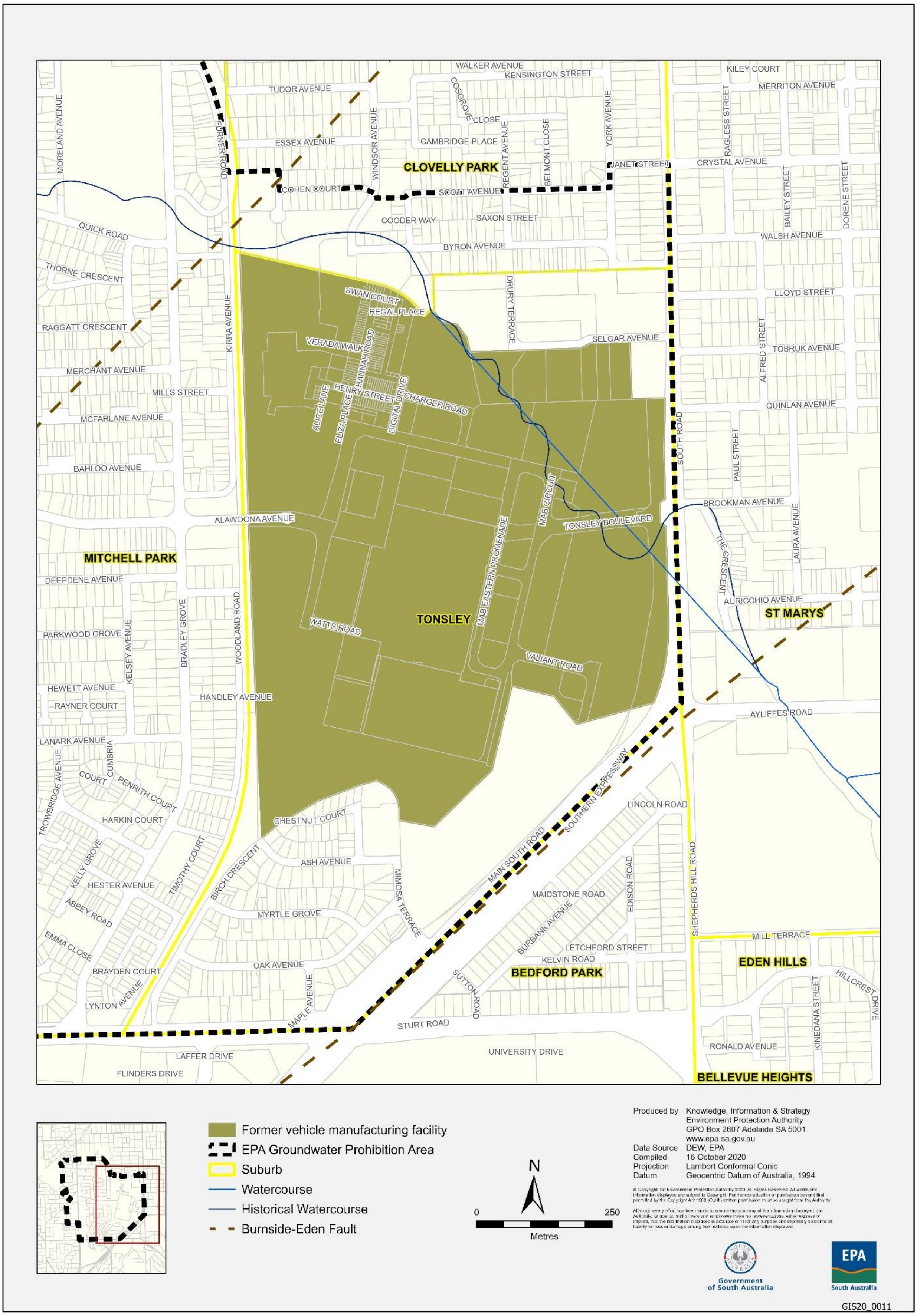

Figure 16 Former vehicle manufacturing facility

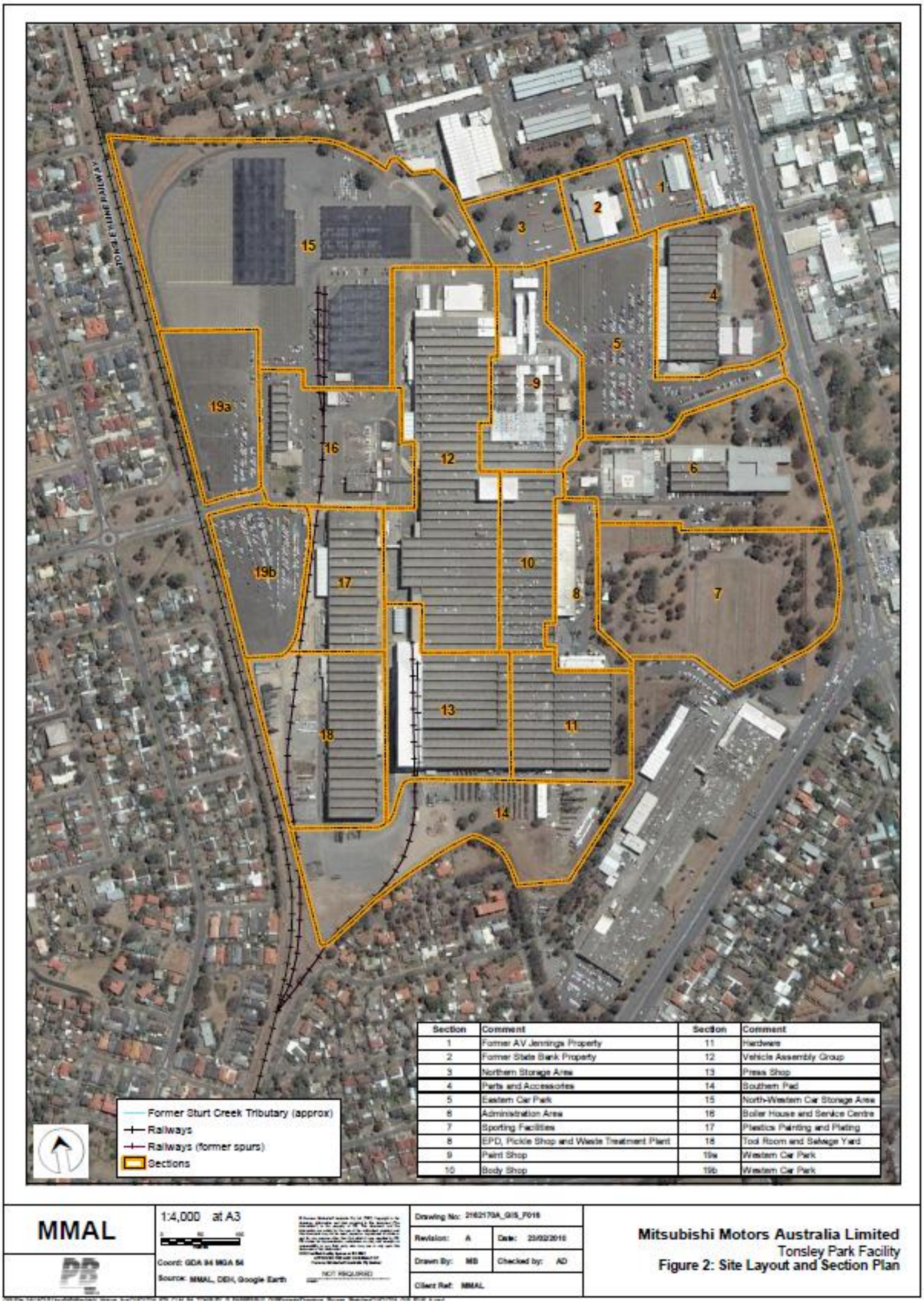

Figure 17 Isolated investigation of petroleum hydrocarbon plume arising from an underground storage tank area[134]

[134] Parsons Brinckerhoff Australia 2010, *Additional Groundwater Assessment Report, MMAL Tonsley Park*, March 2010.

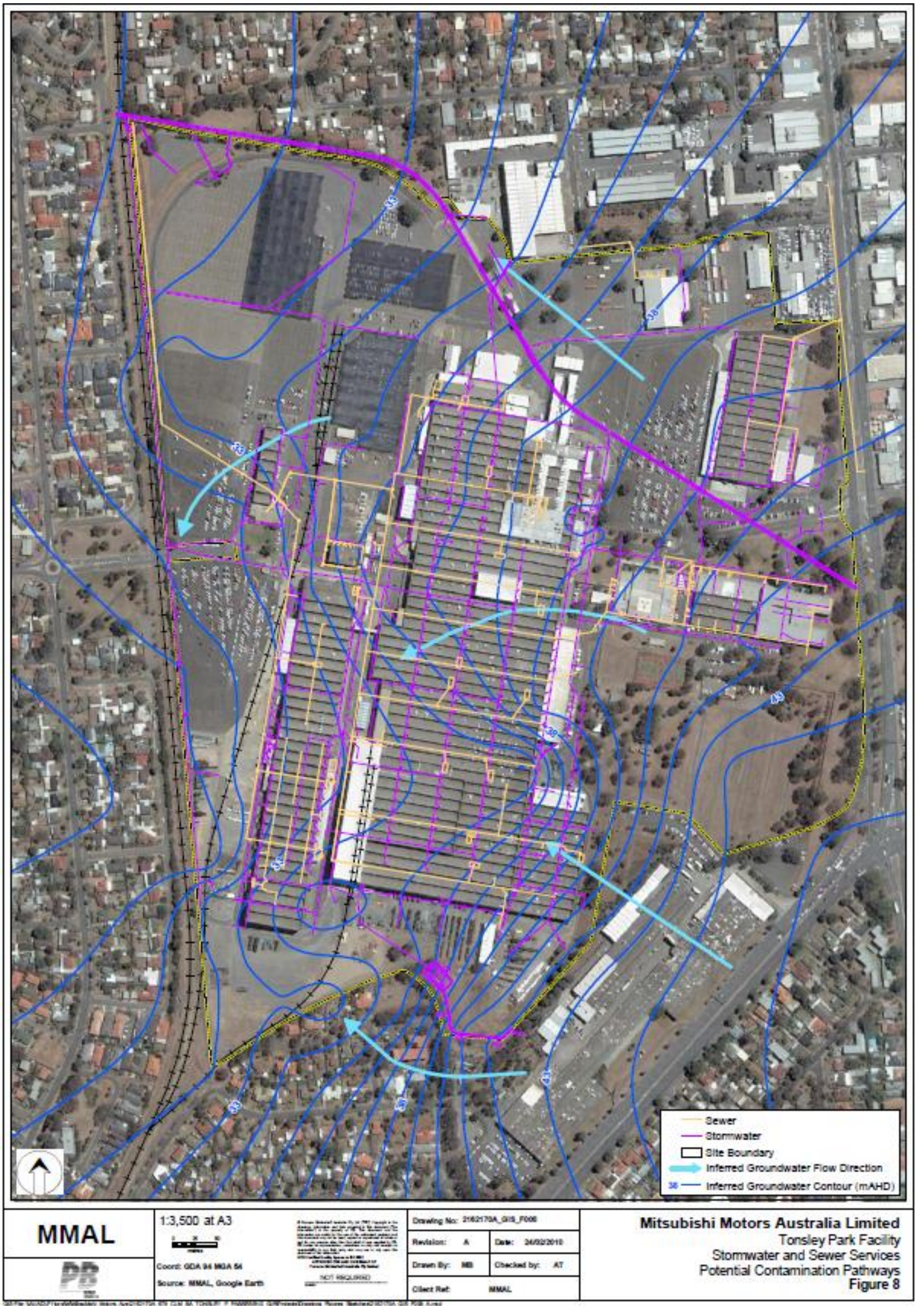

Figure 18 Interpreted groundwater flow direction, including stormwater drains[135]

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[135] Parsons Brinckerhoff Australia 2010, *Additional Groundwater Assessment Report, MMAL Tonsley Park*, March 2010.

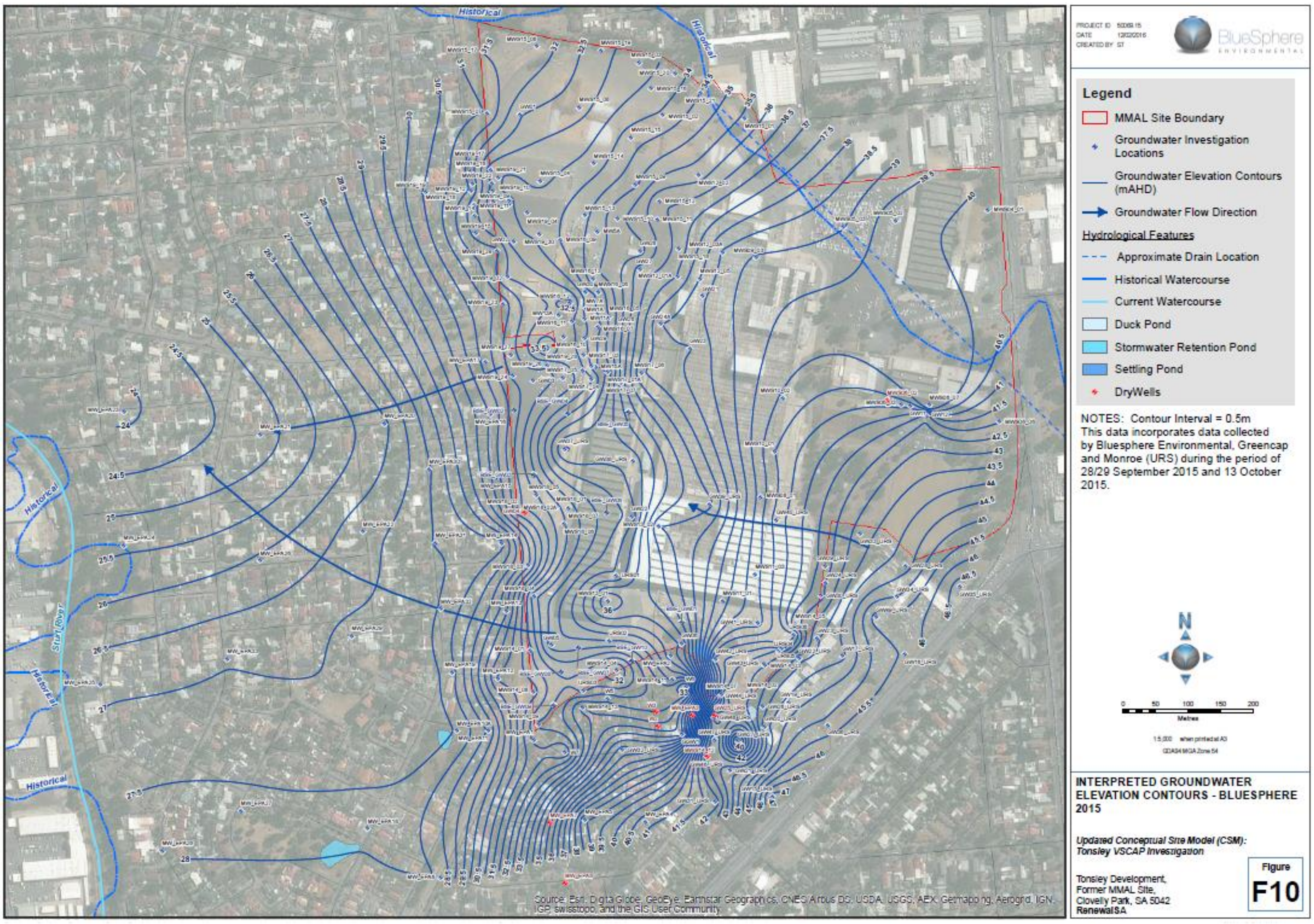

Figure 19 On and off-site interpreted groundwater flow direction[136]

136 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA*.

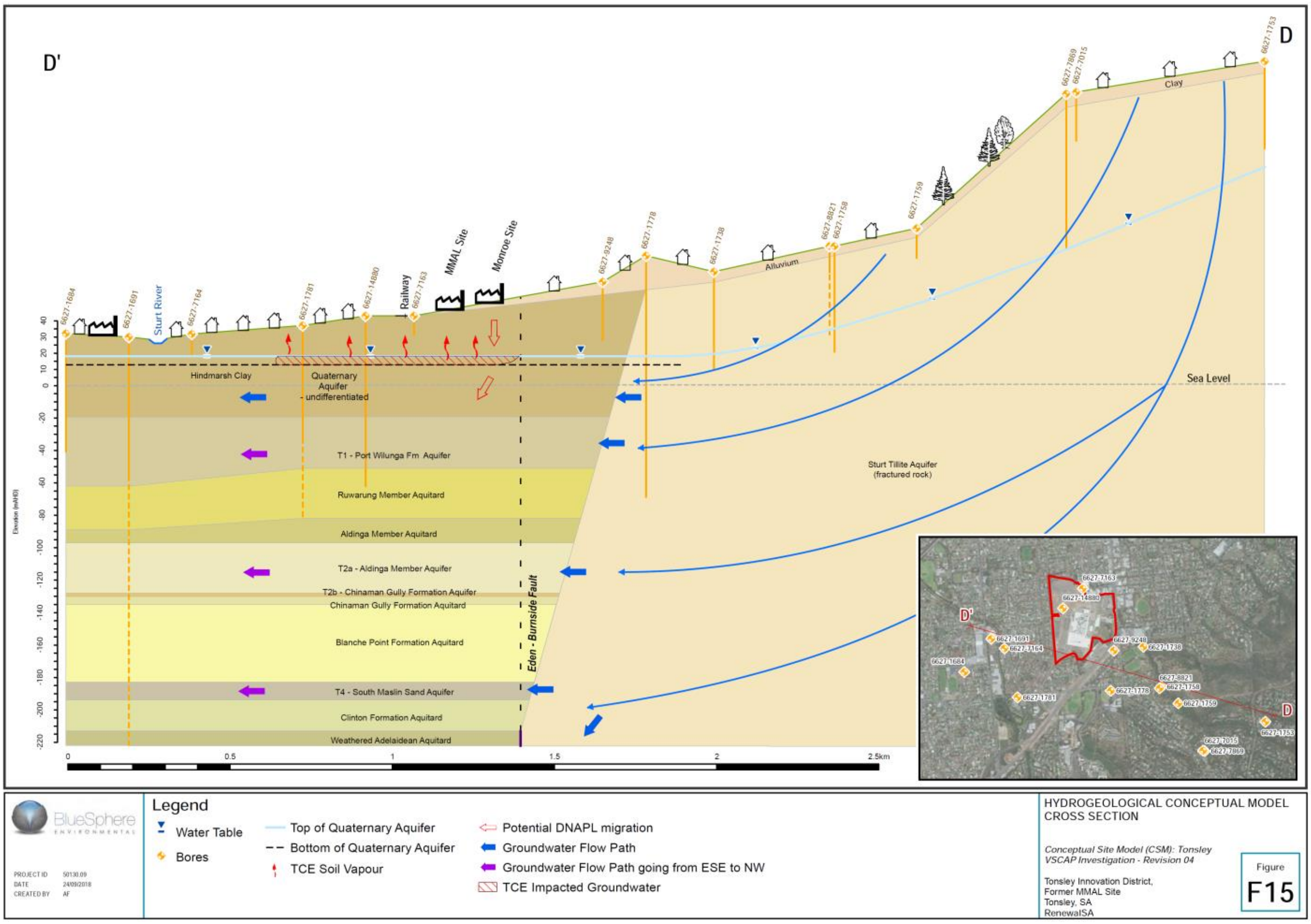

Figure 20 Interpreted regional hydrogeological cross section[137]

137 BlueSphere Environmental 2018, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 04, Tonsley Innovation District, Former MMAL Site, Clovelly Park, SA*, September 2018.

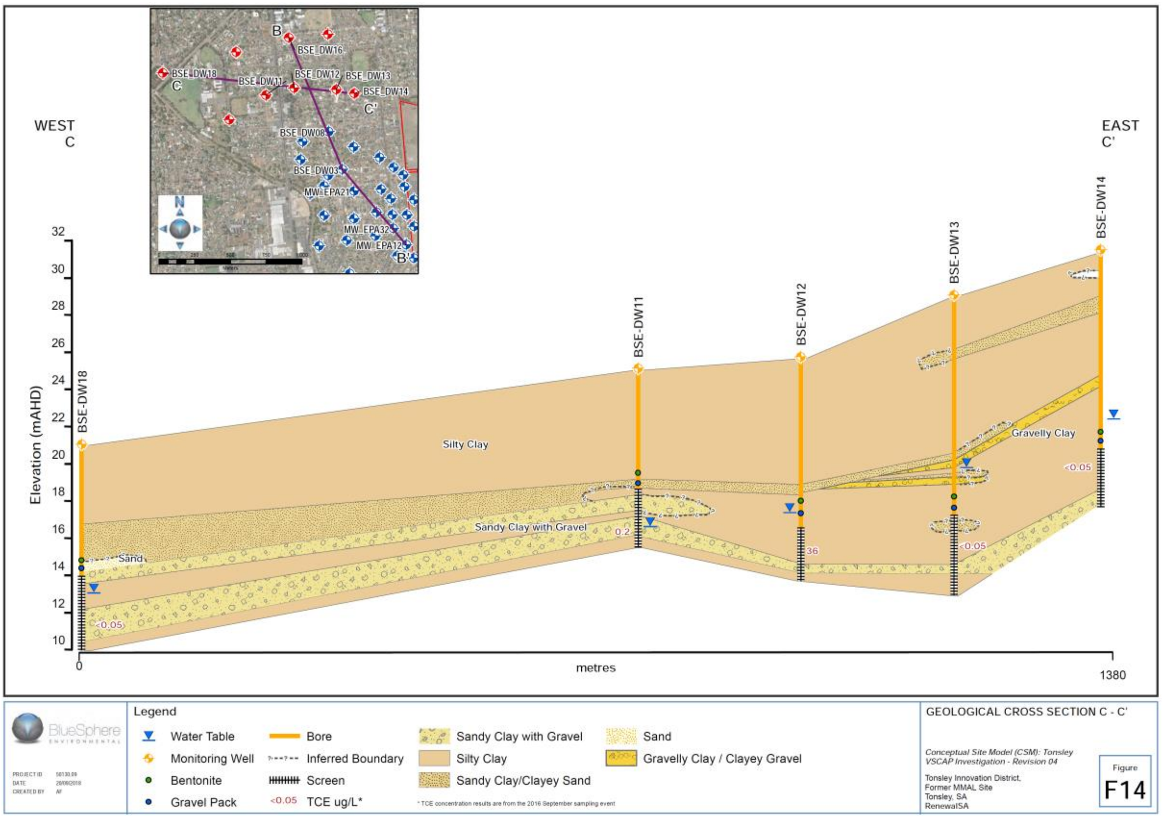

Figure 21 Tonsley/Mitchell Park cross-section[138]

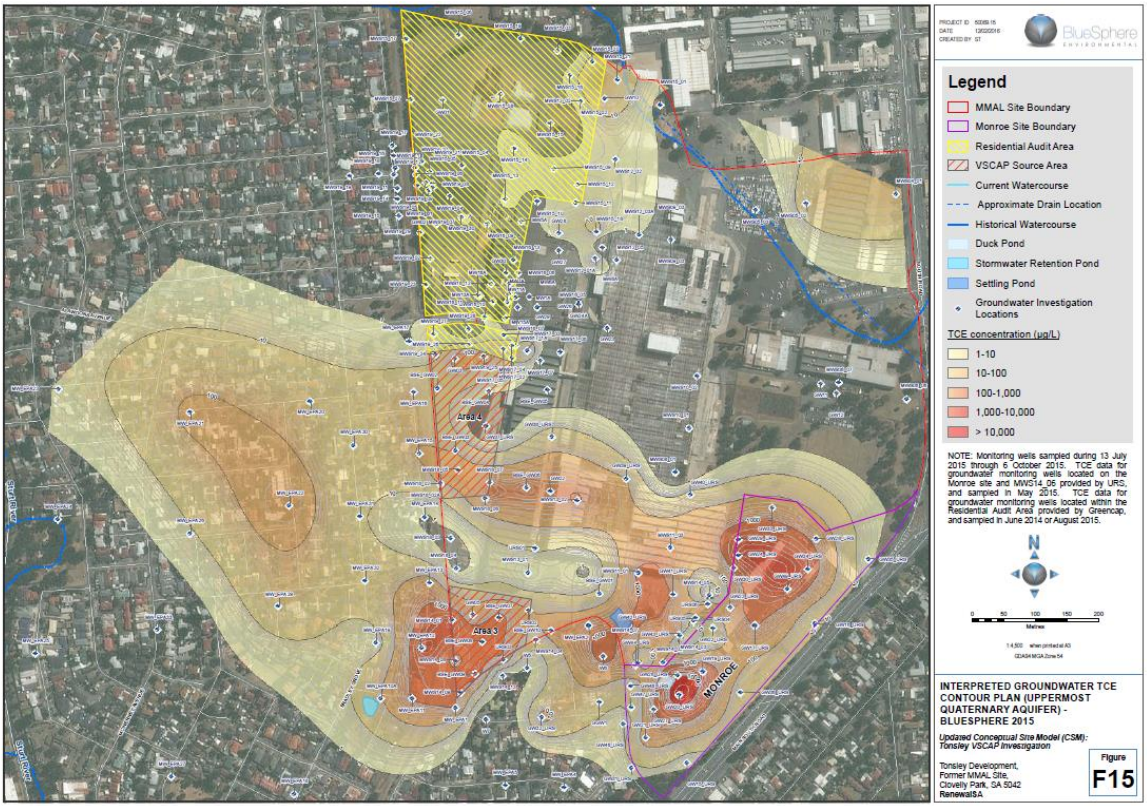

Figure 22 Interpreted groundwater TCE contour plan for Hindmarsh Clay aquifer[139]

138 BlueSphere Environmental 2018, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 04, Tonsley Innovation District, Former MMAL Site, Clovelly Park, SA*, September 2018.

139 BlueSphere Environmental 2016, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site, Clovelly Park, SA.*

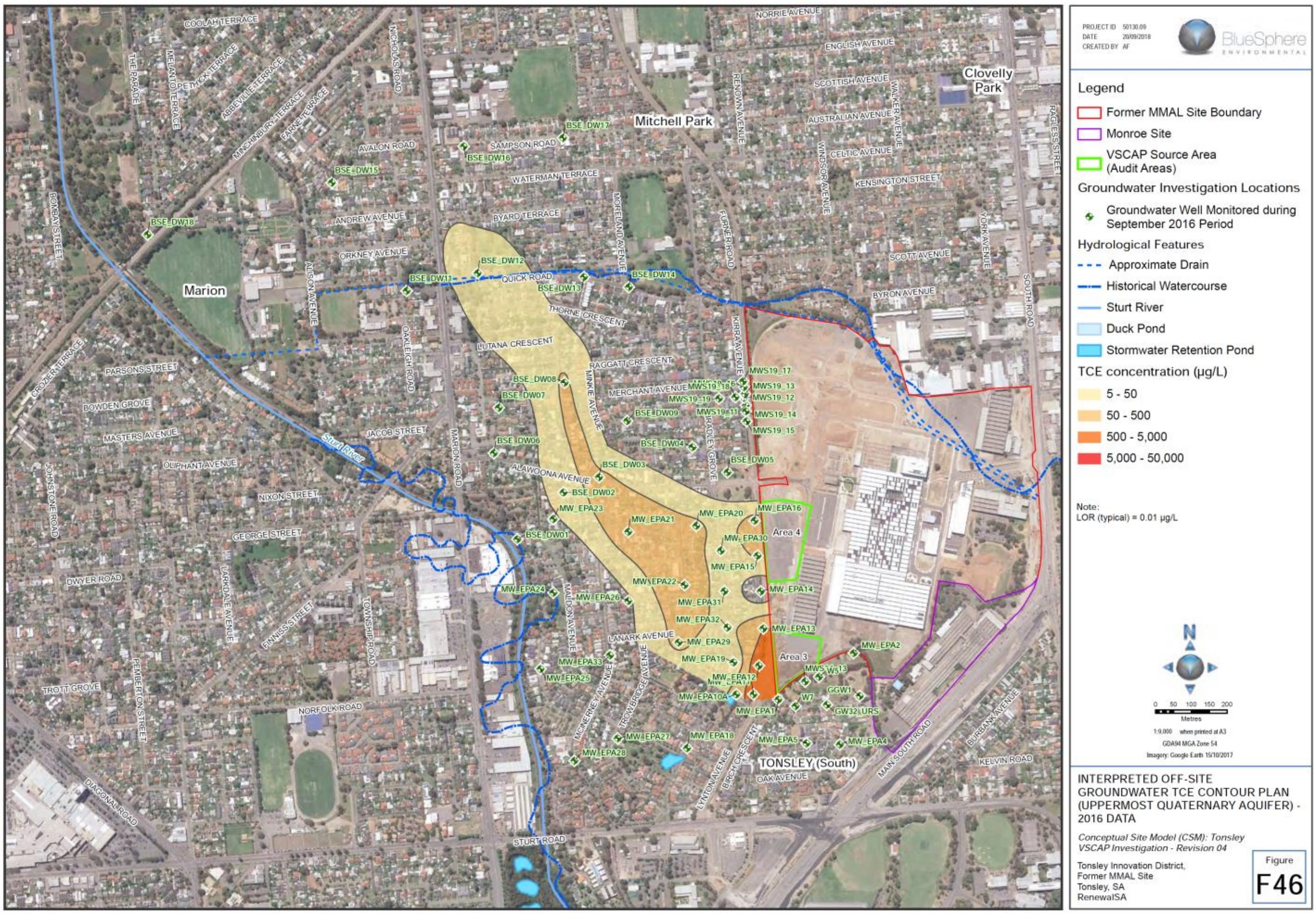

Figure 23 Interpreted TCE concentrations in groundwater within the Mitchell Park area[140]

4.1.3 Works depot and recycling depot (Figure 23)

935 Marion Road, Mitchell Park

In 2000, assessment commenced in three portions of the site – nursery, operations depot and recycling depot. Petroleum hydrocarbons were identified in the groundwater derived from leaking of five underground fuel storage tanks, located in the southeastern area of the operating depot[141]. Petroleum-based products identified at the operations depot have been identified in groundwater above relevant health based guidelines[142].

140 BlueSphere Environmental 2018, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 04, Tonsley Innovation District, Former MMAL Site, Clovelly Park, SA*, September 2018.

141 Hall A 2000, *Site Audit Report, City of Marion Operations Depot, 935 Marion Road, Mitchell Park, SA*.

142 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

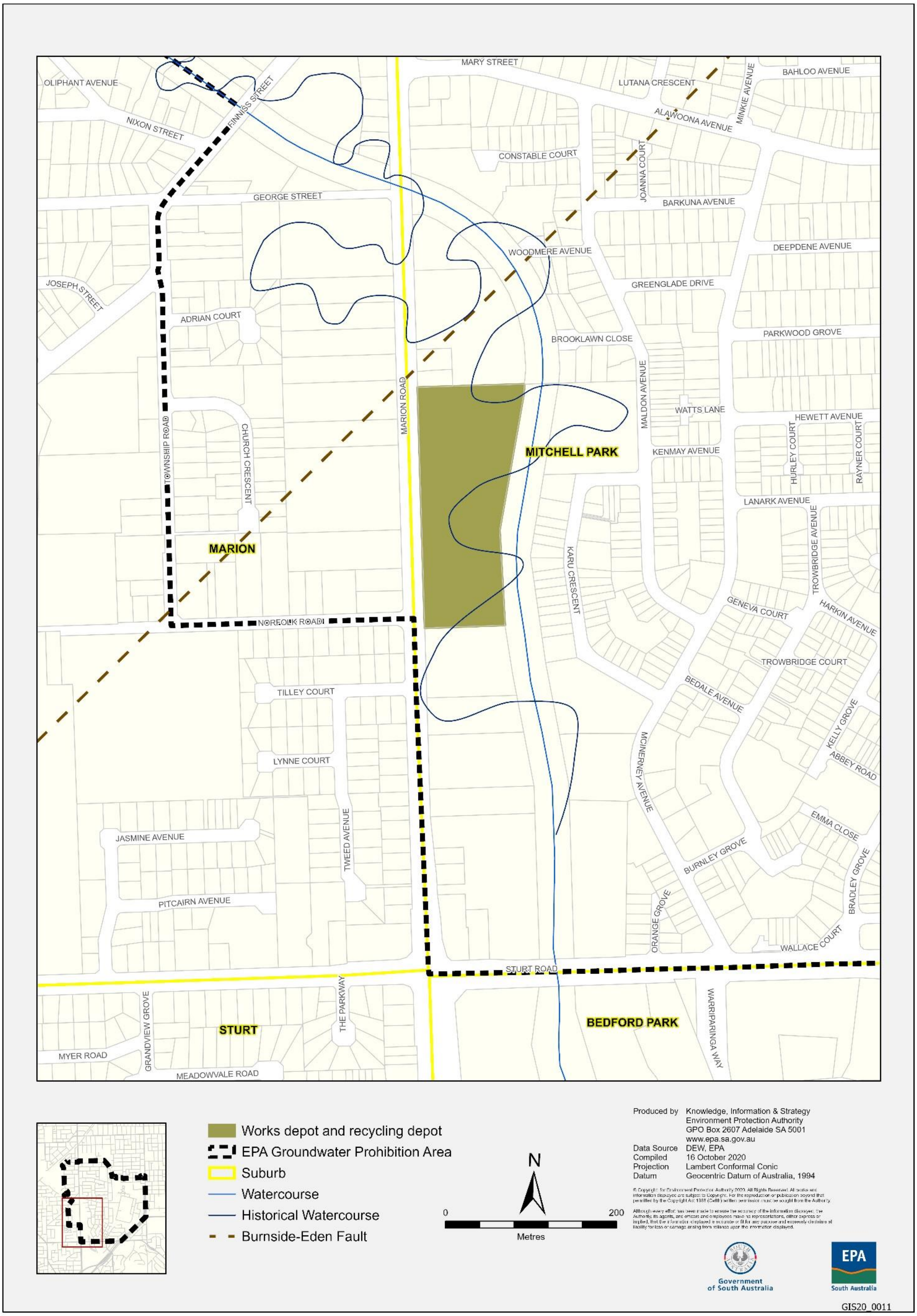

Figure 24 **Works depot and recycling depot**

5 Factors in considering a groundwater prohibition area

5.1 Groundwater users

Within the proposed GPA (incorporating Tonsley and portions of Clovelly Park, Mitchell Park and Marion) there are approximately 377[143] registered groundwater wells.

Of those registered wells:

- 12 are potentially for domestic purposes, accessing the upper Hindmarsh Clay Quaternary aquifer (8–25 m below ground level)
- 4 are potentially for domestic purposes, accessing the deeper Hindmarsh Clay and Carisbrook Sands Quaternary aquifers (30–60 m below ground level)
- 18 are registered accessing the Tertiary aquifer for irrigation purposes (greater than 60 m but less than 100 m below ground level)
- 5 are Department of Environment and Water observation wells accessing the Quaternary and Tertiary aquifer (various depths below ground level)
- 338 are registered as monitoring wells (various depths below ground level).

The groundwater within the upper and deeper Hindmarsh Clay Quaternary aquifers generally contains total dissolved solids between 750 and 3,000 mg/litres, with the average abstraction yield in the upper aquifers of 0.7 litres per second. The deeper Hindmarsh Clay Quaternary aquifer yields groundwater at an average abstraction rate of 1 litre per second. The Carisbrook Sand aquifer and the deeper Tertiary aquifer yield groundwater at 5–10 litres per second and generally have lower total dissolved solids or salinities[144]. The groundwater is considered suitable to marginal as a domestic water and domestic irrigation supply. Groundwater in this area is known to be used for gardening (including water for home-grown produce), irrigating lawns, filling swimming pools and greywater use, such as toilet flushing.

5.2 Groundwater plume delineation

Investigations within the Tonsley area and portions of Clovelly Park, Mitchell Park and Marion provide evidence of groundwater plumes arising from the former automotive parts manufacturing facility, former vehicle manufacturing facility, and the works and recycling depot. To understand the delineation of the groundwater plumes, a conceptual understanding of the area was developed through the documented investigations, including assessment and remediation reports in the area. The documented nature and extent of the groundwater plumes supports the formulation of the broad conceptual site model, which facilitates the prediction of the final area potentially impacted by groundwater contamination.

The estimated final extent of the leading edges of the groundwater contamination within the GPA was determined by direct measurements, with the assistance of data trend analysis to indicate fate predictions. During the investigation process, groundwater hydraulic parameters were determined, and included hydraulic gradient, hydraulic conductivity and aquifer sediment porosity estimations. Hydraulic parameters were utilised to calculate the groundwater flow velocity or seepage velocity and the flow direction. Measured hydraulic conductivity within the area varies four orders of magnitude from 10^{-0} to 10^{-4} m per day. Hydraulic gauging of groundwater wells in the area has indicated that the groundwater flows generally in a northwesterly direction towards the Gulf St Vincent.

During review of site-based conceptual site models for the area, it was observed that the heterogeneity within the sedimentary aquifer beds varies significantly throughout the assessed areas of Tonsley and portions of Clovelly Park, Mitchell Park and Marion. This is viewed as a challenge when utilising numerical modelling for the determination of

143 www.waterconnect.sa.gov.au accessed 22 September 2020

144 www.waterconnect.sa.gov.au accessed 22 September 2020

contaminant fate and transport, reducing the validity of any model presented. Theoretically, a realistic approach to contaminant plume determination can be determined through statistical analysis of time series trend data from direct measurement over multiple groundwater monitoring events[145].

In 2018 consultants characterised and statistically analysed the groundwater plume trend data to determine the stability of the groundwater plume within the Mitchell Park area. The groundwater plumes from the former automotive parts and vehicle manufacturing facilities determined through direct measurement to have migrated approximately 1,500 m from these sites. This is consistent with the high hydraulic conductivity range identified within the laterally interconnected sandy/gravelly lenses of the upper Hindmarsh Clay Quaternary aquifer[146].

When considering the fate and transport of the groundwater plume, contaminants move with the groundwater through advection[147], diffusion[148], dispersion[149] and chemical reactions, such as molecular and bimolecular degradation (see Appendix 3). These processes of contaminant movement also degrade or attenuate the chemicals within the groundwater and this is known as natural attenuation. Determining the degree of natural attenuation of contaminants assisted in the understanding of the dimensions and stability of the groundwater plume. This enabled predictions to be made on when groundwater conditions will temporally and spatially stabilise.

Based on the broad conceptual site model development, the contaminants within the upper Hindmarsh Clay Quaternary aquifer were thought to be well characterised and the groundwater plume has been determined to be stable[150]. As the development of a conceptual site model is a iterative process, continuing groundwater monitoring events can provide additional data to enhance reliability of any model.

5.3 Buffer zone

The determination of the necessity to establish a GPA can incorporate both the measured groundwater plume footprint and a potential conservative plume expansion area, known as a 'buffer zone'. Incorporating a buffer zone into a GPA will also prevent further expansion for the plume through groundwater abstraction at a rate that would be higher than the natural groundwater flow.

The proposed GPA includes the known source sites (discussed in section 4) and surrounding properties within portions of the suburbs of Clovelly Park, Tonsley, Mitchell Park and Marion. The majority of the properties in the western proposed GPA are residential and are located down hydraulic gradient of the two main source sites. The buffer zone extends beyond the known and inferred groundwater plume extents where direct measurement of groundwater contamination has identified concentrations at 10% of EPA recognised drinking water criteria[151] [152] at the leading edges of the groundwater plumes. The buffer zone is incorporated around the groundwater plumes within the GPA to prevent expansion of the plumes due to groundwater abstraction and to allow for variations in model calibrations.

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145 ITRC 2013, *Groundwater Statistics and Monitoring Compliance, Statistical Tools for the Project Life Cycle, December 2013.* Guidance document prepared by The Interstate Technology and Regulatory Council Groundwater Statistics and Monitoring Compliance Team.

146 Bluesphere 2018, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – revision 04, Tonsley Innovation District, Former MMAL Site, Tonsley, SA*, September 2018.

147 The process by which solutes are transported by the motion of flowing groundwater

148 The movement of a substance from an area of high concentration to an area of low concentration

149 The extent to which a liquid substance introduced into a groundwater system spreads as it moves through the system

150 Bluesphere 2018, *Conceptual Site Model (CSM): Tonsley VSCAP Investigation – revision 04, Tonsley Innovation District, Former MMAL Site, Tonsley, SA*, September 2018.

151 National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

152 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

5.4 Exposure pathways and human health assessment

The risk to human health and safety predicted by the presence of contaminated groundwater is determined by investigation and source–pathway–receptor linkages previously discussed in section 2.3. This process is used to consider whether the presence of contaminants of concern present a risk to human health or the environment by examining if there are pathways through which these contaminants can impact sensitive receptors.

5.4.1 Groundwater abstraction

The movement of contaminants within the groundwater from a site to a well creates a valid groundwater pathway from source to receptor. When groundwater is abstracted, a risk to human health and safety exists from the exposure to contaminants within the groundwater and the use of that groundwater by the receptor. Through the process a link has been established between source and receptors through a pathway of potential groundwater abstraction. Where this pathway exists, it has been determined that a risk to human health and safety may exist.

6 Buffer zone

The buffer zone is an important part of the GPA, as it is designed to prevent the groundwater plume expanding due to groundwater abstraction from currently installed nearby wells.

Reports held and reviewed by the EPA (Appendix 2) describe the site contamination at point-in-time within Tonsley and portions of Clovelly Park, Mitchell Park and Marion. Based on the broad conceptual site model, the EPA has identified the boundaries of the proposed GPA, which includes the known lateral and vertical extent of the groundwater contamination, and a buffer zone surrounding the groundwater contamination.

The EPA holds no information that indicated the deeper Hindmarsh Clay Quaternary aquifer is affected by site contamination. At this stage potential impacts to the deeper aquifers have not been assessed. Due to the confining nature of the clays, and a depth of greater than 30 metres below ground level, the risk to the deeper aquifers is unlikely.

Based on data held by the EPA during the review for the GPA, the estimated extent of groundwater contamination can be predicted, and the margins of the GPA, which incorporate both a measureable groundwater contamination and a potential conservative expansion area (buffer zone), can be determined. Incorporating these margins as a buffer zone aims to prevent further expansion of the contamination through groundwater abstraction at a rate higher than the natural groundwater flow.

The proposed GPA includes the source sites (section 2) and portions of the surrounding suburbs in a west and northwest direction. The majority of the properties are down groundwater hydraulic gradient of the source sites. The buffer zones extend to 10% of EPA recognised drinking water criteria[153] [154] at the leading edges of the groundwater plumes (Figure 24). This is to allow for inaccuracies in modelling assumptions and prevent expansion of the plume due to groundwater abstraction.

The proposed GPA includes the upper Hindmarsh Clay aquifer for approximately 2.5 km in a northwesterly direction from the corner of Main South Road and Shepherds Hill Road to Minchinbury Terrace.

[153] National Health and Medical Research Council and National Resource Management Ministerial Council 2011, *Australian Drinking Water Guidelines 6* (Version 3.5 updated August 2018).

[154] WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

7 Community information

7.1 Community engagement

Historically, the EPA and the proponents for the redevelopment of the former vehicle manufacturing site have engaged periodically with residents in the Tonsley, Clovelly Park and Mitchell Park area from November 2008. Engagement with the community was concerned the ongoing assessments in the area and the identification of site contamination, which included soil, vapour and groundwater impacts. The various methods of communicationwere letters, fact sheets and a 'drop-in' engagement session. All letters and fact sheets are available on the EPA website[155].

The EPA will now undertake a specific 90-day community engagement program to discuss the proposal to establish a GPA in the Tonsley, Clovelly Park, Mitchell Park and Marion area.

The community consultation will include the use of an online engagement forum at www.engage.epa.sa.gov.au/Clovelly Park and conclude with the compilation of a community engagement report.

7.2 Access to EPA information

When the EPA establishes a GPA pursuant to section 103S of the EP Act, there is a requirement to place the details of the GPA in the Public Register[156].

It is important that all current and future owners of properties within a GPA are made aware of the prohibition or restriction. The EPA cannot notate the existence of a GPA on the Certificate of Title. It will write to all current land owners and tenants within the area to inform them of the pending establishment of a GPA.

Section 7 of the *Land and Business (Sales and Conveyancing) Act 1994* provides a series of questions that the EPA must respond to in relation to land. One of the questions relates to the existence of a GPA. Following the declaration of a GPA, notice will be given to potential purchasers of the land through the Form 1 statement. This provides an ongoing method to ensure potential and future owners are aware of a statutory prohibition.

155 https://www.epa.sa.gov.au/environmental_info/site_contamination/assessment_areas/clovelly_park_mitchell_park

156 Pursuant to section 109 of the EP Act

8 Conclusion

The EPA is able to use the provisions of section 103S of the EP Act to prohibit or restrict the taking of groundwater to reduce or prevent human exposure to contamination from former industrial land uses. Establishing a GPA provides interim protection while the contaminants of concern naturally attenuated within the groundwater or until a practicable remediation strategy can be developed.

As it has been determined there is a risk to human health and safety and that action is required, the EPA proposes to establish a GPA in Tonsley and portions of Clovelly Park, Mitchell Park and Marion pursuant to the provisions of section 103S of the EP Act. This report reviews the circumstances and information which gave rise to the proposal to establish a GPA. This action will prohibit the taking of groundwater within the designated area.

The proposed GPA is set out on Figure 1.

The GPA will include the shallow unconfined aquifer at the base of the Pooraka Formation and upper Hindmarsh Clay Quaternary aquifer for approximately 2.5 km in a northwesterly direction from Main South Road and Shepherds Hill Road to Minchinbury Terrace (Figure 1), to a depth of 25 m below ground level.

Following establishment of the GPA, future purchasers of properties within the GPA will be made aware of the prohibition on taking of groundwater via the Form 1 statement pursuant to Section 7 of the *Land and Business (Sales and Conveyancing) Act 1994.*

Following the establishment of a GPA, it will be an offence to use groundwater for any purpose, other than for environmental monitoring, in the prohibition area. A maximum penalty of $8,000[157] applies (Division 5 fine).

157 At the time of publication

9 Glossary

Aquifer	Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit water
Attenuation	Reactions that cause contaminant concentrations to decrease in surface or ground water
Audit	Refer to environmental site audit
Auditor	Refer to environmental site auditor
Background concentration	In relation to chemical substances on a site or below its surface, means results obtained from carrying out assessment of the presence of the substances in the vicinity of the site in accordance with guidelines from time to time issued by the EPA. Refer to the EPA publication, *Site contamination: Assessment of background concentrations (2018).*
Chemical substances	Any organic or inorganic substance, whether a solid, liquid or gas (or combination thereof), and includes waste.
Concentration	The amount of material or agent dissolved or contained in a unity quantity in a given medium or system.
Conceptual site model	A representation of site-related information including the environmental setting, geologic, hydrogeological and soil characteristics together with the nature and extent of contaminants. Concentration sources, exposure pathways and potentially affected receptors are identified. Presentation can be graphical, tabular or explanatory text.
Contaminant	Any chemical existing in the environment above background levels and representing, or potentially representing, a risk to human health or safety and/or the environment
Environmental audit report	A detailed written report that – (a) Sets out the findings of the audit and complies with the guidelines and standards (in particular the Environmental Auditor Guidelines for issue of certificates and statements of environmental audit) issued by the Victorian EPA; and (b) Includes the issue of either a certificate of environmental audit or statement of environmental audit, in the prescribed form, by the environmental auditor who personally carried out or directly supervised the audit.
Environmental auditor	A person accredited under the Victorian *Environment Protection Act 1970* as an environmental auditor. Since 1 July 2009 the South Australian EPA has accredited persons who undertake site contamination audits in the state.
Groundwater	Water held in the pores of an aquifer
Groundwater contaminant plume (groundwater plume)	A mixture of chemicals and groundwater, usually in soluble form
Groundwater prohibition area (GPA)	The establishment by the EPA under section 103S of the *Environment Protection Act 1993*
Hydraulic conductivity	Rate of water movement through an aquifer
Hydraulic head	Specific measurement of water pressure within an aquifer
Hydraulic transmissivity	Measurement of an aquifer's capacity to transmit water
Land	Land as a physical entity, including land covered by water[158]

[158] As defined in the section 3(1) of the Environment Protection Act 1993

Massive	Very thick homogeneous stratification in sedimentary rocks.
Multiple lines of evidence	Uses a combination of information from several independent sources (or lines of evidence) to provide sufficient support to demonstrate success in situations where no one individual line of evidence provides sufficient certainty.
Orogeny	Mountain building structural activity
Potentially contaminating *activity*	Activities that are prescribed for the purposes of regulation through the *Environment Protection Act 1993* (sections 103C and 103H), regulation 50(1) of the *Environment Protection Regulations 2009*
Precautionary principle	Where there are threats or serious irreversible damage to human health and or the environment, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation or human exposure.
Remediate	To remediate a site means treat, contain, remove or manage chemical substances on or below the surface of the site as to – (a) eliminate or prevent actual or potential harm to the health or safety of human beings that is not trivial, taking into account current or proposed land uses; and (b) eliminate or prevent, as far as reasonably – (i) actual or potential harm to water that is not trivial; and (ii) any other actual or potential environmental harm that is not trivial, taking into account current or proposed land uses.
Remediation	Has the same meaning as remediate
Risk	The probability that in a certain timeframe an adverse outcome will occur in a person, a group of people, plants, animals and/or the ecology of a specified area that is exposed to a particular dose or concentration of a specified substance, ie it depends on both the level of toxicity of the substance and the level of exposure.
Site	An area of land (whether or not in the same ownership or occupation)
Site contamination	Exists at a site if – (a) chemical substances are present on or below the surface of the site in concentrations above the background concentration (if any); and (b) the chemical substances have, at least in part, come to be present there as a result of an activity at the site or elsewhere; and (c) the presence of the chemical substances in those concentrations has resulted in – (i) actual or potential harm to the health or safety of human beings that is not trivial, taking into account current or proposed land uses; or (ii) actual or potential harm to water that is not trivial; or (iii) other actual or potential environmental harm that is not trivial, taking into account current or proposed land uses.
Site contamination audit report	A detailed written report that – (a) sets out the findings of the audit and complies with the guidelines issued from time to time issued by the EPA; and (b) includes a summary of the findings of the audit certified, in the prescribed form, by the site contamination auditor who personally carried out or directly supervised the audit.
Site contamination auditor	A person accredited under Division 4 of Part 10A of the *Environment Protection Act 1993* as a site contamination auditor
Site contamination consultant	A person other than a site contamination auditor who, for fee or reward, assesses the existence or nature or extent or site contamination

Steady state	The ongoing migration of contaminants from the source and within the plume is matched by the overall rate of attenuation
Stratigraphy	Vertical sequence of geological units
Sympathetic faulting	Offset faulting which occurs when the strain release along the main fault causes displacement along a minor fault
Total dissolved solids (TDS)	Dissociated compounds and un-dissociated compounds, but not suspended material, colloids or dissolved gases
Water	Water – (a) occurring naturally above or under the ground; or (b) water introduced to an aquifer or other area under the ground; or (c) an artificially created body of water or stream that is for public use or enjoyment.
Water table	Interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

Appendix 1 Summary of penalties and fees

Section 103S – Prohibition or restriction on taking water affected by site contamination
(1) If the Authority is satisfied that – (a) there is site contamination that affects or threatens water; and (b) action is necessary under this section to prevent actual or potential harm to human health or safety, the Authority may, by notice in the Gazette, prohibit or restrict the taking of the water. (2) A notice under this section must – (a) specify the water to which it relates; and (b) give particulars of the site contamination affecting the water. (3) A person must not contravene a notice under this section. Penalty: Division 5 fine. (4) The Authority may, by notice in the Gazette, vary or revoke a notice under this section.

9.1 Penalties

There are a number of offences (and associated expiation fees and penalties) provided for in the *Environment Protection Act 1993*.

A summary of the consequences for relevant division penalties is shown in the following table.

Table A1–1 Summary of relevant division penalties

Division	Maximum imprisonment	Maximum fine	Expiation fee
1	15 years	$60,000	–
2	10 years	$40,000	–
3	7 years	$30,000	–
4	4 years	$15,000	–
5	2 years	$8,000	–
6	1 year	$4,000	$300
7	6 months	$2,000	$200
8	3 months	$1,000	$150
9	–	$500	$100
10	–	$200	$75
11	–	$100	$50
12	–	$50	$25

Appendix 2 Details of reports available in the EPA Public Register, as of September 2020

Table (I) EPA information sources recorded in the EPA Public Register – Clovelly Park, Mitchell Park and Marion

EPA reference	EPA file type	Report name	Author	Report date
1 – Clovelly Park Manufacturing Facility, 1326–1378 Main South Road, Clovelly Park				
12019	**Section 109 of EP Act**	**Environmental Site Assessment** Site Contamination Assessment, Clovelly Park	Rust PPK	31 January 1995
12019	**Section 109 of EP Act**	**Environmental Site Assessment** Stage II Site Contamination Assessment, Clovelly Park	Rust PPK	5 March 1996
12019	**Section 109 of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility Stage 1 Environmental Site Assessment	URS	13 March 2009
12019	**Section 109 of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility Groundwater Monitoring, January 2009	URS	9 June 2009
60107	**Site Contamination Audit Report**	**Site Contamination Audit Report** Notification by auditor after commencement of audit, 1326–1378 South Rd, Clovelly Park, SA, September 2009	Steve Kirsanovs	ongoing
12019	**Section 109 of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility Stage 2 Environmental Site Assessment	URS	16 December 2009
60321	**Section 83A of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility Stage 3 Environmental Site Assessment	URS	8 October 2010
60775	**Section 83A of EP Act**	**Environmental Site Assessment** Monroe, Clovelly Park Facility, On and Off-site Groundwater Investigations, October–December 2011	URS	9 March 2012
60777	**Section 83A of EP Act**	**Environmental Site Assessment** Preliminary Environmental Investigation Report, 22A and 22B Ash Avenue, Clovelly Park, SA	Golder Associates	12 December 2012
60775	**Section 83A of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility, Environmental Investigations, May 2012–March 2013	URS	6 September 2013

EPA reference	EPA file type	Report name	Author	Report date
60775	**Section 83A of EP Act**	**Environmental Site Assessment** Monroe Clovelly Park Facility, Groundwater Monitoring Event, July 2014	URS	26 September 2014
61435	**Voluntary site contamination assessment proposal**	**Environmental Site Assessment** Monroe Clovelly Park Facility, 2015 Groundwater Monitoring Event (GME) Summer Factual Report	URS	28 August 2015
61435	**Voluntary site contamination assessment proposal**	**Environmental Site Assessment** Groundwater Monitoring Event, October 2015	AECOM	21 December 2015
61435	**Voluntary site contamination assessment proposal**	**Environmental Site Assessment** Groundwater Monitoring Event, Monroe Clovelly Park, March 2016	AECOM	31 August 2016
61435	**Voluntary site contamination assessment proposal**	**Environmental Site Assessment** Groundwater Monitoring Event, Monroe Clovelly Park, September 2016	AECOM	23 January 2017
2 – Former Vehicle Manufacturing Facility, Main South Road, Clovelly Park				
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment, Lot 2 Selgar Avenue, Clovelly Park, SA	Koukourou & Partners	9 September 1994
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Site History and Preliminary Contamination Assessment Report of Property at 4 Selgar Avenue, Clovelly Park, SA	Rust PPK	26 July 1995
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Audit of MMAL Tonsley Park Plant	Rust PPK	5 September 1995
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Site Assessment Report, Underground Storage Tanks, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	Fluor Daniel GTI	5 November 1997
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Additional Groundwater Investigation, Underground Storage Tanks – Zones B, D & E, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	Fluor Daniel GTI	14 January 1998
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Additional Groundwater Investigation,	Fluor Daniel GTI	29 May 1998

EPA reference	EPA file type	Report name	Author	Report date
		Underground Storage Tanks – Zones D & E, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA		
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Groundwater Monitoring Event, November 1999, Underground Storage Tanks – Zones B, D, & E, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	IT Environmental	20 April 2000
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Audit of Mitsubishi Motors Australia Ltd, Tonsley Park Plant	PPK Environment and Infrastructure	5 September 2001
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Groundwater Investigation – Zone D, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	IT Environmental	13 December 2001
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Draft Groundwater Monitoring Event 2001, MMAL Solvent Storage Area, South Road, Clovelly Park, SA	IT Environmental	12 October 2004
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Draft Groundwater Monitoring Event 2004, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	IT Environmental	22 December 2004
10129	**Section 109 of EP Act**	**Environmental Site Assessment** UST Area Contamination Delineation, MMAL Product Engineering, 1284 South Road, Melrose Park, SA	IT Environmental	3 January 2005
10129	**Section 109 of EP Act**	**Environmental Site Assessment** UST Excavation Validation, MMAL Product Engineering, 1284 South Road, Melrose Park, SA	IT Environmental	21 July 2005
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Groundwater Monitoring Event 2005, Mitsubishi Motors Australia Ltd, South Road, Clovelly Park, SA	IT Environmental	8 May 2006
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Groundwater Monitoring Event 2007, Mitsubishi Motors, Clovelly Park, SA	Coffey Environments	20 July 2007
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Installation of Two Groundwater Monitoring	Coffey Environments	1 August 2007

EPA reference	EPA file type	Report name	Author	Report date
		Wells at Mitsubishi Motors Australia Ltd, Clovelly Park, SA		
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Site Assessment, Former AV Jennings Building, Mitsubishi Motors Australia Ltd, Clovelly Park, SA	Coffey Environments	24 October 2007
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Stage 1 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	20 May 2008
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Stage 2 Environmental Site Assessment – Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	8 August 2008
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 5	Parsons Brinckerhoff Australia	7 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 1	Parsons Brinckerhoff Australia	8 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 2	Parsons Brinckerhoff Australia	8 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 3	Parsons Brinckerhoff Australia	8 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 8	Parsons Brinckerhoff Australia	8 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 11	Parsons Brinckerhoff Australia	8 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 6	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 9	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 10	Parsons Brinckerhoff Australia	9 October 2009

EPA reference	EPA file type	Report name	Author	Report date
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 12	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 13	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 15	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 16	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 18	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 19	Parsons Brinckerhoff Australia	9 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 4	Parsons Brinckerhoff Australia	12 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 7	Parsons Brinckerhoff Australia	12 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Environmental Assessment Report, MMAL Tonsley Park – Section 17	Parsons Brinckerhoff Australia	12 October 2009
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-dimensional Groundwater Model Assessment – Section 6, Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	6 January 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-dimensional Groundwater Model Assessment – Section 9, Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	6 January 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-dimensional Groundwater Model Assessment – Section 12, Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	6 January 2010

EPA reference	EPA file type	Report name	Author	Report date
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-dimensional Groundwater Model Assessment – Section 16, Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	9 January 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-dimensional Groundwater Model Assessment – Section 17, Mitsubishi Motors Production Plant, Tonsley Park, SA	Parsons Brinckerhoff Australia	25 February 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Additional Groundwater Assessment Report, MMAL Tonsley Park	Parsons Brinckerhoff Australia	22 March 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** One-Dimensional Groundwater Model Assessment – Section 19, Mitsubishi Motors Production Plant, Tonsley Park, SA.	Parsons Brinckerhoff Australia	9 June 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Section 19 Carpark Soil and Groundwater Investigation – Tonsley Park	Parsons Brinckerhoff Australia	28 June 2010
10129	**Section 109 of EP Act**	**Environmental Site Assessment** Groundwater Monitoring Event, Tonsley Park Sections 11 & 13, Clovelly Park, SA	AEC Environmental	9 July 2011
60773	**Section 83A of EP Act**	**Environmental Site Assessment** Groundwater Monitoring Report, Former Mitsubishi Manufacturing Australia Ltd Plant, Tonsley Park, South Australia.	Golder Associates	9 May 2012
60773	**Section 83A of EP Act**	**Environmental Site Assessment** Groundwater assessment, former Mitsubishi Manufacturing Australia Ltd Plant, Section 9, Flinders University (Kinetica) Site, Tonsley Park Development.	Land and Water Consulting	12 September 2013
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Interim Detailed Site Investigation, Suburban Activity Node Zone – Tonsley	Greencap	27 February 2015
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Site Investigation Results Update – Suburban Activity Node Zone (SANZ) – Tonsley	Greencap	19 October 2015
60513	**Site Contamination Audit Report**	**Site Contamination Audit Report** Site Contamination Audit Report, Section 11 & Portion of Section 13, Tonsley Park Redevelopment, Tonsley Park, SA	Phillip Hitchcock	10 November 2015

EPA reference	EPA file type	Report name	Author	Report date
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Conceptual Site Model (CSM): Tonsley VSCAP Investigation – Revision 01, Tonsley Development, Former MMAL Site Clovelly Park, SA	BlueSphere Environmental	12 February 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations: Progress Factual Report No. 1, Tonsley Development Former MMAL Site, Clovelly Park, SA	BlueSphere Environmental	1 March 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations: Progress Factual Report No. 1, Tonsley Development, Former MMAL Site, Clovelly Park, SA	BlueSphere Environmental	5 May 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations, Mitchell Park Delineation Drilling	BlueSphere Environmental	22 July 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Conceptual Site Model (CSM), Tonsley VSCAP Investigation – Revision 1, Tonsley Development, Former MMAL Site, Clovelly Park, SA	BlueSphere Environmental	22 July 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations, Stage 2 Delineation Drilling Mitchell Park and Marion, August/September 2016	BlueSphere Environmental	17 November 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Conceptual Site Model (CSM), Tonsley VSCAP Investigation – Revision 02, Tonsley Development, Former MMAL Site, Clovelly Park, SA	BlueSphere Environmental	16 December 2016
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Conceptual Site Model (CSM), Tonsley VSCAP Investigation – Revision 03, Tonsley Development, Former MMAL Site, Clovelly Park, SA	BlueSphere Environmental	24 February 2017
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Detailed Site Investigations – Tonsley SANZ, Suburban Activity Node Zone – Tonsley,	Greencap	1 October 2017
61778	**Site Contamination Audit**	**Site Contamination Audit Report** Site Contamination Audit Report, Lot 331 South Road, Tonsley, SA	Phillip Hitchcock	27 November 2017

EPA reference	EPA file type	Report name	Author	Report date
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations, Further Groundwater and Soil Vapour Investigations November 2017–April 2018, Tonsley Innovation District, former MMAL Site, Tonsley SA	BlueSphere Environmental	26 July 2018
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Tonsley VSCAP Investigations, Source Investigations February 2017–April 2018, Tonsley Innovation District, Former MMAL Site, Tonsley, SA	BlueSphere Environmental	2 August 2018
61473	**Voluntary site contamination proposal**	**Environmental Site Assessment** Conceptual Site Model (CSM), Tonsley VSCAP Investigation – Revision 04, Tonsley Innovation District, Former MMAL Site, Tonsley, SA	BlueSphere Environmental	26 September 2018
61286	**Site Contamination Audit Report**	**Site Contamination Audit Report** Site Contamination Audit Report, Residential Audit Area – Suburban Activity Node Zone, portions of Former Mitsubishi Motors Australia Ltd Site, Tonsley	Adrian Webber	7 December 2017
61986	**section 109 of EP Act**	**Environmental Site Assessment** Tonsley Groundwater and Soil Vapour Monitoring (February & April 2018), Tonsley Residential Audit Area	Greencap	26 June 2018
62023	**Site Contamination Audit Report**	**Site Contamination Audit Report** Site Contamination Audit Report (Waste Derived Fill), PEET Limited, Stages 2 + 2A of Tonsley Village	Adrian Webber	23 July 2018
61986	**section 109 of EP Act**	**Environmental Site Assessment** Tonsley – Groundwater and Soil Vapour Monitoring (October 2018), Tonsley Residential Audit Area	Greencap	8 February 2019
61986	**section 109 of EP Act**	**Environmental Site Assessment** Tonsley – Groundwater and Soil Vapour Monitoring (April 2019), Tonsley – Residential Audit Area	Greencap	30 September 2019
61504	**Site Contamination Audit**	**Site Contamination Audit Report** Site Contamination Audit Report (Restricted Scope), EPA Identified Source Areas 3 and 4, 1284 South Road, Tonsley, SA	Anthony Lane	18 June 2020
62020	**Site Contamination Audit**	**Site Contamination Audit Report**	Adrian Webber	Ongoing

EPA reference	EPA file type	Report name	Author	Report date
3 – Works Depot and Recycling Depot, 935 Marion Road, Mitchell Park				
12330	**Site Audit Report**	**Site Audit Report** City of Marion Works Depot, Nursery Area, 935 Marion Road, Mitchell Park, SA	Adrian Hall	4 October 2000
12331	**Site Audit Report**	**Site Audit Report** City of Marion Works Depot, Recycling Depot, 935 Marion Road, Mitchell Park, SA	Adrian Hall	4 October 2000
Off-site EPA Assessment Area				
61324	**EPA Assessment**	**Environmental Site Assessment** Clovelly Park/Mitchell Park Environmental Assessment, Volume 1 & 2 Report	Fyfe	3 December 2014

Table (II) Additional EPA information recorded in the EPA Public Register – Clovelly Park, Mitchell Park, Marion and St Mary

EPA reference	EPA file type	Report name	Author	Report date
Former Marion High School (UST, OCPs, PCBs), York Avenue, Clovelly Park				
10064	**Site Audit Report**	**Site Audit Report** Environmental Audit, Marion High School	Alex Eadie	9 October 1996
11427	**section 109 of EP Act**	**Environmental Site Assessment** Supplementary Environmental Assessment Report, York Avenue, Clovelly Park, SA	Koukourou Engineers	19 September 1997
11427	**section 109 of EP Act**	**Environmental Site Assessment** Certification of Satisfactory Completion of Environmental Remediation	Koukourou Engineers	27 October 1997
11427	**section 109 of EP Act**	**Environmental Site Assessment** Certification of Satisfactory Completion	Koukourou Engineers	27 November 1997
10064	**Site Audit Report**	**Site Audit Report** Supplementary Audit Report, Former Marion High School Site, York Avenue, Clovelly Park, SA	Alex Eadie	23 March 1998

EPA reference	EPA file type	Report name	Author	Report date
Marion Road service station, 843 Marion Road, Mitchell Park				
60020	**Section 83A of EP Act**	**Environmental Site Assessment** Monitoring Well Installation and Groundwater Sampling – BP Mitchell Park, SA	URS Australia	5 December 2008
60020	**Section 83A of EP Act**	**Environmental Site Assessment** October 2013 Groundwater Monitoring Event – BP Mitchell Park Service Station, Mitchell Park, SA	URS Australia	19 March 2014
Former SA Department of Housing and Construction (SACON) regional office and depot, 818 Marion Road, Mitchell Park				
12052	**Section 109 of EP Act**	**Site History Investigation** Site History Report	Lands SA	1 September 1992
Former mixed industrial/commercial use (now childcare centre) (Pb, As, Cu, Mn, Zn, Cr), 1244 South Road, Clovelly Park				
12569	**Site Audit Report**	**Site Audit Report** Site Audit Report, 1244 South Road, Clovelly Park, SA	Phillip Sinclair	9 February 2005
Former Council Nursery, 935 Marion Road, Mitchell Park				
12330	**Site Audit Report**	**Site Audit Report** City of Marion Works Depot Nursery Area, 935 Marion Road, Mitchell Park, SA	Adrian Hall	4 October 2000
Former service station, 961-963 Marion Road, Mitchell Park				
18038	**section 109 of EP Act**	**Site History Investigation** Site History Report	SA Lands	20 May 1992
18038	**section 109 of EP Act**	**Environmental Site Assessment** Petroleum Hydrocarbon Site Assessment, Safari Motors, Cnr Sturt/Marion Roads, Marion, SA	Nicolas Calabrese & Associates	1 March 1993
Former welding and metal fabrication business, 9–13 Nellie Avenue, Mitchell Park				
61635	**Site Contamination Audit**	**Site Contamination Audit Report** Site Contamination Audit Report, 9–13 Nellie Avenue, Mitchell Park, SA	Peter Ramsay	8 September 2016

EPA reference	EPA file type	Report name	Author	Report date
Former Sturt primary school , Norfolk Road, Marion				
10070	**Site Audit**	**Site Audit Report** Sturt Primary School, Marion, SA	Timothy Marshall	19 May 1997
Former Minister of Education owner land, Jasmine Avenue, Marion				
12155	**South Australian Health Commission**	**Environmental Site Assessment Summary** Site Assessment Report, Lot 100, Jasmine Avenue, Project No. 26-30-00-01	South Australian Health Commission	22 January 1992
Former Church of Christ Life Care property, 14 Finniss Street, Marion				
60232	**Section 83A of EP Act**	**Environmental Site Assessment** Phase 1 and 2 Environmental Site Assessment, 14 Finniss Street, Marion, SA	LBW Environment	15 December 2009
61508	**Site Contamination Audit Report**	**Site Contamination Audit Report** Site Contamination Audit Report: 1–2/14 Finniss Street, Marion, SA	Craig Barker	23 February 2016
South Road Service Station, 1131 South Road, St Marys				
60794	**Section 83A of EP Act**	**Environmental Site Assessment** Groundwater Well Installation and GME at the Caltex St Marys Service Station (Caltex Site ID 44174), 1131 South Road, St Marys, SA	Parson Brinckerhoff	3 December 2015
60794	**Section 83A of EP Act**	**Environmental Site Assessment** Further Groundwater Assessment Report, Caltex St Marys Service Station (Caltex Site ID 44174), 1131 South Road, St Marys, SA	Parson Brinckerhoff	28 March 2013
60794	**Section 83A of EP Act**	**Environmental Site Assessment** Soil Validation Report – Caltex Service Station, (Caltex Site ID 44174), 1131 South Road, St Marys, SA	Parson Brinckerhoff	18 September 2015
60794	**Section 83A of EP Act**	**Groundwater Monitoring Event** Caltex St Marys Service Station (Caltex Site ID 44174), Groundwater Monitoring Event 2017	AECOM	15 March 2019
60794	**Section 83A of EP Act**	**Groundwater Monitoring Event** Caltex St Marys Service Station (Caltex Site ID 44174), Groundwater Monitoring Event 2019	AECOM	15 March 2019

Appendix 3 Contaminants in the groundwater

Chlorinated hydrocarbons

Chlorinated hydrocarbons are denser (heavier) than water. When released to the environment they can leach through the soil into groundwater and form a dense non-aqueous layer (DNAPL). Depending on the sediment type, microbial activity within the groundwater and aquifer hydraulic conditions, chlorinated hydrocarbons may persist for hundreds of years in aquifer sediments and groundwater[159].

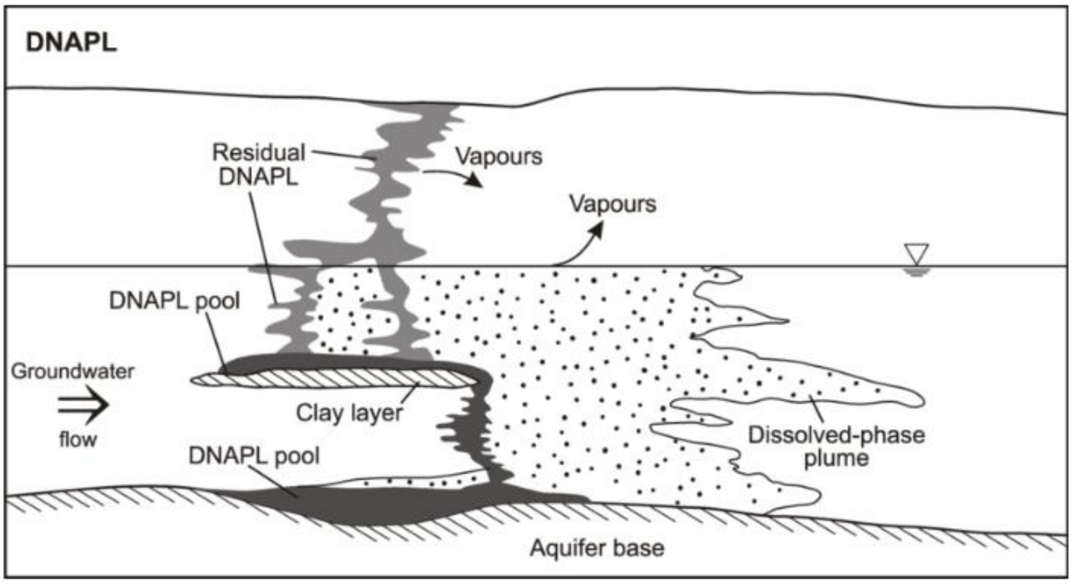

Figure 25 Conceptual model of DNAPL (dense non-aqueous phase liquid) release[160]

Breakdown of the chlorinated hydrocarbons via reductive dehalogenation to ethene may occur under anaerobic conditions and PCE can be intrinsically biodegraded to form additional chemicals of concern such as TCE, DCE and VC. Biodegradation via microbial activity occurs when the groundwater conditions are suitable, resulting in the capacity to remove contaminant mass and reduce the plume concentrations[161]

[159] Wisconsin Department of Natural Resources 2014, *Understanding Chlorinated Hydrocarbons Behavior in Groundwater: Guidance on the Investigation, Assessment and Limitations of Monitored Natural Attenuation*.

[160] Rivett M, Drewes J, Barrett M, Chilton J, Appleyard S, Dieter H, Wauchope D and Fastner J, 2006, 'Chapter 4 Chemicals: Health relevance, transport and attenuation' in: *Protecting Groundwater for Health, Managing the Quality of Drinking-water Sources*, edited by Schmoll O, Howard G, Chilton J, and Ingrid Chorus I, World Health Organization, IWA Publishing.

[161] Suarez MP and Rifai HS 1999, 'Biodegradation rates for fuel hydrocarbons and chlorinated hydrocarbons in groundwater', *Bioremediation* 3: 337–362.

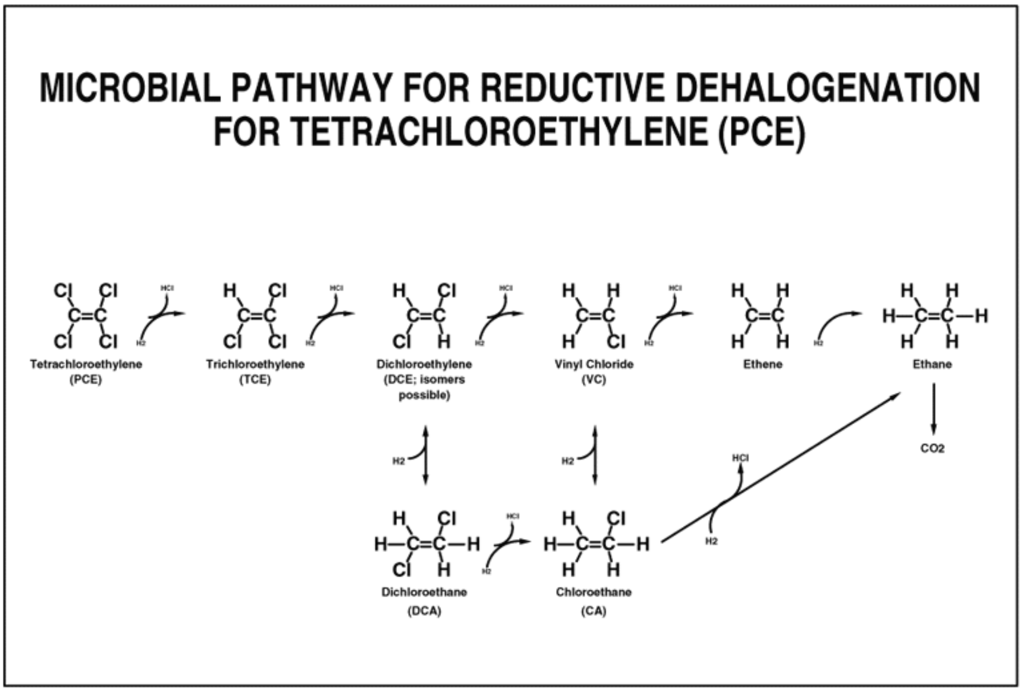

Figure 26 Microbial pathway for reductive dehalogenation for tetrachloroethylene (PCE)[162]

The International Agency for Research on Cancer (IARC)[163] has classified TCE as Group 2A – probably carcinogenic to humans (1995). A review by the United States Environment Protection Agency (US EPA)[164], characterised TCE as carcinogenic in humans by all routes of exposure (2011). The reduced chemical products from this dehalogenation process are also known to be harmful in varying degrees, the exception being ethene.

Petroleum hydrocarbons

Due to the ability of petroleum hydrocarbons to be readily biodegraded by microbial activity in the groundwater under aerobic conditions, it is generally understood that there are appreciably higher rates of natural attenuation within petroleum hydrocarbon plumes. The longevity of petroleum-based groundwater plumes is much less than chlorinated hydrocarbon plumes and the extent of the plumes are relatively smaller and the reduction in in plume size is more rapid[165].

162 WHO 2017, *Guidelines for drinking water quality,* fourth edition, World Health Organization, Geneva, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/.

163 IARC 1995, *Dry cleaning, some chlorinated solvents and other industrial compounds*, Lyon, International Agency for Research on Cancer, IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, Vol 63.

164 US EPA 2011, 'Toxicological review of trichloroethylene', *Support of summary information on the integrated risk information system (IRIS)*, US Environmental Protection Agency, EPA/635/R-09/011F.

165 Wiedemeier TH, Rifai HS, Newell CJ and Wilson JT 1999, *Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface*, John Wiley & Sons, New York, USA.

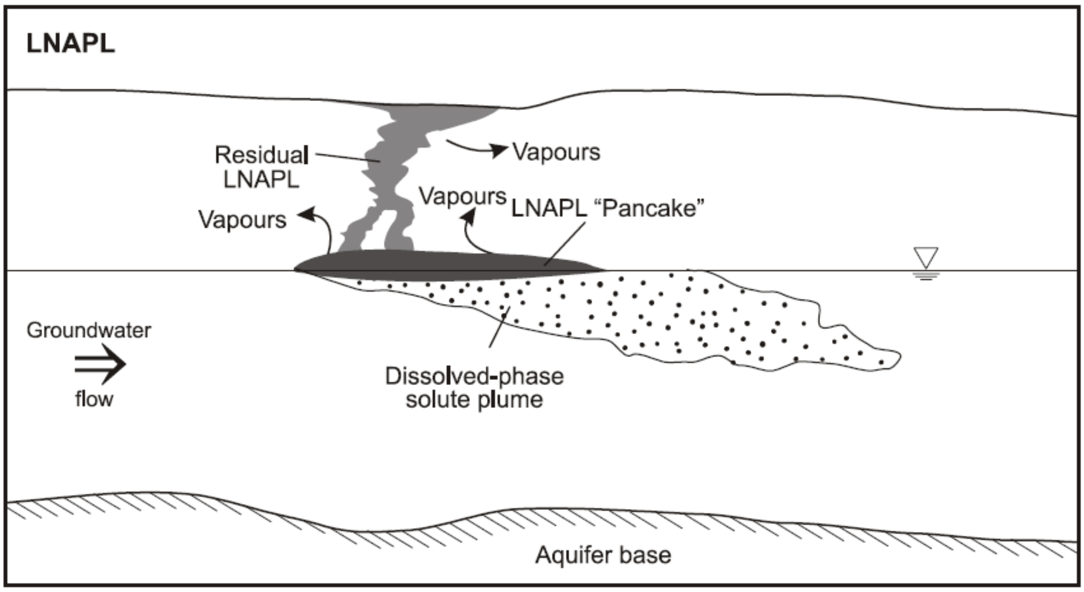

Figure 27 Conceptual model of LNAPL (light non-aqueous phase liquid) release[166]

The United States Agency for Toxic Substances and Disease Registry has classified benzene as carcinogenic to humans and total petroleum hydrocarbons as probably carcinogenic to humans[167].

Heavy metals and metalloids

Heavy metals (and metalloids) are utilised in various industrial processes, but predominantly for fabrication and electroplating. Metals used in fabrication and electroplating include copper, zinc, chromium, nickel, gold, silver, lead, ruthenium, rhodium, osmium, iridium and alloys such as, nickel-iron, copper-tin and gold-copper-cadmium. Once exposed to the ground, through outdated waste disposal practices, storage, and spill capture mechanisms (bunding), the metals can leach through the soil profile and potentially contaminate the groundwater environment.

Metals exhibit varying behavioural associations with groundwater depending on the aquifer conditions or parameters, which can include pH, organic matter content, temperature and redox potential. Some metals, such as hexavalent chromium (Cr VI) are readily soluble and mobile in groundwater under a highly oxidising and alkaline (pH > 7) environment. However, the presence of organic matter, ferrous iron (Fe II) and sulfide can reduce hexavalent chromium to trivalent chromium (Cr III). Once reduced, chromium becomes less soluble in water and immobile, enabling adsorption onto clayey soil particles within the aquifer. This means that groundwater plumes comprising hexavalent chromium contamination can more readily expand with groundwater flow in an aquifer than trivalent chromium contamination. Understanding aquifer conditions when assessing metal groundwater contamination is important for quantifying contaminant fate and transport within an aquifer system.

The United States Agency for Toxic Substances and Disease Registry has determined that there is sufficient evidence for probable carcinogenicity in humans from chromium VI compounds as used in the chromate production, chromate pigment production and chromium plating industries[168].

[166] Rivett M, Drewes J, Barrett M, Chilton J, Appleyard S, Dieter H, Wauchope D and Fastner J, 2006, 'Chapter 4 Chemicals: Health relevance, transport and attenuation' in: *Protecting Groundwater for Health, Managing the Quality of Drinking-water Sources*, edited by Schmoll O, Howard G, Chilton J, and Ingrid Chorus I, World Health Organization, IWA Publishing.

[167] Agency for Toxic Substances and Disease Registry (ATSDR) 2012, *Toxicology Profile for Chromium,* US Department of Health and Human Services, Public Health Service.

[168] Agency for Toxic Substances and Disease Registry (ATSDR) 1999, *Total Petroleum Hydrocarbons,* US Department of Health and Human Services, Public Health Service.

Per-and poly-fluroalkyl substances

Per-and poly-fluroalkyl substances (PFAS) are chemicals that are very effective at resisting heat, stains, grease and water, making them useful chemicals for a range of applications, including;

- stain and water protection for carpets, fabric, furniture and clothing
- paper and cardboard coating
- metal plating
- photographic materials
- aviation hydraulic fluid
- cosmetics and sunscreen
- medical devices
- firefighting foams

PFAS is problematic in the environment due to its high mobility in water, its persistency in the environment and its toxicity to animals. The human health effects of long-term PFAS exposure is still being investigated, however, due to potential health impacts the use of these chemicals area being progressively phased out[169].

Contaminant fate and transport

The principal objectives of groundwater contaminant fate and transport determination and modelling are assessed by understanding:

- The impact of groundwater contamination in the down hydraulic gradient direction, prior to and after source removal.
- The influence of groundwater contamination on a down hydraulic gradient contaminant plume extent, with removal of the source.

Hydraulic parameters and more specifically hydraulic conductivity estimates can be highly variable due to local heterogeneity of aquifer sediments, preferential pathways for groundwater flow and natural attenuation of contaminants within the aquifer. Due to the inherent difficulties in developing representative hydraulic parameter values giving rise to accurate plume migration, a conservative approach to groundwater plume prediction is generally observed. This being said, numerical model calculations may differ from the monitored plume front by many hundreds of metres. To this end, utilised observed time measured patterns can assist in informing site numerical fate and transport models for model calibrations and sensitivity analysis reiterations[170].

Natural attenuation, where the contaminant load in reduced within the aquifer, include the mechanisms of dispersion, adsorption, ion exchange, precipitation, co-precipitation (abiotic) and biological degradation (or biodegradation). This process of natural attenuation can vary considerably depending on chemical, physical and geochemical properties of the aquifer, and the microbial activity present. Due to natural attenuation contaminants will migrate in a non-linear longitudinal extent over time through the aquifer sediments until a stable groundwater plume extent is attained.

[169] Per-and poly-fluoroalkyl Substances (PFASO Australian information portal), www.pfas.gov.au accessed 22 September 2020.

[170] Anderson MP and Woessner WW 2002, *Applied groundwater modelling – simulation of flow and advective transport,* Academic Press, San Diego, California, USA.

Appendix 4 Summary of South Australian geology and hydrogeology

The geology of South Australia has had a very distinctive and interesting history over the last 2.7 billion years. Its geological provinces and basins have been shaped by depositional, igneous, orogenic and other alteration events. The main geological provinces are the Curnamona Province, Gawler Craton, Musgrave Province and the Adelaide Fold Belt and Stuart Shelf, which includes the Kanmantoo Trough. Within these provinces are the various sedimentary basins including the Officer, Murray, Gambier, Uley and Eucla Basins[171] [172].

South Australian groundwater is known to flow through Precambrian fractured rock and the Palaeozoic, Mesozoic and Cainozoic era sediments.

Pre-Cambrian and Cambrian

The understanding of groundwater flow mechanisms in fractured rock aquifers of the Mount Lofty Ranges, Northern Adelaide Plains and Kangaroo Island is still developing. Due to the difficulty in understanding groundwater flows and the natural mineralisation in these fractured rock aquifers, groundwater contamination is difficult to characterise. In the Adelaide Metropolitan region that groundwater migration is across the Para and Eden–Burnside Faults from the Mount Lofty Ranges to the sedimentary aquifers of the Northern Adelaide Plains, Adelaide Plains and McLaren Vale areas. This groundwater migration provides a significant amount of recharge to the Quaternary and Tertiary aquifers in these receiving areas[173]. The groundwater recharging process in the Mount Lofty Ranges is still not well understood.

Palaeozoic

In central/northern South Australia, deep aquifer systems flow through the Permo-Carboniferous Boorthanna Formation (groundwater abstracted by Prominent Hill Mine) and the Cambrian Andamooka Limestone (groundwater abstracted by Olympic Dam Mine). The Boorthanna Formation is predominantly recharged from northern aquifer systems[174] [175] [176]. The Andamooka Limestone aquifer is recharged predominantly through surface infiltration following significant rainfall events[177]. Pressures on these aquifers arise principally from mining abstraction. Mine waste infiltration from mining activities and township irrigation are potentially contaminating activities that may threaten the unconfined Andamooka Limestone.

Mesozoic (Jurassic and Cretaceous)

In central/northern South Australia, the most significant aquifers are the Mesozoic Cadnaowie Formation and Algebuckina Sandstone, which comprise in part the South Australian portion of the Great Artesian Basin. Recharge rates

[171] Cowley W 2010, *Summary Geology of South Australia*. Primary Industries and Resources, South Australia.

[172] Woodhouse A, Reid AJ, Cowley WM and Fraser GL 2010. *Overview of the geology of the northern Gawler Craton and adjoining Musgrave Province, South Australia,* in GOMA (Gawler-Officer Basin-Musgrave Province-Amadeus Basin) Seismic and MT Workshop, pp 47–62.

[173] Stewart S, Banks E, Wilson T 2009, *Groundwater flow mapping across the Mount Lofty Ranges*, Technical Note 2009/26, Department of Water, Land and Biodiversity Conservation.

[174] Wohling D, Keppel M, Fulton S, Costar A, Sampson L, and Berens V 2011, *Australian Government Initiative on Coal Seam Gas and Large Coal Mining – Arckaringa Basin and Pedirka Basin Groundwater Assessment Projects*, DEWNR Technical Report 2013/11, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide.

[175] Kellett J, Veitch S, McNaught I and van der Voort A 1999, *Hydrogeological Assessment of a Region in Central Northern South Australia,* Bureau of Rural Sciences, Australia, Division of Land and Water Sciences.

[176] Arup 2011, *Olympic Dam supplementary environmental impact statement*, May 2011.

[177] BHP 2009, *Olympic Dam Draft Environmental Impact Statement, Main Report Volume 1*.

of these aquifers are very low, ranging from 0.1–5 mm/year, with residence times as long as 7,000 years[178]. These Mesozoic artesian aquifers are not susceptible to surface site contamination due to the protection of the partly confining layer of the Bulldog Shale. Pressure on these aquifer systems arise from pastoral and mining abstraction[179].

Cainozoic (Tertiary and Quaternary)

The sediments of the Tertiary basins build deep groundwater aquifers. These deep aquifers are especially important for the supply of potable water to various market gardens, orchards, vineyards and stock watering in the Northern Adelaide Plains, Clare Valley, McLaren Vale and the Peninsulas, and industries in the Adelaide metropolitan region. The Tertiary aquifers are mostly protected by the overlaying layers of widely impermeable confining sediments of the Hindmarsh Clay[180].

Managed Tertiary aquifer storage and recovery schemes are being increasingly used to 'waterproof 'an area against low surface water availability during times of drought or low rainfall periods. Managed aquifer storage and recovery is the process of recharging surface water from created wetland areas into an aquifer for storage and then recovered months later for potable use. Contamination of the Tertiary aquifers could arise from poorly managed aquifer storage and recovery schemes.

Overlying the Tertiary sediments are the shallow, unconfined to semi-confined aquifers of the Adelaide Plains, Kangaroo Island and the Peninsulas, built up by Quaternary sands, gravels and clays, and calcareous sandstones, respectively. Due to the largely unconfined nature of the upper Quaternary aquifers, they can be particularly susceptible to chemical substances entering the groundwater from contaminating activities[181].

Groundwater within the aquifers of the Quaternary sands is abstracted primarily for market gardens, vineyards and localised domestic use.

Table A4–1 Summary of Quaternary stratigraphic sequence[182]

Unit name and age	Thickness (m)	Lithology and occurrence	Environment of deposition
St Kilda Formation	4	Sand and silt, numerous shell remains adjacent to coast	Marine
Pooraka Formation	4	Clay—light brown, gravelly and sandy in basal deposits	Alluvial
Glanville Formation	6	Highly fossiliferous limestone adjacent to northwest coast	Marine
Keswick Clay	5	Mainly green clay with minor sand. Occurs in isolated areas	Non-marine
Hindmarsh Clay	16	Clay—mottled, brown, pale olive-grey, with thin layers of gravel, sand. Green-grey clay 3–5 m thick at the base	Fluviatile, estuarine
Carisbrook Sand	20	Yellow fine sand with thin layers of clay and silt. Occasionally carbonaceous. Occurs in vicinity of large palaeo-rivers and adjacent to fault zones	Fluviatile, estuarine

178 Fulton S, Wohling D and Keppel M 2015, *Pedirka Basin Aquifer Connectivity Investigation,* DEWNR Technical report 2015/08.

179 GABCC 2000, *Great Artesian Basin Strategic Management Plan*, Great Artesian Basin Coordinating Committee, Brisbane

180 Gerges N 2006, *Overview of the hydrogeology of the Adelaide metropolitan area,* Knowledge and Information Division, Department of Water, Land and Biodiversity Conservation, 2006/10.

181 Zulfic H, Kwadwo O and Barnett S 2008, *Adelaide Metropolitan Area Groundwater Modelling Project, Volume 1 Review of Hydrogeology, Volume 2 Numerical model development and prediction run*, Knowledge and Information Division, Department of Water, Land and Biodiversity Conservation, 2008/05.

182 Zulfic H, Kwadwo O and Barnett S 2008, *Adelaide Metropolitan Area Groundwater Modelling Project, Volume 1 Review of Hydrogeology, Volume 2 Numerical model development and prediction run*, Knowledge and Information Division, Department of Water, Land and Biodiversity Conservation, 2008/05.