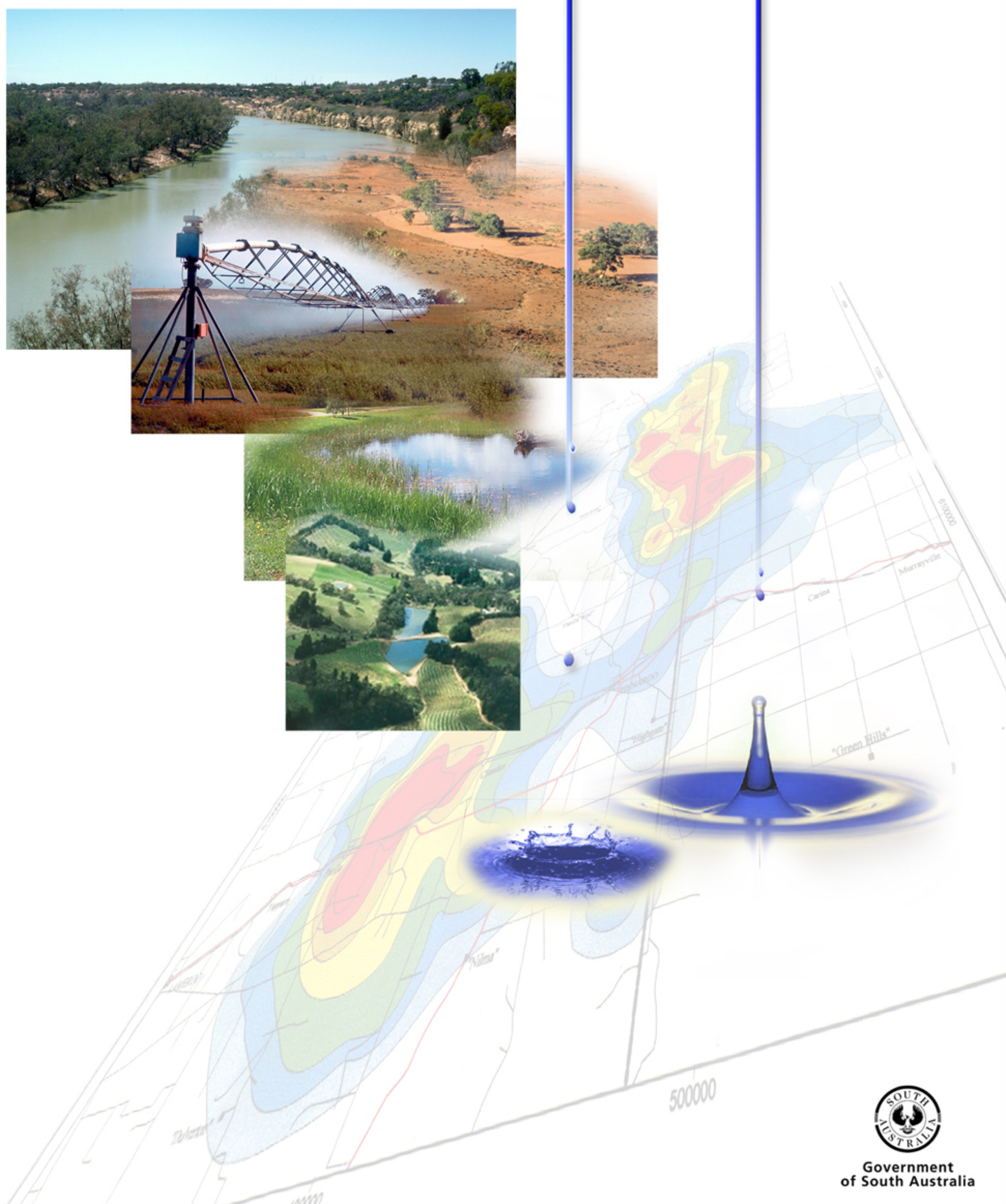
Department for
Water Resources

Shallow groundwater quality monitoring program for the Onkaparinga Catchment Water Management Board area

Report DWR 2001/018



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Deborah S. Clarke

Resource Assessment Division
Department for Water Resources

November 2001

DWR Report 2001/018

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Water Resources

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of South Australia

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FOREWORD

South Australia's water resources are fundamental to the economic and social wellbeing of the State. Water resources are an integral part of our natural resources. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between rainfall, vegetation and other physical parameters. Development of surface and groundwater resources changes the natural balance and causes degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of a resource to continue to meet the needs of users and the environment. Degradation may also be very gradual and take some years to become apparent, imparting a false sense of security.

Management of water resources requires a sound understanding of key factors such as physical extent (quantity), quality, availability, and constraints to development. The role of the Resource Assessment Division of the Department for Water Resources is to maintain an effective knowledge base on the State's water resources, including environmental and other factors likely to influence sustainable use and development, and to provide timely and relevant management advice.

Bryan Harris
Director, Resource Assessment Division
Department for Water Resources

ABBREVIATIONS

General

ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
drn.	drainage
dom.	domestic
DWR	Department for Water Resources
EC	electrical conductivity
FC	faecal coliforms
FeB	heterotrophic iron bacteria
FIB	faecal indicator bacteria
FS	faecal streptococci
gen.	general
ind.	industry
irr.	irrigation
N	nitrogen
NH_3	ammonia
NH_4^+	ammonium
NHMRC	National Health and Medical Research Council
NO_3	nitrate
NO_2	nitrite
OCWMB	Onkaparinga Catchment Water Management Board
obs.	observation
PO_4	phosphate
stk	stock
TDS	total dissolved solids
TOC	total organic carbon

Measurement

Units of measurement used in this volume are those of the International System of Units (SI) as well as units outside the SI which have been authorised for use within Australia's metric system.

cm	centimetre (length; 10^{-2} m)
km	kilometre (length; 10^{3} m)
L	litre (volume; 10^{-3} m^3)
t	tonne (mass; 10^{3} kg)
m	metre (length)
mg	milligram (mass; 10^{-6} kg)
mL	millilitre (volume; 10^{-6} m^3)
*u*g	microgram (mass; 10^{-9} kg)
*u*S	microsiemens (electrical conductance; 10^{-6} $A^2.s^3/kg.m^2$)

CONTENTS

FIGURES

TABLES

Department for Water Resources

Report DWR 2001/018

Shallow groundwater quality monitoring program for the Onkaparinga Catchment Water Management Board area

Deborah S. Clarke

INTRODUCTION

The Onkaparinga Catchment Water Management Board (OCWMB) is responsible for an area of ~920 km^2 which includes the Onkaparinga Catchment in the Adelaide Hills and the Noarlunga and Willunga sedimentary embayments south of Adelaide, South Australia (Fig. 1). Under the requirements of the South Australian *Water Resources Act 1997,* the board has prepared a five-year management plan to guide the management of water resources within its area. One of the goals of the management plan is to maintain and, if possible, enhance the quality of surface and groundwaters. The board has established a partnership with the Department for Water Resources to design an ongoing program to monitor the water quality within the shallow groundwater system throughout the catchment area.

The objectives of the first stage of the program are to identify areas where the shallow groundwater aquifers are potentially threatened by point-source pollution and to establish an ongoing sampling program to monitor changes in groundwater quality. Land-use activities such as unsewered residential areas, abattoirs, waste depots and wineries within the board's area were selected as possible point-source pollution threats.

The aquifer systems vary throughout the catchment, ranging from a fractured basement rock system dominating the northern and central areas to multiple sedimentary aquifer systems within the Noarlunga and Willunga Embayments. Using total well depth and aquifer type as criteria, existing shallow boreholes located down gradient of areas considered to be at risk were selected as potential sample points. Sampling commenced during March 2001 and analyte suites were tailored to measure contaminants expected from the targeted land uses.

PHYSICAL CHARACTERISTICS OF THE ONKAPARINGA CATCHMENT BOARD AREA

LOCATION

The OCWMB area has been divided into two smaller areas for simplification; northern and southern (Fig. 2).

- In the northern area the Onkaparinga River, which begins in the central Mount Lofty Ranges above Lobethal, flows in a southwesterly direction, discharging into the Mount Bold Reservoir. This section comprises part of the Mount Lofty Ranges

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Onkaparinga Catchment Water Management Board Area

LOCATION PLAN

Figure 1

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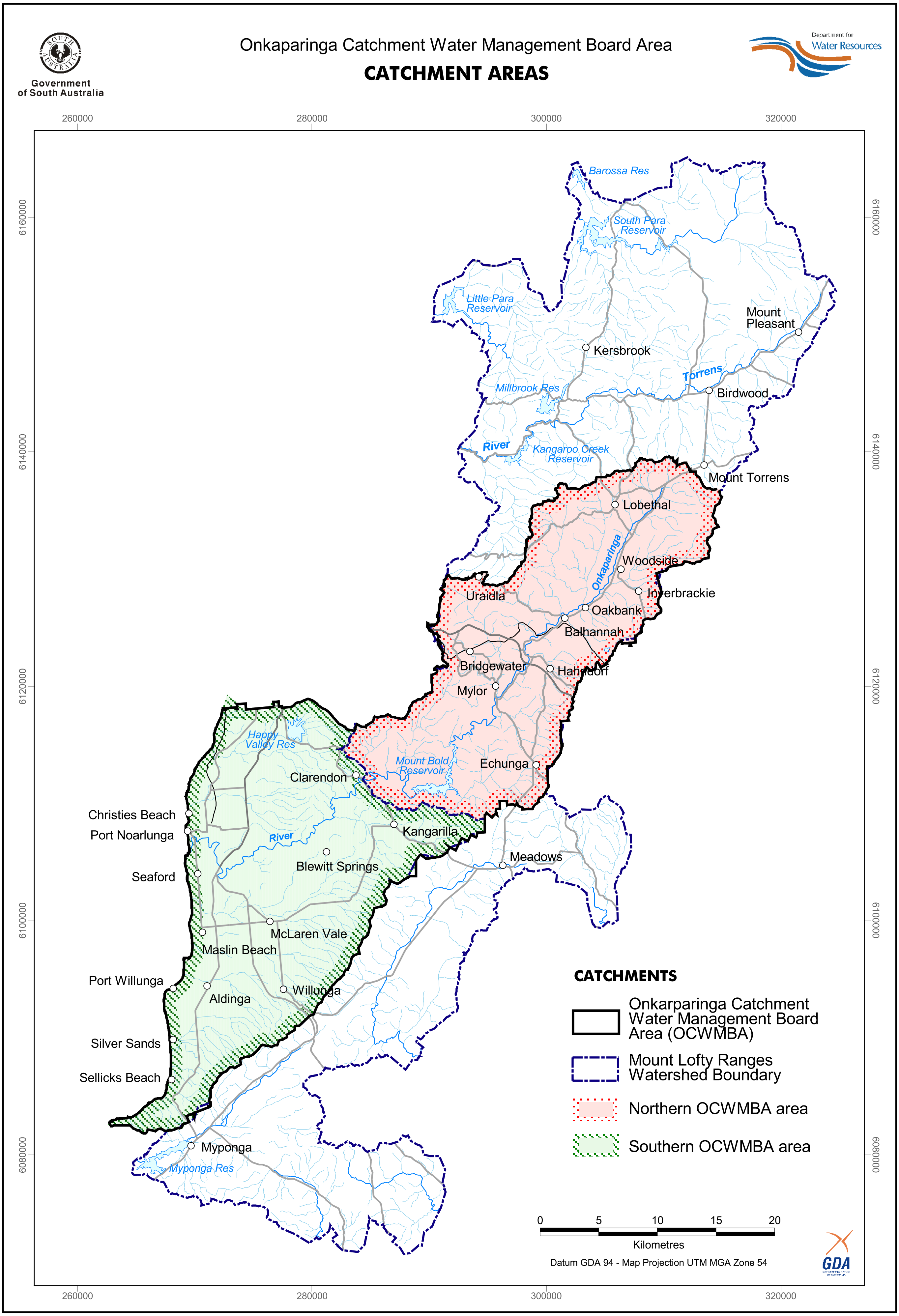

Figure 2

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Watershed and water collected in the Mount Bold Reservoir supplies Adelaide, via the Clarendon Weir and the Happy Valley Reservoir, with ~45% of its total water supply.

- In the southern area, water from the Clarendon Weir overflows into the Onkaparinga River which continues to flow in a southwesterly direction out of the Mount Lofty Ranges, adjacent to the Noarlunga and Willunga Embayments and terminating in St Vincent Gulf at Port Noarlunga (Onkaparinga Catchment Water Management Board, 2000). The coastal boundary of the catchment extends for 45 km along St Vincent Gulf from O'Halloran Hill in the north to Sellicks Hill in the south and incorporates many coastal urban and semi-urban areas.

GEOLOGY AND HYDROGEOLOGY

The northern part of the OCWMB area is situated in the central section of Mount Lofty Ranges (Fig. 3). The Mount Lofty Ranges are developed on the southern part of the Adelaide Geosyncline; an elongate region of folded and faulted Precambrian sediments forming intrusions of crystalline rocks (granite) with extensive outcrops of metamorphic rocks in the east and south. The main aquifer system in the Adelaide Geosyncline is a fractured rock system.

Fractured rock aquifers are those systems in which groundwater is primarily stored in and transported through fractures or fissures in an essentially impervious rock mass. Fractures include cracks, joints and faults, and can vary in length and width. Recharge and groundwater movement can be rapid and the potential for transmission of pollutants may be increased in a fractured rock system.

The southern part of the OCWMB area is situated in the Noarlunga and Willunga Embayments (Fig. 3). The embayment regions, which comprise late Tertiary and Quaternary sediments, are part of the much larger St Vincent Basin which formed in response to reactivation of Palaeozoic faults in the Eocene period following continental separation of Australia and Antarctica. The sedimentary sequences contain a complex multi-aquifer system. Groundwater is withdrawn from aquifer layers within Quaternary sediments, Tertiary sediments and basement rocks and is divided into four aquifers; basement, Maslin sands, Port Willunga Formation and Quaternary.

In porous sedimentary aquifer systems water moves slowly through the pores between sand or gravel grains so that the aquifers essentially act as storage reservoirs. The shallow Quaternary aquifer is subject to direct potential pollution from land-use activities. In the deeper confined aquifers of the Willunga and Noarlunga Embayments, water quality may be affected indirectly by poorly constructed or leaky wells.

The shallow Quaternary aquifer is unconfined and is principally recharged through infiltration of a small proportion of rainfall runoff through the soil profile and streambeds. Therefore there is potential risk of contamination by pollutants through the soil to the aquifer. Deeper aquifers, such as Port Willunga Formation and Maslin sands, are also unconfined in parts exposing them to the same contamination risks. However, as the shallow aquifer is most likely to be used for domestic purposes, this is a health concern and therefore sampling has targeted this groundwater resource.

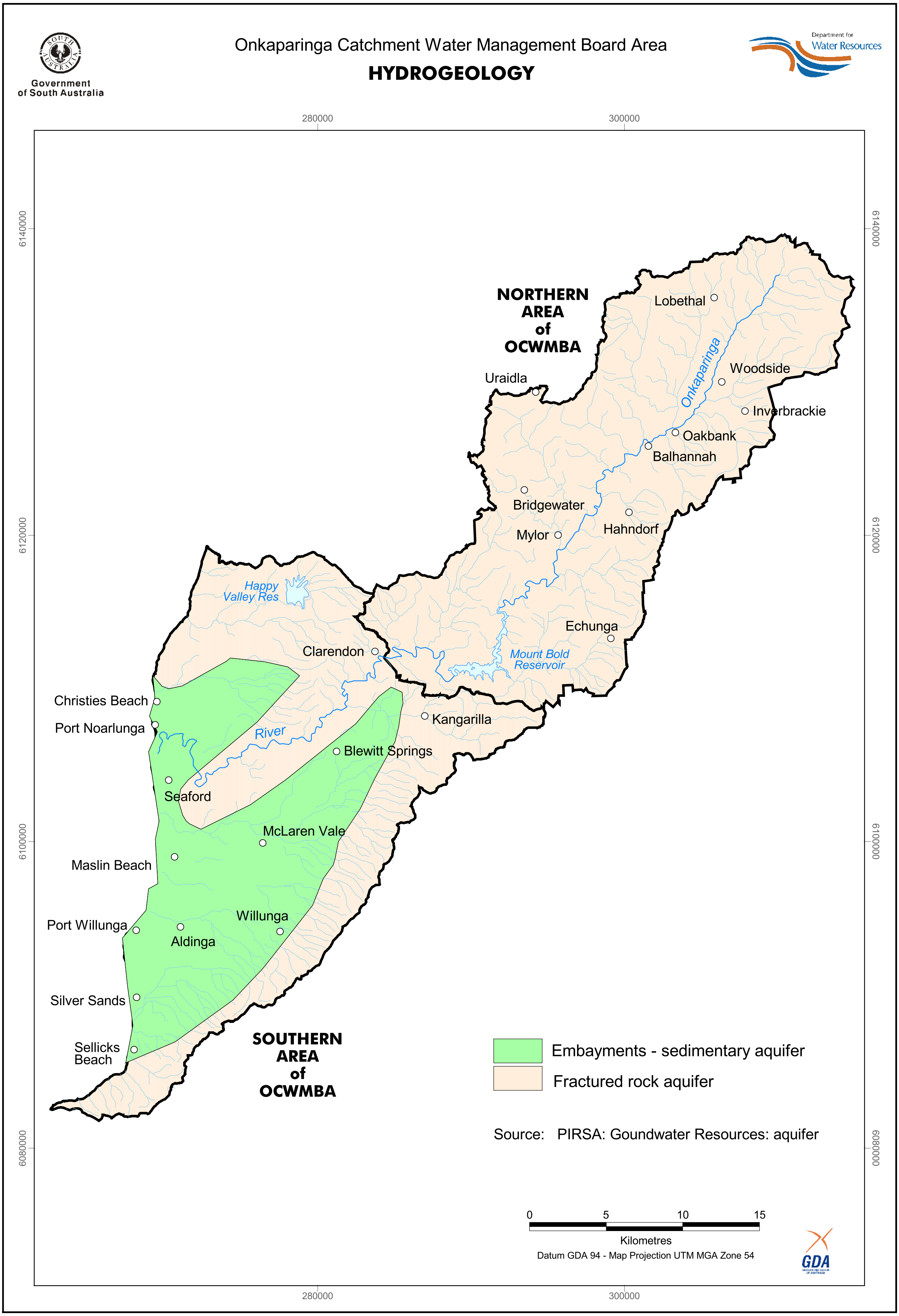

Figure 3

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LAND AND WATER USE

The catchment area encompasses a wide range of land uses, all of which impact on the water resources of the region to some degree. These uses (based on Mount Lofty land-use data 1999), (Fig. 4) include urban development along the fringe of metropolitan Adelaide, intensive horticulture and agriculture in the Adelaide Hills and Willunga Embayment areas, and industrial activities in the Lonsdale area and some Adelaide Hills townships. The groundwater resources are extracted for irrigated agriculture, industrial, stock and domestic purposes without restriction, except in the McLaren Vale Prescribed Wells Area in the Willunga Embayment. The groundwater resources in the McLaren Vale Prescribed Wells Area have been allocated in accordance with McLaren Vale Prescribed Wells Water Allocation Plan, adopted November 2000, to protect the resource from overuse and degradation of groundwater quality and quantity.

SAMPLING STRATEGY AND DATA MANAGEMENT

The primary objectives of this project are to identify areas where the shallow groundwater aquifers are potentially threatened by land-use activities and may be at risk from point-source pollution and establish an ongoing sampling program to monitor the pollution levels and changes in groundwater quality.

It is recognised that diffuse source pollution is also a threat to the shallow groundwater resources and although there is some overlap the focus of this study is point-source pollution.

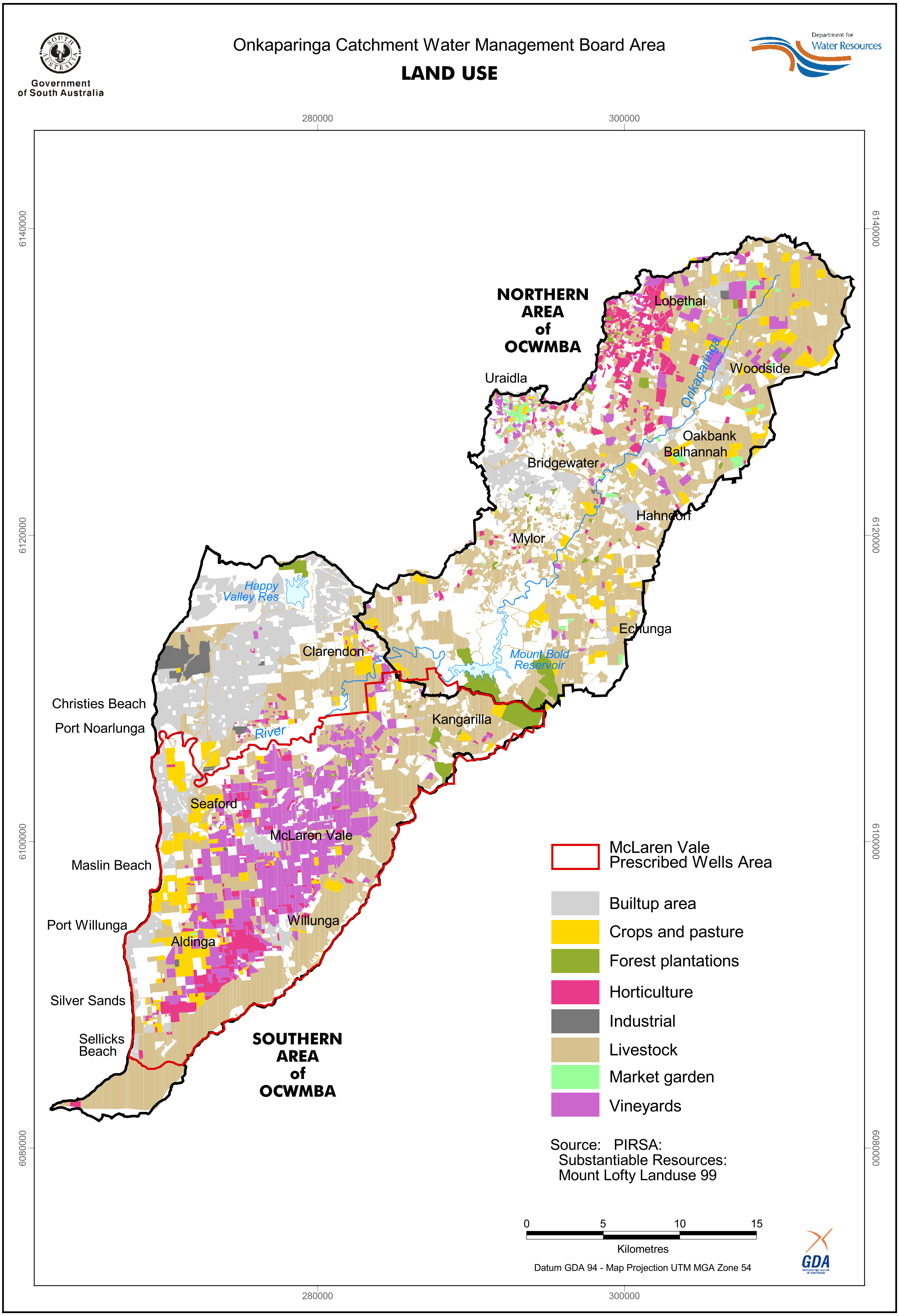
Identifying potential risk areas

Identification of the potential risk areas was achieved through discussion with the OCWMB and the Environment Protection Authority, researching records of previous groundwater pollution and other groundwater assessment projects, analysing records of land-use registration and engaging the assistance of land-use databases. This information was then represented spatially using a geographical information system. By selecting, overlaying and manipulating the required spatial databases, a unique coverage was created. This enabled potential risk areas to be identified and targeted for groundwater contamination monitoring (Fig. 5).

The potential risk areas were grouped into eight categories based on land use and industrial activities (Table 1).

Table 1 Selected land-use categories and areas considered to be at potential risk of groundwater contamination for point-source pollution

Land-use category	Area
Wineries	Mount Lofty Ranges and Willunga Basin
Unsewered areas	Summertown, parts of Stirling, parts of Bridgewater, Mylor, Old Noarlunga and Aldinga
Abattoirs	Lobethal and Old Noarlunga
Effluent and sludge ponds	Willunga, Aldinga, Echunga and Onkaparinga estuary
Waste depots	Stirling, Southern Waste and Pedler Creek Depot
Service stations (underground storage tanks)	Throughout catchment, Port Stanvac and Mitsubishi
Mine sites	Sites throughout Mount Lofty Ranges
Forest plantations	Kuitpo Forest only
Chicken sheds	Bridgewater only



Onkaparinga Catchment Water Management Board Area
LAND USE
Government of South Australia
Department for Water Resources
280000
300000
6140000
6120000
6100000
6080000
NORTHERN AREA of OCWMBA
Lobethal
Woodside
Onkaparinga
Uraidla
Oakbank
Balhannah
Bridgewater
Hahndorf
Mylor
Echunga
Happy Valley Res
Mount Bold Reservoir
Clarendon
Christies Beach
Port Noarlunga
River
Kangarilla
Seaford
McLaren Vale
Maslin Beach
Willunga
Port Willunga
Aldinga
Silver Sands
Sellicks Beach
SOUTHERN AREA of OCWMBA
McLaren Vale Prescribed Wells Area
Builtup area
Crops and pasture
Forest plantations
Horticulture
Industrial
Livestock
Market garden
Vineyards
Source: PIRSA: Substantiable Resources: Mount Lofty Landuse 99
0
5
10
15
Kilometres
Datum GDA 94 - Map Projection UTM MGA Zone 54
GDA

Figure 4

Onkaparinga Catchment Water Management Board Area

SELECTED LAND USE CATEGORIES CONSIDERED TO BE AT POTENTIAL RISK OF GROUNDWATER CONTAMINATION

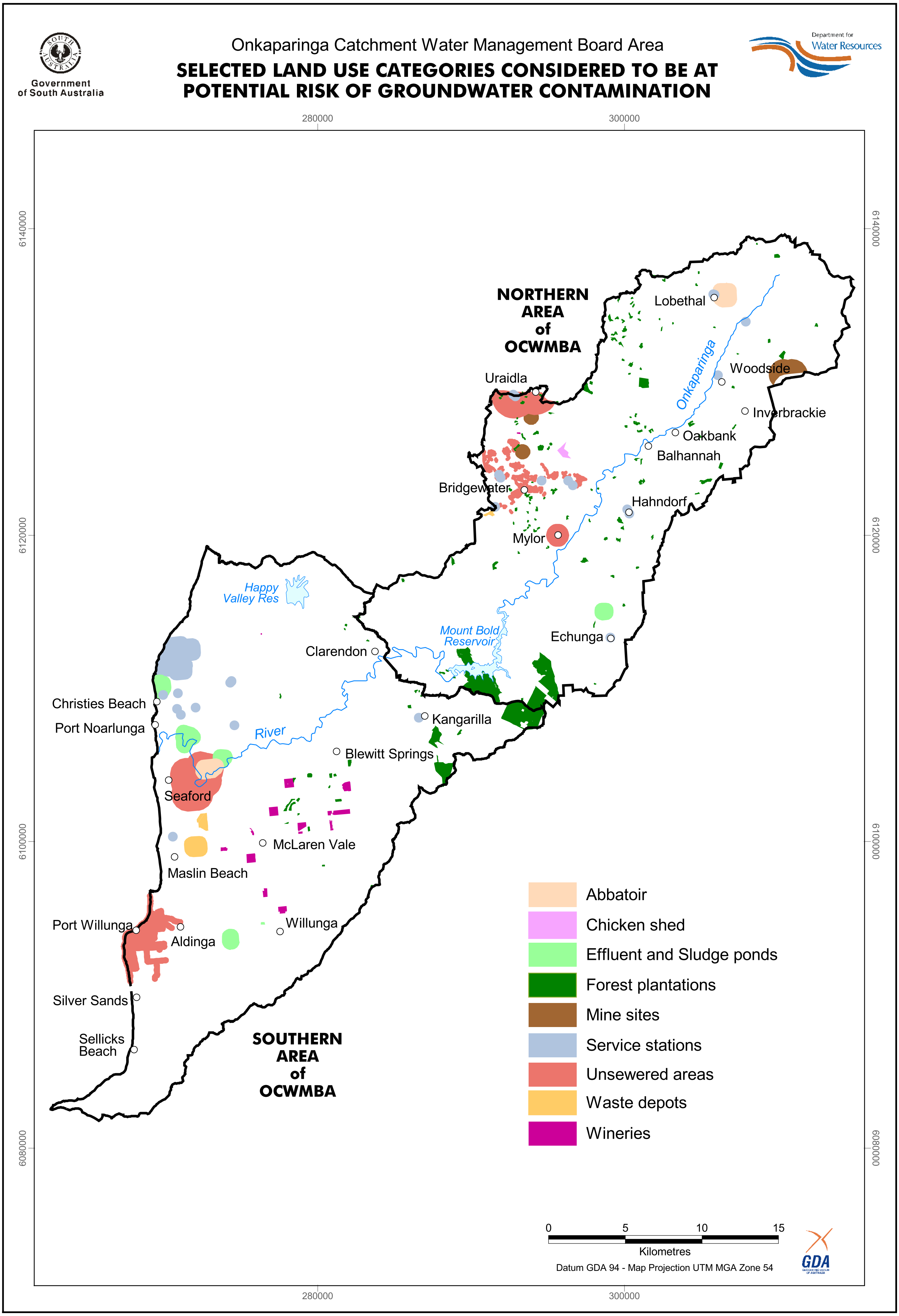


Figure 5

PIRSA Publishing Services AV : 201129-005

Electrical transformer sites, chemical depots and importation and irrigation from the Willunga effluent pipeline are also considered to be potential risk land uses, however, they have not been included in this study because:

- Electrical transformer sites were not selected for sampling as part of this study. Electrical transformers are built to safety standards within concrete bays to prevent seepage of petrochemicals into the soil and central alarms are triggered if any leakages are detected. With these safety standards in place the risk of contamination from leakage of petrochemicals from electrical transformers in very low.
- There are also numerous small chemical depots (local councils) throughout the catchment area that have not been included in this study for sampling because it is believed that these sites should or would have appropriate precautions like storage bays to prevent spillage to the soil. Further investigation is required to ensure all small chemical depots has appropriate precautions.
- Importation and irrigation from the Willunga effluent pipeline is subject to Environment Protection Authority sampling and therefore have also been excluded in this project.

Selecting sampling points

The criteria for the selection of suitable groundwater sampling points or wells to target the shallow aquifer were based on the type of aquifer system from which the groundwater was being sampled —- the fractured rock aquifer system that dominates the northern section of the OCWMB area, or the sedimentary sequences of the Noarlunga and Willunga Embayments in the southern section of the OCWMB area.

To make an appropriate well selection the following assumptions were made:

- The direction of shallow groundwater flow is generally consistent with land surface slope direction.
- Aquifers in sedimentary systems are deemed to be shallow if the watertable is cut within 20 m of the ground surface. Due to irregularities of fractured rock systems wells where the production zone starts at a depth less than 50 m from ground surface are deemed as shallow.

A selection of boreholes, within 100 m down hydraulic gradient of the land-use areas, were collated using an online spatial coverage of the South Australian Government drillhole database (SA_Geodata).

The sample point selection was restricted by availability of suitable wells with the required criteria.

- Many of the petrol retailing outlets scattered throughout the catchment did not have suitable wells within 100 m. It was agreed during discussions with the officers from the Department for Water Resources, Environment Protection Authority and the OCWMB that it would be impractical to drill a well at every outlet site. Therefore, outlets with underground tanks older than 20 years were targeted, as these have a higher probability of leakage and pose a greater risk of groundwater contamination than more recent underground tanks which have been designed, built and installed under more stringent safety regulations.
- Wineries that crush 400 tonnes or more of grapes in a calendar year and dispose of the effluent on site were selected as being a potential risk to the shallow groundwater system. The method of effluent disposal needed to be identified and

suitable wells selected. The drillhole database identified that there were very few suitable sampling wells within 100 m down gradient from the selected winery areas. More piezometers would need to be drilled as sampling points.

- Many mine sites were found to be no longer active and therefore their exact position is uncertain. Further research is required to ascertain the position of the mine, active licences and suitable sampling wells.

The sample point selection also included boreholes that had been previously sampled by the Australian Geological Survey Organisation in the Piccadilly Valley (Summertown to Stirling) (Ivkovic et al., 1998), and the Bureau of Rural Sciences in the Upper Onkaparinga Region, southern Mount Lofty Ranges (Lobethal to Hahndorf) (Radke et al., 2000) which showed positive results for faecal indicator bacteria (FIB). Results from this sampling program are compared with the results in these reports to identify changes in bacterial contamination.

Initially, 193 operational boreholes were selected and maps of their positions were generated. A field survey of the selected wells began in December 2000 and was completed in January 2001.

Of the selected wells 104 were eliminated for the following reasons:

- could not be located
- unsuitable for sampling (no access, no sampling take-off, difficult to reach, pump stuck in hole)
- borehole backfilled or collapsed
- well used for stormwater injection
- landowner did not wish to take part in the project
- low yield.

The remaining 89 wells were surveyed (Fig. 6 southern OCWMB and Fig. 7 northern OCWMB). Global positioning system coordinates were recorded, headwork and sample access details documented and landowner permission was sort and established. A detailed table of the 89 selected wells is documented in Appendix 1. Petrol retailing outlets, waste depots and mine site potential risk areas were omitted from this phase of the project. The reasons for these omissions are:

- More research is required to establish the age of the underground storage tanks. In addition many of the petrol retailing outlets submit returns to the Environment Protection Authority on bulk fuel delivered and sales as part of a monitoring program.
- Historic mine sites were extremely difficult to locate. More research is required.
- The waste depots are required to sample groundwater within the site area for the Environment Protection Authority twice a year.

Sampling

Sampling occurred between 5 and 20 March 2001. A minimum of three well volumes of water was discharged from each well after which samples were collected. The owner’s pump was used where the well was equipped and portable submersible pumps were used in open boreholes or piezometers.

Onkaparinga Catchment Water Management Board Area

GROUNDWATER SAMPLE WELLS FOR SOUTHERN AREA

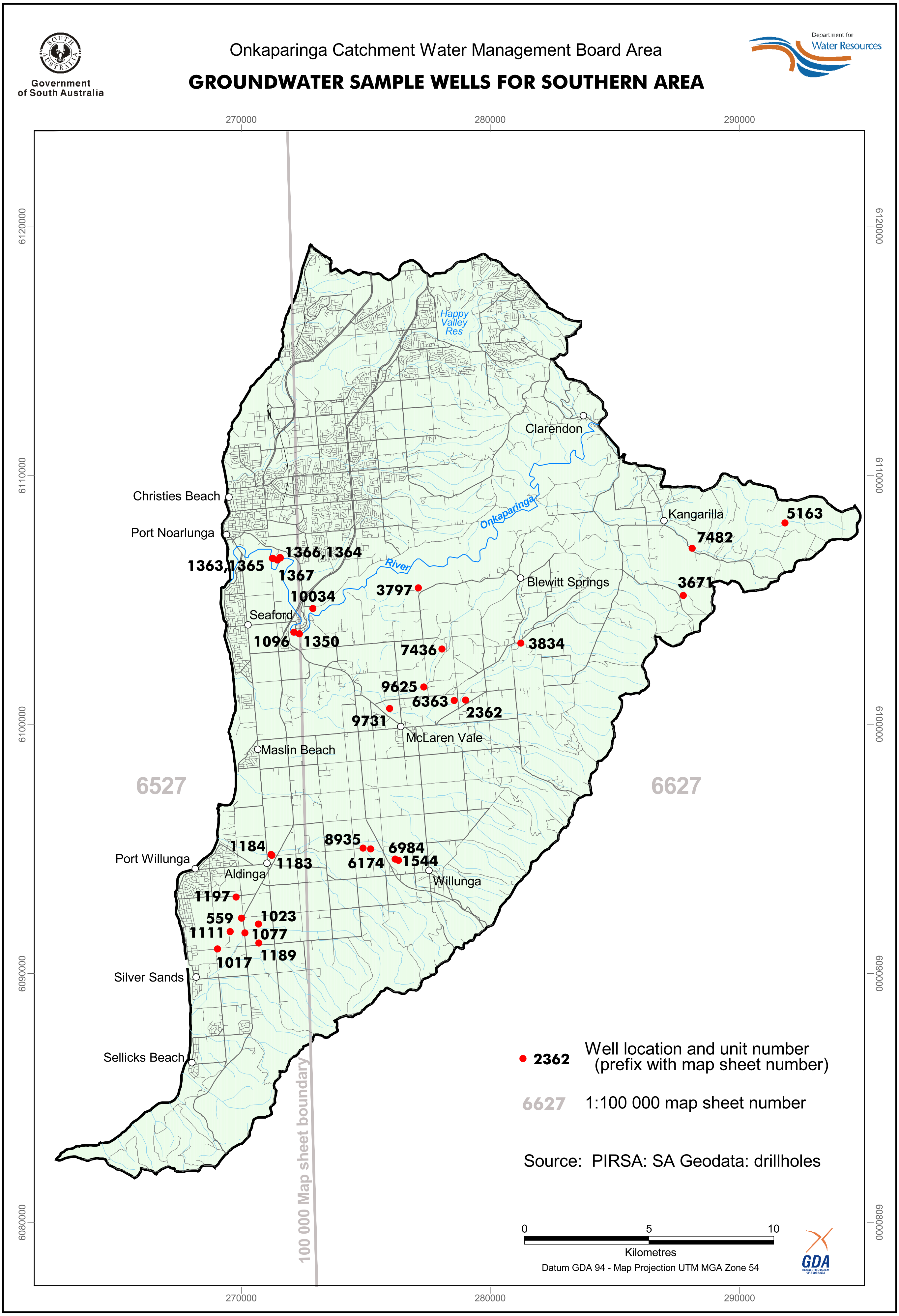


Figure 6

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Onkaparinga Catchment Water Management Board Area

GROUNDWATER SAMPLE WELLS FOR NORTHERN AREA

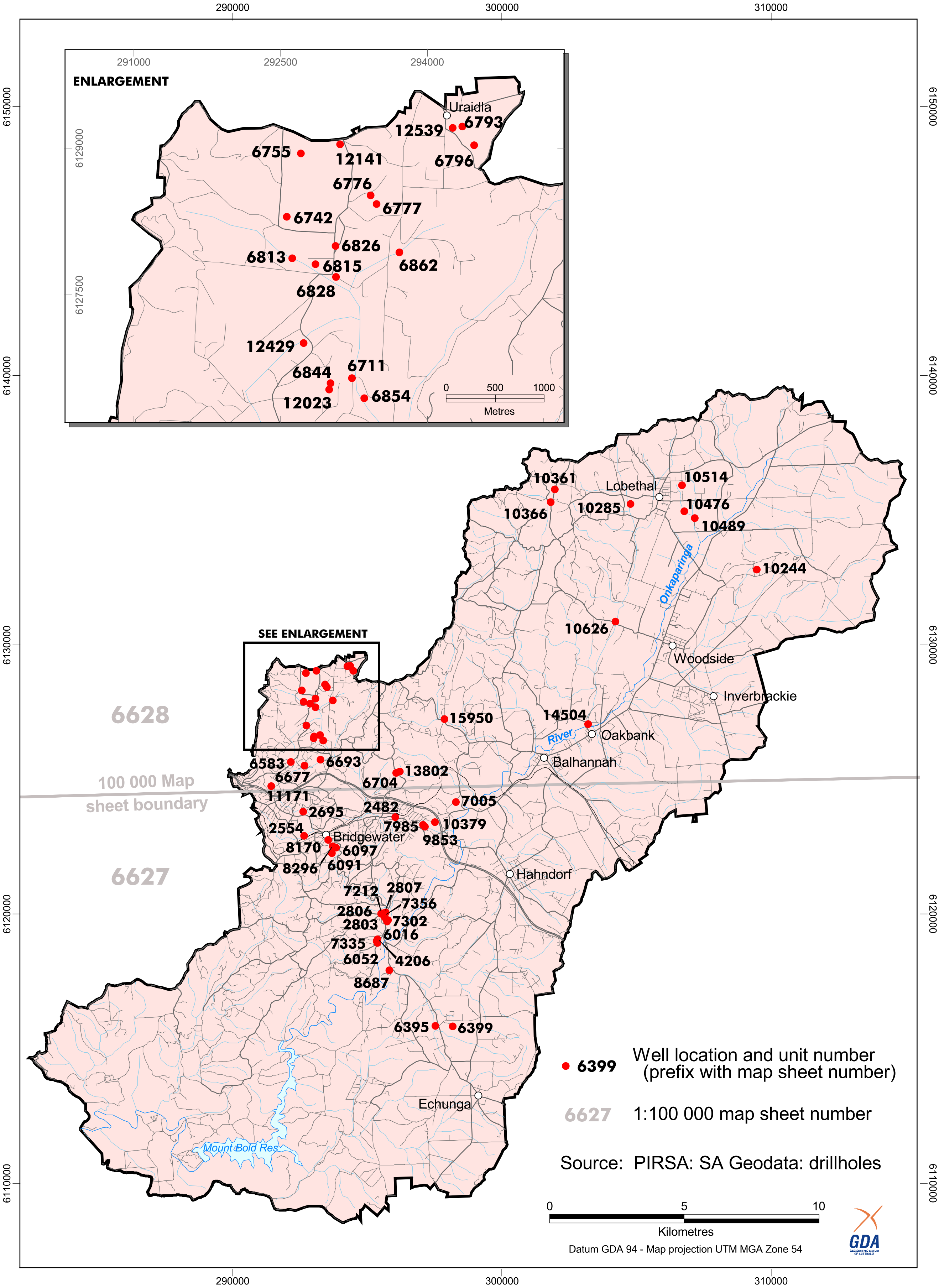

Figure 7

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The method of water sample collection is based on the type of analysis being undertaken:

- Sampling inorganic constituents and nutrients — 1.25 L plastic bottle, pre-rinsed with water from the well and then filled.
- Sampling microbiological constituents — 500 mL sterilised plastic bottle filled to 20 mm below the top of the bottle and then covered with aluminium foil and lid.
- Sampling pesticides and hydrocarbons — 1 L glass bottle, pre-rinsed with water from the well, filled to just below the neck of the bottle.

All samples were immediately put on ice and kept in a controlled environment. At the end of the day the samples were taken to the Australian Water Quality Centre laboratories for analysis. The laboratory was advised in advance on how many microbiological samples could be expected and the approximate arrival time so staff could begin setting up the tests on the same day. The centre is a certified laboratory under the National Accredited Testing Authority.

The analyte suites for samples were tailored to fit the potential risk land-use category (Table 2). The analyte suites were agreed upon by the OCWMB and Environment Protection Authority.

Table 2 Analyte suites of each potential risk land-use category

Wineries	Effluent and sludge ponds, unsewered area, chicken sheds and abattoirs	Forests
Total phosphorus	Total phosphorus	Total phosphorus
Nitrate	Nitrate	Nitrate
Nitrite	Nitrite	
Ammonia	Ammonia	
Total dissolved solids (TDS)	TDS	TDS
Electrical conductivity	Electrical conductivity	
Heterotrophic iron bacteria (FeB)	FeB	
Total Organic Carbon (TOC)	TOC	
Sulphate		
Potassium		
	FS includes *Enterococci* count	
	FC includes E. coli count	
		Organo-phosphate and triazine pesticides
		Hexazionone, atrazine, simazine

Detailed tables of the analysis results are documented in Appendix 2 for the southern OCWMB area and Appendix 3 for the northern OCWMB area. The analyte results for each well has been graphed and documented in Appendix 4 Figures A4.1 to A4.22 and discussed in 'Hydro-chemical analyses'.

The discussion also includes guideline values for chemical parameters for:

- drinking and domestic use (*Australian drinking water guidelines* (NHMRC and ARMCANZ, 1996))
- irrigation and livestock drinking use (*Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC and ARMCANZ, 1999)).

As wells accessing the shallow aquifer are most likely to be used for domestic and livestock purposes the results are compared with guidelines for these purposes. Groundwater is considered to be at risk to health and livestock when these guidelines are exceeded.

HYDRO-CHEMICAL ANALYSES

INORGANIC CONSTITUENTS

TDS

The concentration of TDS should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Aesthetic value: 500 mg/L.
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no guideline value set; dependant on many factors.
  Livestock drinking water guidelines: dependent on livestock type.

The groundwater salinity (measured as TDS mg/L) value was derived by conversion from the electrical conductivity. The groundwater salinity of the southern area ranges between 82 and 24 000 mg/L with a medium of 1500 mg/L. The northern area groundwater salinity ranges between 100 and 2700 mg/L with a medium of 380 mg/L. The NHMRC and ARMCANZ (1996) drinking water guideline value is an aesthetic value based on taste. The TDS in drinking-water should not exceed 500 mg/L although up to 1000 mg/L may generally be considered to be acceptable for human consumption. Only one of 31 of the sampled wells in the southern area is under 500 mg/L whereas 40 out of 58 of the sampled wells of the northern area are under 500 mg/L.

- The Quaternary aquifer of the Willunga Basin in the southern areas has a naturally higher salinity than the fractured rock aquifer in the northern area. The average salinity of the southern area is 1710 mg/L where the fractured rock aquifer in the northern area has an average salinity of 840 mg/L.
- The difference between the TDS in the southern and northern areas indicates that lower groundwater TDS occurs at higher elevations. The northern area has a higher rainfall, which recharges the aquifer with fresh water more frequently. Additionally, the aquifer system in the northern area is fractured rock where groundwater recharge is considered to be rapid as water infiltrates to the aquifer through fissures. Recharge to shallow sedimentary aquifers, as in the southern area, is subject to concentration of TDS in the soil profile.
- A source of TDS is airborne sea salts deposited over the area by wind and rainfall, with salt deposition decreasing with increased distance from coast (Kayaalp and Bye, in prep.). However water/rock interaction and biological reactions may also pay a role in influencing aquifer salinity. It is recommended that chloride, total sulphate and total nitrogen (N) analysed in subsequent sampling to verify the origins of TDS.

Potassium

The concentration of potassium should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  No guideline value set.
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no guideline value set.
  Livestock drinking water guidelines: no guideline value set.

Potassium was a parameter selected for analysing groundwater down gradient from wineries. It is an indicator of contamination from winery effluent. There are no prescribed health guidelines for potassium in drinking water. Although potassium is quite abundant in rocks, it is not easily liberated into solution from minerals and has a tendency to be reincorporated. Potassium does not commonly occur in high concentrations in groundwater. The inclusion of chloride in future sampling will provide information on the source of the potassium.

The results indicated higher concentrations generally in the southern area and very low concentration in the northern area. These concentration levels are not considered to be the result of contamination.

Sulphate

The concentration of sulphate should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Health value: 500 mg/L.
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no guideline value set.
  Livestock drinking water guidelines: no adverse effects to stock are expected if the concentration of sulphate in drinking water does not exceed 1000 mg/L.

Sulphate is a parameter selected for analysing groundwater down gradient from wineries. It is an indicator of contamination from winery effluent. Sulphate is an oxidised form of sulphur and can be formed by oxidation of pyrite and other sulphides widely distributed in igneous and sedimentary rocks. However, the source of sulphate is probably predominantly from sea salts deposited by wind and rainfall. The inclusion of chloride in future sampling may indicate the origins of sulphate in these systems.

The results indicated that the concentration of sulphate is well below 500 mg/L; the recommended NHMRC and ARMCANZ (1996) guideline level for health in the southern and northern areas. These concentration levels are not considered to be the result of contamination.

NUTRIENTS

Ammonium as N (NH_4^+-N)

The concentration of ammonium as N should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Aesthetic value: 0.4 mg/L.
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no guideline value set.
  Livestock drinking water guidelines: no guideline value set.

Sources of ammonia in groundwater include natural precipitation, geological deposits, fertilisers, plant residues and waste water (including domestic sewage). Ammonium ion is quickly lost in the N cycle through nitrification, immobilisation and mineralisation. Its concentration is generally low in groundwaters because it adsorbs to soil particles and clays and is not readily leached from soils. There is no health guideline value set for ammonium although it is an indicator of contamination. The recommended NHMRC and ARMCANZ (1996) guideline value of ammonium as N is based on aesthetic considerations with a guideline level of 0.4 mg/L.

The wells sampled in the southern area contained ammonium as N concentrations ranging from 0.005 to 193 mg/L with a median concentration of 0.063 mg/L, which is an order of magnitude lower than the NHMRC and ARMCANZ (1996) guideline level. Eight wells contained ammonium as N at concentrations greater than 0.4 mg/L. Table 3 identifies the potential risk land-use category for these wells and compares this with the FIB count (The results of the FIB count are discussed in 'Microbiology').

Seven of the wells show FIB levels greater than 74 cells/100 mL. The NHMRC and ARMCANZ (1996) guideline level for the FIB, E. coli, is zero and therefore the presence of FIB indicates groundwater contamination. It is clear that these wells are contaminated by anthropogenic sources such as leaky septic tanks or leakage from the sludge ponds, which is making a major contribution to the ammonium as N in the groundwater. However the source of a high concentration of ammonium as N in well 6527-1096 is not obvious as a zero FIB count has also been identified in this well.

Table 3 Ammonia as N for wells with values over the *Australian drinking water guideline* (ADWG) values compared with the wells FIB count

Well unit number	Land use	NH_4^+ as N	FIB:FS
6527-1111	Aldinga unsewered	3.27	520
6527-1350	Old Noarlunga unsewered	1.72	>4800
6527-1096	Old Noarlunga unsewered	5.04	0
6527-1364	Onkaparinga estuary sludge pond	20.5	200 000
6527-1365	Onkaparinga estuary sludge pond	140	560
6527-1366	Onkaparinga estuary sludge pond	5.66	74
6527-1363	Onkaparinga estuary sludge pond	32.2	2200
6527-1367	Onkaparinga estuary sludge pond	193	610

Organic matter such as septic tank and sludge pond effluent will decay to ammonia under reducing conditions and normally have high ammonia and very little nitrate (Fetter, 1993). This is supported by the following nitrate results for the above wells, all of which have high ammonia and low nitrate.

The wells sampled in the northern area contained low ammonium concentrations ranging from 0.005 to 0.068 mg/L. A median concentration from the sampled wells of 0.0055 mg/L is several orders of magnitude lower than the NHMRC and ARMCANZ (1996) guideline level.

Nitrite as N

The concentration of nitrite as N should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Health value: 0.9 mg/L..
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no guideline value set.
  Livestock drinking water guidelines: 30 mg/L (as nitrite).

The low frequency of detection of Nitrite is consistent with the environmental behaviour of nitrite as N, which is characterised by its susceptibility to chemical and microbial oxidation and consequent instability in oxygenated waters. Under anoxic conditions nitrite as N constitutes an intermediate in the process of microbial denitrification.

All sampled wells in the southern and northern areas showed values significantly less than the NHMRC and ARMCANZ (1996) health guideline value for nitrite as N of 0.9 mg/L. The highest value of Nitrite as N was 0.195 mg/L in the southern area and 0.14 mg/L in the northern area with a median concentration of 0.005 mg/L throughout the total catchment.

Nitrate as N

The concentration of nitrate as N should not exceed the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Health value: 11.3 mg/L..
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: acceptable contaminate concentration 15 mg/L.
  Livestock drinking water guidelines: 400 mg/L (as nitrate).

Elevated nitrate concentrations may occur naturally or as a consequence of contamination from sources such as livestock wastes, septic tanks and the application of nitrogenous fertilisers. The NHMRC and ARMCANZ (1996) health guideline value for nitrate as N is 11.30 mg/L.

All sampled wells in the southern and northern areas showed values less than the guideline values. The highest value in the southern area was 5.07 mg/L with a median concentration of 0.35 mg/L. The highest value in the northern region was 7.38 mg/L with a median concentration of 0.255 mg/L.

TOC

> *The concentration of TOC should not exceed the following:*
> - **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
>   *No guideline value set.*
> - **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
>   *Water quality for irrigation use: no guideline value set.*
>   *Livestock drinking water guidelines: no guideline value set.*

All natural waters contain organic material, generally in low concentrations. Organic carbon concentration in natural waters can be variable and tends to be lower in groundwater than in surface waters. High concentrations often indicate contamination from sewage, animal wastes or industrial organic chemicals.

The TOC concentration is higher in the southern area ranging between 0.3 and 251 mg/L and between 0.3 and 2.4 mg/L in the northern area. There is a strong correlation between elevated TOC levels and high ammonium levels in the southern area, particularly in the sludge ponds adjacent to Onkaparinga Estuary and several of the unsewered areas. The TOC concentration in groundwater from wells in the northern area is comparatively lower and show low ammonium levels.

Total dissolved phosphate

> *The concentration of total dissolved phosphate should not exceed the following:*
> - **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
>   *No guideline value set.*
> - **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
>   *Water quality for irrigation use: not determined.*
>   *Livestock drinking water guidelines: no guideline value set.*

Phosphorus occurs in natural water almost solely as phosphates. Anthropogenic phosphorus include fertilisers, sewage, animal waste, detergents and other organophosphorous compounds such as insecticides. The range of naturally occurring phosphorous levels in groundwater has not been established. Phosphorus levels in groundwater are generally considered to be elevated when the concentration exceeds about 0.2 mg/L (Ivkovic et al., 1998).

The results of wells sampled in the southern area indicate elevated concentrations of Phosphorus in the sampling points adjacent to the Onkaparinga estuary sludge ponds and the Old Noarlunga unsewered sampling well 6527-1350. These wells are previously described as having high concentrations of ammonium, TOC and FIB.

Only two wells indicated elevated concentration (> 0.3 mg/L) in the northern area - well 6628-10244 in the southern Mount Lofty FIB land-use category and well 6628-10514 within the Lobethal abattoir land-use category. It is not understood why the groundwater from these wells indicates a higher phosphorus value.

MICROBIOLOGY

Like natural habitats everywhere, the subsurface environment, including groundwater, has been found to contain a broad spectrum of microbial types similar to those found in surface soils and waters. On occasion, pathogenic viruses, bacteria and protozoans of gastrointestinal origin from domestic, agricultural and other anthropogenic activities, may infiltrate through soils, sediments and rocks to the underlying groundwaters.

FIB

The concentration of E. coli must not exceeded the following:

- **Australian drinking water guidelines *(NHMRC and ARMCANZ, 1996)***
  Should not be detected in any sample of drinking water.
- **Australian and New Zealand guidelines for fresh and marine water quality *(ANZECC and ARMCANZ, 1999)***
  Water quality for irrigation use: no more than 1000 FC/100 mL for use on agricultural produce for direct human consumption.
  Livestock drinking water guidelines: should contain no more than 1000 FC/ 100 mL (based on not less than five water samples taken per month. No more than 20% of these sample should exceed 5000 FC /100 mL)

Faecal indicator bacteria are used as an indicator for pathogenic microbes of gastrointestinal origin (including bacteria, viruses and protozoa). Their presence in a water sample indicates that the water has received faecal contamination from humans and/or other warm-blooded animals.

The most likely sources of FIB contamination would be nearby septic tanks lying up gradient from the sampling well, along a fracture, seepage from the sludge and effluent ponds or poultry effluent. However, remote sources (eg. livestock) cannot be precluded.

Two classes of FIB were analysed as target indicators in groundwater sampled from wells within the potential risk land-use areas (effluent and sludge ponds, unsewered areas, chicken sheds and abattoirs). These classes of FIB were FC (alternatively E. coli) and FS (alternatively *Enterococcus* spp.).

Although faecal streptococci (FS) has no guideline value, it provides an additional, and possibly more sensitive, indicator than faecal coliforms (FC) because it may be present in some faecal material in considerably higher numbers than FC and appear to be more persistent in aquatic environments. It has been observed, however, in surface water samples taken within 24 hours of flow, that the quantities of FC and FS that are discharged by humans are significantly different from the quantities discharged by animals (Metcalf and Eddy Inc., 1991). The ratio of FC to FS for domestic animals is less than 1.0 whereas the ratio for humans can be more than 4.0.

Therefore it would be expected that FC:FS ratio would be higher in the unsewered, effluent and sludge pond land-use areas. However the interpretations by Metcalf and Eddy were subject to sampling and testing fresh samples and not aged contamination as may be found in domestic wells or peizometers.

The results indicated that one or more classes of FIB were detected in 35 of the 76 wells sampled (46%) (App. 2 and 3). The results of this study shows the FS cell count is greater than FC cell count in all sampled wells that resulted positive for FIB excepting wells 6527-1183, 6527-1111, 6628-13802 and 6628-6862 (Table 4).

Table 4 Wells testing positive for FIB having a greater FC than FS cell count

Well unit number	Land-use area	FC:FS	Comment
6527-1183	Aldinga unsewered	No FS present	It is unusual that FS is undetected. It is expected because the well is situated adjacent to an urban development and has a high FC result. Suggest resampling.
6527-1111	Aldinga unsewered	3	Expected result however the location of the well is away from the main residential area. There is a rumour of an historic discharge of human waste on Aldinga Scrub Reserve. Suggest further investigation.
6628-13802	Bridgewater chicken sheds	3	Unexpected as the origin is animal waste. An unmapped source of human waste could exist. Suggest further investigation.
6628-6862	Summertown unsewered	16	Unexpected as this well is situated in a vineyard. An unmapped source of human waste could exist. Suggest further investigation.

The following is a discussion of the FIB results.

SOUTHERN OCWMB AREA

Aldinga effluent pond

Four wells were sampled down gradient of the Aldinga effluent pond. One well, 6527-1023, showed a positive result for FS. This positive result albeit relatively low, may be due to leakage from the effluent pond but requires further sampling points and investigation close to the source.

Aldinga unsewered

Five wells were sampled within the Aldinga rural area to the east of the Aldinga Beach urban area. Four wells showed a positive result for all FIB. Wells 6527-1184 and 6527-1183 are situated close to the Aldinga township and well 6527-1197 is situated close to the Aldinga light industrial area. Both areas are unsewered. Well 6527-1111, which is situated on the western edge of the Aldinga Scrub, recorded a high count for both FC and FS with a FC:FS ratio of 3 indicating contamination by human faeces (Metcalf and Eddy Inc., 1991). There is some evidence that a waste water irrigation trial was conducted within the Aldinga Scrub over a short period. The FIB contamination of this well may be a result of this trial. Further information about the trial and subsequent sampling will be necessary to determine the extent of the contamination.

Old Noarlunga abattoir

The one well sampled in this potential risk land-use category showed a low but positive result for FS. This area was historically used as an abattoir but is now used for fish farming. The contamination of the groundwater could be a result of waste water from this current industrial activity or remnant contamination from the previous abattoir activity.

Old Noarlunga unsewered

Three wells were sampled with one positive result. Wells 6527-1350 and 6527-1096 are both situated in the township of Old Noarlunga. However 6527-1096, with a negative FIB result, is situated within the sports complex, adjacent to the oval, while 6527-1350, which shows a strong positive result for both FC and FS, is situated near the river down gradient from a residential area. This high level contamination is most likely due to leaky septic tanks. It is recommended that more sampling sites be installed in this area for monitoring. Well no 6627-3797, situated outside the urban area, did not indicate any groundwater contamination.

Onkaparinga estuary sludge ponds

The Onkaparinga River borders the site of the Christies Beach Waste Water Treatment Plant Sludge Ponds which is located in the Onkaparinga Estuary, Port Noarlunga. Sludge ponds have the potential to infiltrate leachate into the watertable.

Five wells were sample for FIB within this site. The wells are positioned between the ponds and the Onkaparinga River. Wells 6527-1363 and 6527-1365 are positioned 6 and 20 m respectively from the west side of the ponds. Wells 6527-1366 and 6527-1364 are positioned 6 and 20 m respectively from the east side of the ponds. Well 6527-1367 is situated 6 m from the south side of the ponds. All the wells showed positive results for FIB with higher values in the 20 m wells (those furthest from the ponds). This contaminated groundwater could discharge into the river.

Results from studies by Metcalf and Eddy Inc. (1991), for removal of bacteria and parasites common to most natural treatment systems, have shown that in medium to fine textured soils complete removal of organisms can be achieved within 1.5 m of travel through the soil. Therefore bacteria present in seepage from the sludge ponds should attenuate through absorption and subsequent die-off within the soil but the results show this has not occurred.

Further investigation is recommended to investigate why contamination of the groundwater is occurring and sampling of river water is recommended upstream and downstream of the sludge ponds to establish whether the contaminated water is discharging into the river.

Willunga effluent pond

Four wells were sampled down gradient of the effluent pond along the creek. One well, 6627-8935, showed a weak positive result for FS. This well is situated furthest from the effluent pond just beyond the junction of two creeks. It is unlikely that the contamination is due to seepage from the effluent pond since the other three wells indicated no FIB. It is more likely that the contamination is due to a diffuse source such as grazing animals.

Results for all the southern area wells that indicated a positive result for FIB are detailed in Table 5.

Table 5 Wells in the southern OCWMB area that recorded a positive result for FIB

Land use	Well unit number	FC (/100 mL)	FS (/100 mL)	FC:FS	Depth of hole (m)	Lithology description at total depth of hole	Production zone (m)
Aldinga effluent pond	6527-1023	0	7		49	sandy limestone	32–49
Aldinga unsewered	6527-1111	1600	520	3	16.2	sand	14.2–16.2
Aldinga unsewered	6527-1183	4	0		29.4	soft marly limestone	16–29.4
Aldinga unsewered	6527-1184	2	12	0.16	14	marly clay	8–14
Aldinga unsewered	6527-1197	5	>100	0.05	55	limestone	32–55
Old Noarlunga abattoir	6627-10034	0	2		146	hard rock	36–146
Old Noarlunga unsewered	6527-1350	>1800	>4800	0.375	6.9	unknown	–
Onkaparinga estuary sludge pond	6527-1363	10	2200	0.005	5.8	unknown	–
Onkaparinga estuary sludge pond	6527-1364	1000	200 000	0.005	5.5	unknown	–
Onkaparinga estuary sludge pond	6527-1365	0	560		4.9	unknown	–
Onkaparinga estuary sludge pond	6527-1366	0	74		5.5	unknown	–
Onkaparinga estuary sludge pond	6527-1367	0	610		5.3	unknown	–
Willunga effluent ponds	6627-8935	0	2		64	limestone	42–64

NORTHERN OCWMB AREA

Mylor unsewered

Seven wells were sampled in the Mylor township and four in rural holdings just outside the township. Of the eleven wells sampled six showed positive results for FIB.

The six contaminated wells are all situated in the township, which is overlying the fractured rock aquifer system. The township is unsewered and household waste is stored in septic tanks. Septic tanks historically overflow especially in the winter time. The contamination of the groundwater in the identified wells is probably due to leakage from septic tanks into the fractured rock aquifer system. Well 6627-2806 shows a high number of FC and FS in comparison to the other sampled wells. The reason for this is difficult to determine due to the variability of groundwater flow in fractured rock aquifers.

Southern Mount Lofty FIB

The Piccadilly and southern Mount Lofty Ranges have previously been subject to water quality investigations.
These include:

- A *Groundwater quality assessment of the fractured rock aquifers of the Piccadilly Valley, South Australia* sampled by the Australian Geological Survey Organisation in 1994 (Ivkovic et al., 1998)
- A *Groundwater quality assessment of the upper Onkaparinga region, southern Mount Lofty Ranges, South Australia* sampled by the Bureau of Rural Sciences, between 1994–95 (Radke et al., 2000).

Many of the wells sampled for these projects are situated in the OCWMB area and the reports identified contamination with FIB. These positive FIB wells were included, where practical, in the Shallow Groundwater Quality Monitoring program for the OCWMB area. Although the wells are not related to any potential risk land-use category, re-sampling will be valuable to observe the changes in groundwater quality of FIB contamination over time.

Nine wells initially sampled for the Southern Mount Lofty Ranges Project (Radke et al., 2000) revealed positive results for FIB. These nine wells were re-sampled. Six of the re-sampled wells show no FIB contamination and three have positive results for FS. Comparisons of the results are detailed in Table 6.

Wells 6628-10285, 6628-10626 and 6628-15950 are all situated in rural areas outside townships. The source of the contamination is most likely diffuse pollution source such as animal wastes. Further investigation is required to identify the land-use activity that would be contributing to the positive FIB counts. Of these wells only well 6628-10626 shows a large increase in FIB count. Wells 6628-10285 and 6628-15950, although positive for FIB, have decreased or remained relatively constant. Comparing the 1994/5 results with the latest results shows an overall decrease in FIB contamination.

Table 6 Comparison of groundwater FIB water quality results from the southern Mount Lofty Ranges report and latest OCWMB sampling

Well unit number	Southern Mount Lofty Ranges Project sampled 1994–95		OCWMB Monitoring Program sampled 2001	
	FC (/100 mL)	FS (/100 mL)	FC (/100 mL)	FS (/100 mL)
6627-6091	3	3	0	0
6627-7005	<1	2	0	0
6628-10244	630	7 300	0	0
6628-10285	12	23	0	4
6628-10361	<1	3	0	0
6628-10366	2	25	0	0
6628-10626	<1	1	1	>200
6628-14504	1	5	0	0
6628-15950	0.5	2.5	0	3

Piccadilly FIB

Four wells, initially sampled for the Piccadilly Project (Ivkovic et al., 1998), revealed positive results for FIB. These four wells were re-sampled. One of the re-sampled wells showed a negative result for FIB leaving three with positive results for FS (Table 7).

Table 7 Comparison of groundwater FIB water quality results from the Piccadilly report and latest OCWMB sampling

Well unit number	Piccadilly Project sampled 1995		OCWMB Monitoring Program sampled 2001	
	FC (/100 mL)	FS (/100 mL)	FC (/100 mL)	FS (/100 mL)
6628-12429	<1	1	0	0
6628-6583	<1	1	0	8
6628-6742	5	8	0	10
6628-6776	26	120	0	8

The contamination in well 6628-6583, which situated in an urban property is likely to be from a leaky septic tank. However, the source of contamination in well 6628-6742, located in a vineyard and 6628-6776, located in a market garden, is unknown. Further investigation is required to establish the source. Comparing the 1995 results with the latest results indicates a reduction of FIB contamination.

Lobethal abattoir

Three wells were sampled. Well 6628-10514 is situated in the abattoir property and the other wells, 6628-10476 and 6628-10489, are situated down gradient of the abattoir. One well, 6628-10476, showed a positive FS result.

Well 6628-10514 is situated up gradient of the abattoir and therefore unlikely to show a positive result to contamination from abattoir activities. The contaminated well, 6628-10476, is ~1 km down gradient of the abattoir and the first well along the creek line in a fractured rock aquifer system. The positive result may be due to contamination from the abattoir but could also be caused by a diffuse source of FIB (e.g. livestock).

In addition, well 6628-10476 was sampled in the Southern Mount Lofty Ranges Project, revealing a historical positive FIB result. The results show there is a decrease in the FIB count between the two project samplings. The results of the 1994–95 and 2001 samplings are detailed in Table 8.

Table 8 Comparison of groundwater FIB water quality results from the southern Mount Lofty Ranges report and latest OCWMB sampling

Well unit number	Southern Mount Lofty Ranges Project sampled 1994–95		OCWMB Monitoring program sampled 2001	
	FC (/100 mL)	FS (/100 mL)	FC (/100 mL)	FS (/100 mL)
6628-10476	8	13	0	9

Echunga effluent pond

Of the two wells sampled, one, 6627-6395, resulted in a positive for FS. This well is situated right next to a large dam where cattle gather to drink. It is therefore impossible to conclude whether the source of contamination is due to the cattle or leakage from the effluent pond. Another well, away from the main grazing and drinking area, upstream of well 6627-6395 could be used for sampling. However, this well requires the removal of a defunct pump before it can be used for sampling.

Bridgewater chicken sheds

Two wells adjacent to the chicken sheds were sampled one resulted positive for FIB. The FC:FS ratio of the positive result is 3 which according to Metcalf and Eddy Inc. (1991) would indicate contamination from human faecal matter. However the contaminated well, 6628-13802, is positioned between two large chicken sheds and therefore it is more likely that the source of contamination is chicken effluent. An unmapped source of human waste could exist. Further investigation is suggested.

Stirling unsewered

Twelve wells were sampled with five showing a positive result for FS. All the wells are situated in urban Stirling which is only partly sewered and therefore the most probable cause of FIB contamination is leaky septic tanks. Two wells, 6628-6677 and 6628-11171, showed high counts for FC and FS.

Summertown unsewered

Eleven wells were sampled with two having measurable FIB contamination. Well 6628-6862, positive for FC and FS, is situated in a vineyard. The FC:FS ratio is 16 and therefore could be contaminated by an unmapped source of human faecal wastes (Metcalf and Eddy Inc., 1991). Further investigation is suggested. Well 6628-6755, with a low FS count, is situated in the township where the source of contamination is likely to be leaky septic tanks.

Results for all the northern area wells that indicated a positive result for FIB are detailed in Table 9.

Table 9 Wells in the northern OCWMB area that recorded a positive result for FIB

Land use	Well unit number	FC (/100 mL)	FS (/100 mL)	FC:FS	Depth of hole (m)	Lithology description at total depth of hole	Production zone (m)
Bridgewater chicken sheds	6628-13802	3	1	3	147	sandstone	56–147
Echunga effluent pond	6627-6395	0	72		101.5	unknown	5.5–101.5
Lobethal abattoir	6628-10476	0	9		56	unknown	6.1–56
Mylor unsewered	6627-2803	0	4		100	unknown	85.7–100
Mylor unsewered	6627-2806	18	33	0.5	41.2	unknown	–
Mylor unsewered	6627-6016	0	5		30.5	unknown	30.3–30.5
Mylor unsewered	6627-7212	0	8		80	unknown	16–80
Mylor unsewered	6627-7302	0	4		34.8	unknown	–
Mylor unsewered	6627-7356	0	4		41	unknown	36–41
Piccadilly FIB	6628-6583	0	8		29	sandstone	–
Piccadilly FIB	6628-6742	0	10		91.37	sandstone	39.29–91.37
Piccadilly FIB	6628-6776	0	8		39.01	unknown	18.6–39.01
Southern Mt Lofty FIB	6628-10285	0	4		50.9	unknown	6.1–50.9
Southern Mt Lofty FIB	6628-10626	1	>200	0.005	60.96	quartzite	–
Southern Mt Lofty FIB	6628-15950	0	3		34.4	quartzite	13–34.4
Stirling unsewered	6627-2482	0	6		45.72	unknown	–
Stirling unsewered	6627-6097	0	9		26.82	unknown	–
Stirling unsewered	6627-8170	1	3	0.33	49.3	unknown	5.7–49.3
Stirling unsewered	6628-11171	28	220	0.127	25.7	unknown	–
Stirling unsewered	6628-6677	20	>100	0.2	98	unknown	36–98
Summertown unsewered	6628-6755	0	1		91.37	unknown	–
Summertown unsewered	6628-6862	16	1	16	120	unknown	91.44–120

Iron bacteria

Iron bacteria is a common problem in wells but is not considered a health hazard. Although iron bacteria is known to be endemic in some aquifers in most cases wells become contaminated from external sources such as infiltration of contaminated surface water or from contaminated drilling or maintenance equipment.

Iron bacteria metabolises soluble ferrous iron into insoluble ferric iron resulting in a reddish-brown gelatinous mass or biofilm comprised of bacteria, iron hydroxides and water. If left untreated the biofilm will grow and block wells, pumps and pipelines affecting the well yield, pump efficiency and accuracy of mechanical meters.

Additionally, there appears to be a proportional relationship between water velocity and the rate of bacterial growth. Forward (2001) postulates that higher well velocities provide increased supply of nutrients.

A total of 88 wells were tested for FeB. The limit of detection for FeB is 10 cells/mL. Fifty per cent (44) of the tested wells indicated a cell count of equal to or greater than 10 cells/mL

Tables 10 and 11 list the wells with positive FeB results in the southern and northern OCWMB areas, respectively. The tables also indicate which of FeB positive wells are also FIB positive, which may suggest that, the FeB contamination could be a result of general bacterial contamination. Furthermore, the tables indicate whether the groundwater from the FeB contaminated wells is used for irrigation or stock and domestic purposes. If the groundwater is used for irrigation purposes it is likely that the pumping flow would be high and therefore may show a greater count of cells than that of the stock and domestic wells. The results reveal that the level of FeB contamination in the southern area is greater than in the northern area. This may be because more irrigation from groundwater occurs in the southern area, the environment favours higher FeB or drilling equipment may not have been adequately decontaminated between wells.

The results from Table 10 indicate that 48% of wells contaminated with FeB are also contaminated with FIB. The results from Table 11 indicate that 65% of wells contaminated with FeB are also contaminated with FIB.

These results show wells with high FIB contamination also have relatively high FeB, thus contamination maybe caused mainly by leaky septic tanks. This is also very evident in the Onkaparinga estuary sludge pond wells. Many of the wells with high FeB counts and low to no FIB counts are used for irrigation, supporting the theory that growth may be enhanced due to high velocity pumping.

Pesticides

Three wells (6627-3671, 6627-5163 and 6627-7482) situated down gradient from Kuitpo Forest were tested for a range of pesticides. The results indicate that no contamination from pesticides is currently detectable in these wells (App. 2).

Table 10 Wells in the southern OCWMB area contaminated with FeB and their relationship with FIB contamination and well purpose

Well unit number	Land use	FeB (/mL)	FC (/100 mL)	FS (/100 mL)	Well use[1]
6527-1017	Aldinga effluent pond	20	0	0	irr., obs.
6527-1077	Aldinga effluent pond	3200	0	0	irr.
6527-1189	Aldinga effluent pond	110	0	0	irr.
6527-1111	Aldinga unsewered	240 000	1600	520	obs.
6527-1183	Aldinga unsewered	10	4	0	dom., irr., stk
6527-1184	Aldinga unsewered	200	2	12	dom., stk
6527-1197	Aldinga unsewered	2700	5	100	drn
6627-2362	McLaren Vale wineries	40	not tested	not tested	irr.
6627-7436	McLaren Vale wineries	30	not tested	not tested	irr.
6627-9625	McLaren Vale wineries	2200	not tested	not tested	irr.
6527-1350	Old Noarlunga unsewered	700	1800	4800	obs.
6527-1096	Old Noarlunga unsewered	10 000	0	0	obs.
6627-3797	Old Noarlunga unsewered	150	0	0	–
6527-1364	Onkaparinga estuary sludge ponds	110 000	1000	200 000	–
6527-1366	Onkaparinga estuary sludge ponds	1100	0	560	–
6527-1363	Onkaparinga estuary sludge ponds	2300	10	74	–
6527-1367	Onkaparinga estuary sludge ponds	260	0	2200	–
6627-1544	Willunga effluent ponds	30	0	610	irr.
6627-6174	Willunga effluent ponds	170	0	0	irr.
6627-6984	Willunga effluent ponds	20	0	0	irr.
6627-8935	Willunga effluent ponds	50	0	2	irr.

1 drn, drainage; irr., irrigation; obs, observation; dom., domestic; stk, stock.

Table 11 Wells in the northern OCWMB area contaminated with FeB and their relationship with FIB contamination and well purpose

Well unit number	Land use	FeB (/mL)	FC (/100 mL)	FS (/100 mL)	Well use
6628-13802	Bridgewater chicken sheds	20	3	1	stk
6627-2803	Mylor unsewered	40	0	4	dom., irr.
6627-2806	Mylor unsewered	150	18	33	dom.
6627-7302	Mylor unsewered	10	0	0	irr.
6628-6583	Piccadilly FIB	700	0	8	dom.
6628-6776	Piccadilly FIB	10	0	8	irr.
6628-12023	Piccadilly wineries	10	not tested	not tested	irr.
6628-6854	Piccadilly wineries	10	not tested	not tested	gen.
6627-6091	Southern Mt Lofty FIB	10	0	0	–
6628-10285	Southern Mt Lofty FIB	90	0	4	irr.
6628-10366	Southern Mt Lofty FIB	20	0	0	irr.
6628-10626	Southern Mt Lofty FIB	50	1	200	gen.
6628-15950	Southern Mt Lofty FIB	10	0	3	dom./stk
6627-2482	Stirling unsewered	500	0	6	dom.
6627-2554	Stirling unsewered	880	0	0	–
6627-6097	Stirling unsewered	280	0	9	–
6627-7985	Stirling unsewered	10	0	0	dom.
6628-11171	Stirling unsewered	1100	28	220	dom.
6628-6677	Stirling unsewered	10	20	0	dom.
6628-6693	Stirling unsewered	30	0	0	gen.
6628-6755	Summertown unsewered	40	0	1	dom.
6628-6828	Summertown unsewered	3500	0	0	irr.
6628-6862	Summertown unsewered	20	16	1	irr.

1 dom., domestic; gen., general; irr., irrigation; obs, observation; stk, stock.

SUMMARY OF GROUNDWATER QUALITY RESULTS AND POSSIBLE CONTAMINANTS

INORGANIC CONSTITUENTS

It is evident from the first sampling that the inorganic constituents analysed in groundwater samples from the 89 selected wells did not exceed the NHMRC and ARMCANZ (1996) health guideline values. Although 85% of the wells analysed for TDS resulted in values greater than the aesthetic guideline values this is not necessarily due to contamination. There are many areas where groundwater is naturally saline or salinity is increasing due to stress on the aquifer from increased pumping. However leakage of saline water from deeper aquifers through deteriorating and leaking wells contaminating the shallow aquifer also cannot be overlooked.

ANTHROPOGENIC CONTAMINATION

Nutrients

- The principle form of N above the aesthetic guideline values is ammonium. Organic matter from the potential risk land-use areas such as unsewered areas, chicken sheds and sludge ponds will decay to ammonia under reducing conditions.

- There were no groundwater samples indicating levels of nitrite or nitrate above the health guideline values.
- Elevated levels of TOC were detected in wells in the Old Noarlunga unsewered and the Onkaparinga estuary sludge ponds areas.
- Phosphate levels are elevated in those wells with high levels of organic matter, particularly in the Onkaparinga estuary sludge ponds and Old Noarlunga unsewered land-use areas in the southern OWMCB area. Therefore the high phosphate levels are greater where contamination is a result of concentrated anthropogenic effluent.

Microbiology

- FIB were detected in 35 of the 76 wells sampled for FIB. The highest cell counts were recorded in Onkaparinga estuary sludge ponds, the unsewered Areas, Mount Lofty and Piccadilly FIB area and one well in the Bridgewater chicken sheds potential risk land-use area. These wells are believed to be contaminated by sludge waste, leaky septic tanks and/or livestock. It is assumed that the contamination of the two positive FIB wells in the Willunga and Aldinga effluent pond land-use area and one in the Lobethal abattoir land-use area are from diffuse sources.
- The presence of FIB in groundwater indicates the potential for the transmission of gastrointestinal-borne pathogens when untreated groundwater is used as a drinking source
- The presence of iron bacteria in wells, although not a health hazard, can be an indication of anthropogenic contamination. Results showed that those wells with a high count of FIB cells also had a relatively high count of FeB. However, some wells had a high count of FeB and no FIB contamination. It is believed this could be a result of increased bacterial growth due to high velocity pumping.

Pesticides

- Three wells down gradient from the Kuitpo Forest were analysed with negative results.

CONCLUSIONS

The objectives of the first stage of the program were achieved by identifying areas where shallow groundwater aquifers are potentially threatened by point-source pollution and selecting suitable bores where possible to sample the groundwater.

It is evident that the main causes of groundwater contamination from point-source pollution from targeted areas in the OCWMB area are mainly effluent from leaky septic tanks in unsewered area and seepage from the Onkaparinga estuary sludge ponds. Other unknown sources of contamination are possibly due to non-point sources such as animal waste.

Wineries

No groundwater contamination was detected in any of the wells sampled in the winery land-use category. However, there was a difficulty establishing suitable wells down gradient of winery effluent ponds or dispersal areas. The selected wells do not cover the risk area effectively. More investigation and subsequent drilling will be required to adequately capture and assess these risk areas.

Unsewered areas

There were wells within all of the selected unsewered areas - Mylor, Stirling, Summertown, Aldinga and Old Noarlunga - which show positive results for FIB. These wells were mainly situated within urban areas or townships and it is therefore believed that these wells have been contaminated by leaky septic tanks. Some of the well owners in Mylor drink their groundwater because there is no reticulated water. The results show that there is a potential health risk for domestic groundwater users in this area. There are some contaminated wells within this potential risk area that are not directly related to urban areas. In these cases contamination could be a result of diffuse source pollution from animals.

Abattoirs

Two wells sampled in this category showed positive to FIB. One, in the Lobethal abattoir land-use area, is the first well down gradient from the abattoir. The well is some distance from the abattoir and situated very close to a creek. It is highly likely the source of contamination is from a diffuse pollution source like wastes from grazing animals. The other well was within the Old Noarlunga abattoir land-use area. This well showed a low FIB count, which may be a result of the waste from the fish farming land-use activity or remnant contamination from the previous abattoir activity.

Southern Mount Lofty FIB and Piccadilly FIB

The wells in these categories were selected because they showed positive FIB in the BRS Groundwater Quality Assessment Southern Mount Lofty Project (Radke et al., 2000) and the AGSO Groundwater Quality Assessment Piccadilly Valley (Ivkovic et al., 1998). The contamination source for these wells is diffuse. However, it is very likely the Piccadilly wells are contaminated by leaky septic tanks. When comparing the results it is evident there has been a general reduction of FIB contamination.

Effluent pond and sludge ponds

Two wells showed positive results within the effluent pond land-use areas. The positive well sampled for the Echunga effluent pond category is situated near a dam where cattle gather and therefore, the contamination is more likely to be from the cattle. The positive well tested in the Aldinga Effluent category may be a result of leakage from the effluent pond.

All the wells tested around the Onkaparinga estuary sludge ponds showed moderate to high FIB counts which is most likely a result of seepage of the sludge leachate into the groundwater.

Forest plantations

The three wells that were sampled down gradient of the Kuitpo forest revealed no groundwater contamination by pesticides.

Chicken sheds

Only the Bridgewater chicken shed wells were sampled in this category. One well showed FIB and is situated between two sheds. It is possible that the contamination of the groundwater from this well is the result of chicken effluent.

RECOMMENDATIONS

It is recommended that:

- The following wells (Table 12) be included in the ongoing monitoring program for the shallow aquifer system in the OCWMB area.

Table 12 Sample points to retain for the ongoing monitoring program of the shallow aquifer system in the OCWMB area

Potential risk land-use activity	Well unit number	Comments
Aldinga effluent pond	6527-1023	
Aldinga unsewered	6527-1111 6527-1183 6527-1184 6527-1197	It is recommended that all wells that showed a positive FIB result be included in the ongoing monitoring program. Resampling of 6527-1183 recommended to establish a FC count.
McLaren Vales wineries	No Wells	No contamination was revealed apart from iron bacteria.
Old Noarlunga abattoir	6627-10034	
Old Noarlunga unsewered	6527-1350	
Onkaparinga estuary sludge ponds	6527-1364 6527-1365 6527-1366 6527-1363 6527-1367	High level FIB contamination. Recommended that it is included in the ongoing monitoring program.
Willunga effluent pond	6627-8935	
Bridgewater chicken sheds	6628-13802	Investigate waste source — may be human.
Echunga effluent pond	6627-6395	Include another sample point up gradient.
Lobethal abattoir	6628-10476 6628-10489	Although well 6628-10489 shows no contamination continued sampling is recommended because it is down gradient to 6628-10476.
Mylor unsewered	6627-2803 6627-2806 6627-6016 6627-7212 6627-7302 6627-7356 6627-2807	It is recommended that all the wells in the township continue to be sampled.
Piccadilly FIB	6628-6583 6628-6742 6628-6776	The level of contamination has decreased in these wells since the 1994 sampling. Therefore it is recommended that these wells be included in the ongoing program.
Piccadilly wineries	No wells	No contamination was revealed apart from a low count on iron bacteria.
Southern Mount Lofty FIB	6628-10285 6628-10626 6628-15950	The level of contamination of these wells has decreased. Only three well now show positive results. It is recommended that these wells be included in the ongoing program.
Stirling unsewered	6627-2482 6627-6097 6628-6677 6627-8170 6628-11171	It is recommended that all wells that showed a positive FIB result be included in the ongoing monitoring program.
Summertown unsewered	6628-6755 6628-6862	It is recommended that all wells that showed a positive FIB result be included in the ongoing monitoring program. Investigate origin of FIB contamination in well 6628-6862.

- Owners of the positive FIB wells be made aware of the contamination and warned that drinking the bore water could cause serious health problems.
- All well owners be sent a copy of the water quality results for their well.
- The wells within the fractured rock system in the Mylor township unsewered area should continue to be monitored. As there is no mains water system to the township some well owners use the groundwater for drinking and, as five out of the six township wells showed a positive result, there is a potential health risk.
- Ensure Environment Protection Authority and SA Water are aware of the contamination to the groundwater around the Onkaparinga estuary sludge pond. Investigate the reasons why groundwater contamination is occurring and sample river water upstream and downstream of the sludge pond to establish whether the contaminated water is discharging into the river.
- Further sample points required near Aldinga effluent pond and investigate the contamination source for positive FIB in well 6527-1023.
- Groundwater sampling points be established down hydraulic gradient of all intensive livestock land-use activities within the catchment.
- A sampling point between the well and the Echunga effluent pond be established because the well showed positive FIB contamination thought to be due to animal wastes. A well exists in the same property but requires some maintenance to remove the disused pump that is still down the hole.
- Petrol retail outlets with underground petrol storage tanks that are greater than 20 years old or defective sales:purchase ratio be identified. Sampling points within 100 m down hydraulic gradient from these underground storage tanks should be established and included in the ongoing sampling program.
- Areas where mines are active or where mines are no longer active but have not been properly rehabilitated be identified. Sampling points should be established down hydraulic gradient of the mine site land-use activities and included in the ongoing monitoring program.
- Landowners should be encouraged to appropriately backfill disused wells on their property to prevent contamination.
- To provide evidence of origin of the inorganic parameters, chloride, total sulphate, total nitrogen and bicarbonate should be included in future sampling analyte suites.
- Investigate whether waste water was discharged in the Aldinga Scrub Reserve area in the past. Establish time and volumes discharged.
- Further investigation is required to establish the source of FIB contamination in wells in the Mount Lofty FIB and Piccadilly FIB categories.
- Where upward leakage may be a problem from cross contamination resulting from casing corrosion, old unused wells should be appropriately backfilled and abandoned.

APPENDIXES

1 SELECTED SAMPLE POINTS WITHIN POTENTIAL RISK AREAS, OCWMB AREA

Southern OCWMB

Map Sheet no.	Bore Number	Easting	Northing	Land use	Aquifer lithology	Aquifer type	Total depth (m)	Production zone (m)	Production Zone To	Completion date	Well use[1]	Standing water level (m)	Latest observation date
6527	1017	269041	6090976	Aldinga effluent pond	coral	sedimentary	37	21	37	9.11.1983	obs.	14.14	27.06.2001
6527	1023	270671	6091978	Aldinga effluent pond	limestone and coral, sandy.	sedimentary	49	32	49	11.04.1984	irr.	18.4	11.04.1984
6527	1077	270141	6091619	Aldinga effluent pond	limestone and corals with sands.	sedimentary	47	31.5	47	8.09.1989	irr.	15	8.09.1989
6527	1189	270698	6091212	Aldinga effluent pond	coarse sand	sedimentary	56	35	56	8.11.1994	irr.	15	8.11.1994
6527	559	269992	6092209	Aldinga unsewered	–	–	35.05			18.05.1970	irr.	16.76	18.05.1970
6527	1111	269536	6091664	Aldinga unsewered	–	–	16.2	14.2	16.2	25.03.1988	obs.	14.4	25.03.1988
6527	1183	271220	6094732	Aldinga unsewered	soft marly limestone	sedimentary	29.4	16	29.4	26.10.1994	dom., irr., stk	3.4	26.10.1994
6527	1184	271192	6094768	Aldinga unsewered	marly clay	sedimentary	14	8	14	26.10.1994	dom., stk	2.3	26.10.1994
6527	1197	269771	6093057	Aldinga unsewered	hard and soft layers of limestone	sedimentary	55	32.5	55	26.05.1994	drn	20.6	26.05.1994
6627	3671	287728	6105178	Kuitpo Forest	–	–	35.05	–	–	31.07.1972	irr.	3.66	30.05.1973
6627	5163	291819	6108080	Kuitpo Forest	–	–		–	–	26.11.1976	irr., stk	0	26.11.1976
6627	7482	288094	6107076	Kuitpo Forest	grey slate and quartzite	fractured rock	45.5	12	45.5	19.12.1985	irr.	6.5	19.12.1985
6627	2362	278987	6100966	McLaren Vale wineries	–	–	4.3			11.01.1972	irr.	0.66	11.01.1972
6627	3834	281222	6103249	McLaren Vale wineries	–	–				21.07.1950	irr.	0.61	21.07.1950
6627	6363	278530	6100955	McLaren Vale wineries	–	–	6.5	6	6.5	1.08.1980	irr.	1	1.08.1980
6627	7436	278053	6103023	McLaren Vale wineries	coarse white gravel	sedimentary	43	33.5	37.3	6.09.1985	irr.	17	6.09.1985
6627	9625	277314	6101490	McLaren Vale wineries	lignite clay	sedimentary	36	12	36	3.09.1997	irr.	7.1	3.09.1997
6627	9731	275938	6100637	McLaren Vale wineries	sand–gravel	sedimentary	47	36	41.5	6.02.1998	irr.	26.2	6.02.1998
6627	10034	272863	6104650	Old Noarlunga abattoir	hard brown-blue rock	fractured rock	146	36	146	7.04.1999	ind.	25	7.04.1999
6527	1350	272321	6103624	Old Noarlunga unsewered	–	–	6.9			15.02.1990	obs.	4.15	15.02.1990
6527	1096	272102	6103690	Old Noarlunga unsewered	–	–	9			15.02.1990	obs.	4.74	15.02.1990
6627	3797	277096	6105491	Old Noarlunga unsewered	–	–	64	18.29	64	7.05.1973	–	–	–
6527	1363	671232	6106663	Onkaparinga estuary sludge ponds	–	–	–	–	–	28.03.2001	–	–	–
6527	1364	271561	6106676	Onkaparinga estuary sludge ponds	–	–	–	–	–	30.03.2001	–	–	–

Map Sheet no.	Bore Number	Easting	Northing	Land use	Aquifer lithology	Aquifer type	Total depth (m)	Production zone (m)	Production Zone To	Completion date	Well use[1]	Standing water level (m)	Latest observation date
6527	1365	271846	6106666	Onkaparinga estuary sludge ponds	–	–	–	–	–	28.03.2001	–	–	–
6527	1366	271549	6106689	Onkaparinga estuary sludge ponds	–	–	–	–	–	28.03.2001	–	–	–
6527	1367	271436	6106591	Onkaparinga estuary sludge ponds	–	–	–	–	–	28.03.2001	–	–	–
6627	1544	276301	6094532	Willunga effluent ponds	yellow sandstone, shells, grey clay.	sedimentary	70.71	65.18	66.45	12.04.1969	irr.	31.09	3.07.1969
6627	6174	275189	6094985	Willunga effluent ponds	hard limed sandstone with soft areas and few shells when developing.	sedimentary	49.4	42.7	49.4	30.11.1976	irr.	6	30.11.1976
6627	6984	276162	6094576	Willunga effluent ponds	–	–	71	68	71	3.02.1984	irr.	29	3.02.1984
6627	8935	274885	6095017	Willunga effluent ponds	limestone coral	sedimentary	64	42	64	19.05.1994	irr.	7.5	19.05.1994

1 drn., drainage; gen., general; ind., industry; irr., irrigation; obs., observation; dom., domestic; stk., stock.

Northern OCWMB

Map Sheet no.	Bore Number	Easting	Northing	Land use	Aquifer lithology	Aquifer type	Total depth (m)	Production zone (m)	Production Zone To	Completion date	Well use[1]	Standing water level (m)	Latest observation date
6628	6704	296070	6125238	Bridgewater chicken shed	–	–	45.7	2.13	45.7	1.07.1971	stk, dom.	15.6	2.05.1978
6628	13802	296190	6125285	Bridgewater chicken shed	hard rock	fractured rock	147	56	147	3.10.1986	stk	1	3.10.1986
6627	6395			Echunga effluent pond	–	–	–	–	–	–	–	–	–
6627	6399	298155	6115820	Echunga effluent pond	–	–	–	–	–	16.02.1982	dom., stk	32.1	16.02.1982
6628	10476	306761	6134956	Lobethal abattoir	–	–	56	6.1	56	15.01.1968	stk, irr.	11.91	10.07.1969
6628	10489	307160	6134704	Lobethal abattoir	–	–	25.91	9.14	25.91	9.02.1953	irr.	0	10.07.1969
6628	10514	306678	6135924	Lobethal abattoir	–	–	42.37	9.14	42.37	1.01.1953	irr.	13	28.11.1978
6627	2803	295641	6119862	Mylor unsewered	–	–	100	85.7	100	3.08.1982	dom., irr.	2.2	3.08.1982
6627	2806	295505	6120006	Mylor unsewered	–	–	41.2	–	–	4.08.1982	–	–	–
6627	2807	295666	6120046	Mylor unsewered	–	–	6.35	–	–	14.01.1970	dom.	0.3	29.07.1982
6627	4206	295368	6119051	Mylor unsewered	–	–	47	–	–	9.09.1977	dom.	4.5	9.09.1977
6627	6016	295724	6119707	Mylor unsewered	–	–	30.5	–	–	8.05.1979	irr.	2.5	8.05.1979
6627	6052	295371	6118917	Mylor unsewered	–	–	37.5	–	–	30.11.1979	dom.	2.8	30.11.1979
6627	7212	295512	6120024	Mylor unsewered	–	–	80	16	80	6.12.1984	irr.	24	6.12.1984
6627	7302	295759	6119767	Mylor unsewered	–	–	34.8	–	–	25.01.1985	irr.	3.3	25.01.1985
6627	7335	295330	6118992	Mylor unsewered	–	–	53	–	–	9.04.1985	dom.	14	9.04.1985
6627	7356	295636	6119982	Mylor unsewered	–	–	41	36	41	12.04.1985	dom.	2	12.04.1985
6627	8687	295806	6117908	Mylor unsewered	–	–	108.8	23.7	108.8	5.01.1993	irr.	15.5	26.01.1993
6628	6583	292143	6125641	Piccadilly FIB	–	–	29	–	–	12.07.1950	dom.	16.6	18.04.1983
6628	6742	292561	6128298	Piccadilly FIB	sand and quartz seams	fractured rock	91.37	–	–	26.06.1930	–	–	–
6628	6776	293419	6128517	Piccadilly FIB			39.01	18.6	39.01	7.05.1970	irr.	6.46	7.05.1970
6628	12429	292732	6127006	Piccadilly FIB	blue grey slate	fractured rock	96	20.4	96	8.08.1982	irr.	7.62	8.08.1982
6628	6711	293223	6126647	Piccadilly wineries	–		28.96	12.79	28.94	29.05.1952	dom., irr.	3.05	29.05.1952
6628	6844	293008	6126594	Piccadilly wineries	–		54.82			1.01.1950			
6628	6854	293356	6126442	Piccadilly wineries	–		129	12.95	129	4.10.1982	gen.	0.5	4.10.1982
6628	12023	292996	6126530	Piccadilly wineries	grey and white rock	fractured rock	136	30	136	2.07.1982	irr.	18	2.07.1982
6627	6091	293695	6122272	Southern Mount Lofty FIB	–		63	37.8	63	20.11.1991			
6627	7005	298259	6124142	Southern Mount Lofty FIB	–		14			2.03.1984	irr.	2.5	2.03.1984
6628	10244	309362	6132652	Southern Mount Lofty FIB	hard blue rock	fractured rock	79.4	62.5	79.4	13.03.1980	dom., irr., stk	53.2	13.03.1980
6628	10285	304747	6135227	Southern Mount Lofty FIB	–		50.9	6.1	50.9	17.07.1969	irr.	0.91	17.07.1969
6628	10361	301967	6135759	Southern Mount Lofty FIB	–		64.3	7	64.3	20.06.1974	irr., stk	4.57	20.06.1974

Map Sheet no.	Bore Number	Easting	Northing	Land use	Aquifer lithology	Aquifer type	Total depth (m)	Production zone (m)	Production Zone To	Completion date	Well use[1]	Standing water level (m)	Latest observation date
6628	10366	301818	6135293	Southern Mount Lofty FIB	slate	fractured rock	154	100	154	18.01.1992	irr.	61	18.01.1992
6628	10626	304203	6130887	Southern Mount Lofty FIB	quartzite, some quartz	fractured rock	92.3	59.4	92.3	4.01.1995	gen.	8	4.01.1995
6628	14504	303225	6127035	Southern Mount Lofty FIB	–		74	59.6	74	2.02.1989	irr.	6	14.03.1989
6628	15950	297834	6127234	Southern Mount Lofty FIB	quartzite, slate	fractured rock	34.4	13	34.4	27.02.1992	dom., stk	5.3	27.02.1992
6627	2482	296014	6123579	Stirling unsewered	–					16.03.1953	dom.	3.8	6.12.1979
6627	2554	292632	6122907	Stirling unsewered	–					29.03.1951			
6627	2695	292609	6123801	Stirling unsewered	–		36.88	3.05	36.88	28.03.1951			
6627	6097	293823	6122456	Stirling unsewered	–		26.82						
6627	7985	297068	6123301	Stirling unsewered	–		90.5	23.7	90.5	10.01.1989	dom.	14	10.01.1989
6627	8170	293536	6122740	Stirling unsewered	–		49.3	5.7	49.3	10.02.1990	dom., stk	0	1.03.1990
6627	8296	293715	6122502	Stirling unsewered	blue-grey Aldgate Sandstone with quartz seams	fractured rock	89	17.2	89	27.09.1990	dom.	-0.3	27.09.1990
6627	9853	297133	6123235	Stirling unsewered	sandstone	fractured rock	140.8	–	–	10.09.1998	dom.	9	10.09.1998
6627	10379	297500	6123399	Stirling unsewered	–	–	–	–	–	–	–	–	–
6628	6677	292660	6125536	Stirling unsewered	quartzite	fractured rock	98	36	98	9.12.1982	–	–	–
6628	6693	293246	6125732	Stirling unsewered	–	–	2	–	–	1.01.1910	–	–	–
6628	11171	291421	6124752	Stirling unsewered	–	–	25.7	–	–	21.11.1979	dom.	1.5	21.11.1979
6628	6755	292708	612894	Summertown unsewered	–	–	91.37	–	–	3.03.1976	–	–	–
6628	6777	293479	6128429	Summertown unsewered	–	–	1.5	–	–	26.05.1978	–	–	–
6628	6793	294354	6129219	Summertown unsewered	–	–	70	33.5	70	30.03.1978	gen.	3.97	30.03.1978
6628	6796	294477	3129026	Summertown unsewered	–	–	76.15	12.79	52.73		irr	16.54	23.01.1974
6628	6813	292625	6127875	Summertown unsewered	–	–	70.05			14.01.1974	–	–	–
6628	6815	292853	6127810	Summertown unsewered	–	–	36.55	30.46	36.55	1.01.1958	–	–	–
6628	6826	293062	6128000	Summertown unsewered	–	–	45.69	15.23	45.69	1.01.1960	–	–	–
6628	6828	293067	6127680	Summertown unsewered	–	–	120			8.01.1974	irr	1.77	4.12.2000
6628	6862	293714	6127932	Summertown unsewered	–	–	91.44	4.57	91.44	1.01.1969	irr.	1.45	4.12.2000
6628	12141	293105	6129038	Summertown unsewered	sandstone, blue rock, white quartzite	fractured rock	133	48.7	133	11.11.1982	dom.	30	11.11.1982
6628	12539	294256	6129205	Summertown unsewered	hard grey sandstone, some pyrites	fractured rock	64.3	30	64.3	1.11.1983	irr.	3	1.11.1983

1 drn., drainage; gen., general; ind., industry; irr., irrigation; obs., observation; dom., domestic; stk., stock.

2 SOUTHERN OCWMB AREA — RESULTS OF CHEMICAL ANALYSIS

General data, cations and anions

Well unit number	*Sample date*	**Land use**	**TDS (by EC)** (mg/L)	**TOC** (mg/L)	**Electrical conductivity** (*u*S/cm)	**Potassium cation** (mg/L)	**Sulphate anion** (mg/L)
6527-1017	13.03.2001	Aldinga effluent pond	1500	0.4	2730	–	–
6527-1023	20.03.2001	Aldinga effluent pond	1700	0.5	3040	–	–
6527-1077	13.03.2001	Aldinga effluent pond	1800	0.5	3170	–	–
6527-1189	13.03.2001	Aldinga effluent pond	1600	0.3	2820	–	–
6527-559	13.03.2001	Aldinga unsewered	1100	<0.3	1900	–	–
6527-1111	13.03.2001	Aldinga unsewered	3300	119	5910	–	–
6527-1183	20.03.2001	Aldinga unsewered	1800	0.9	3220	–	–
6527-1184	20.03.2001	Aldinga unsewered	2100	1.4	3800	–	–
6527-1197	20.03.2001	Aldinga unsewered	82	4.8	149	–	–
6627-2362	14.03.2001	McLaren Vale wineries	1100	0.8	1970	6	91.5
6627-3834	14.03.2001	McLaren Vale wineries	680	0.9	1230	6.7	97.5
6627-6363	14.03.2001	McLaren Vale wineries	1400	0.5	2440	6.5	127
6627-7436	14.03.2001	McLaren Vale wineries	720	<0.3	1300	2.9	62.3
6627-9625	14.03.2001	McLaren Vale wineries	1300	1.2	2330	12.3	133
6627-9731	20.03.2001	McLaren Vale wineries	1500	1.7	2700	8	142
6627-10034	20.03.2001	Old Noarlunga abattoir	2200	1.1	4030	–	–
6527-1350	14.03.2001	Old Noarlunga unsewered	11 000	251	18 800	–	–
6527-1096	14.03.2001	Old Noarlunga unsewered	24 000	113	38 500	–	–
6627-3797	29.03.2001	Old Noarlunga unsewered	1300	0.3	2320	–	–
6527-1364	30.03.2001	Onkaparinga estuary sludge ponds	12 000	55	20 300	–	–
6527-1365	30.03.2001	Onkaparinga estuary sludge ponds	4500	56	7940	–	–
6527-1366	30.03.2001	Onkaparinga estuary sludge ponds	9600	13.4	16500	–	–
6527-1363	30.03.2001	Onkaparinga estuary sludge ponds	23 000	28	37 000	–	–
6527-1367	30.03.2001	Onkaparinga estuary sludge ponds	5500	23	9680	–	–
6627-1544	13.03.2001	Willunga effluent ponds	950	0.7	1720	–	–
6627-6174	14.03.2001	Willunga effluent ponds	1100	0.3	1920	–	–
6627-6984	13.03.2001	Willunga effluent ponds	900	0.5	1630	–	–
6627-8935	13.03.2001	Willunga effluent ponds	870	0.6	1580	–	–
6627-3671	12.03.2001	Kuitpo Forest	710	–	1290	–	–
6627-5163	12.03.2001	Kuitpo Forest	2600	–	4570	–	–
6627-7482	27.03.2001	Kuitpo Forest	1100	–	2000	–	–

Nutrients

Well unit number	*Sample date*	Land use	NH_3 as N (mg/L)	NO_3 as N (mg/L)	NO_2 as N (mg/L)	PO_4 total as P (mg/L)	NO_3+NO_2 as N (mg/L)	NO_3+NO_2 as NO_3 (mg/L)
6527-1017	13.03.2001	Aldinga effluent pond	0.005	0.23	<0.005	0.016	0.235	1.04
6527-1023	20.03.2001	Aldinga effluent pond	0.012	0.716	<0.005	0.006	0.721	3.19
6527-1077	13.03.2001	Aldinga effluent pond	0.008	0.151	<0.005	0.015	0.156	0.69
6527-1189	13.03.2001	Aldinga effluent pond	0.005	0.792	<0.005	0.011	0.796	3.53
6527-559	13.03.2001	Aldinga unsewered	0.005	0.354	<0.005	0.02	0.359	1.59
6527-1111	13.03.2001	Aldinga unsewered	3.27	5.07	0.195	0.091	5.26	23.3
6527-1183	20.03.2001	Aldinga unsewered	0.005	3.24	0.005	0.008	3.24	14.4
6527-1184	20.03.2001	Aldinga unsewered	0.012	3.95	<0.005	0.048	3.96	17.5
6527-1197	20.03.2001	Aldinga unsewered	0.133	0.006	<0.005	0.204	0.011	0.05
6627-2362	14.03.2001	McLaren Vale wineries	0.01	3.02	<0.005	0.006	3.03	13.4
6627-3834	14.03.2001	McLaren Vale wineries	0.05	0.001	<0.005	0.028	0.006	0.02
6627-6363	14.03.2001	McLaren Vale wineries	<0.01	0.758	<0.005	0.008	0.763	3.38
6627-7436	14.03.2001	McLaren Vale wineries	<0.01	0.698	<0.005	<0.005	0.702	3.11
6627-9625	14.03.2001	McLaren Vale wineries	0.07	1.08	<0.005	0.041	1.09	4.81
6627-9731	20.03.2001	McLaren Vale wineries	0.1	0	<0.005	0.023	<0.005	0.02
6627-10034	20.03.2001	Old Noarlunga abattoir	0.056	0.003	<0.005	0.013	0.008	0.04
6527-1350	14.03.2001	Old Noarlunga unsewered	1.72	0.003	<0.005	1.7	0.008	0.04
6527-1096	14.03.2001	Old Noarlunga unsewered	5.04	0.095	0.02	0.078	0.115	0.51
6627-3797	29.03.2001	Old Noarlunga unsewered	0.005	2.51	<0.005	0.007	2.52	11.2
6527-1364	30.03.2001	Onkaparinga estuary sludge ponds	20.5	0.002	0.007	2.34	0.009	0.04
6527-1365	30.03.2001	Onkaparinga estuary sludge ponds	140	0.002	0.007	0.52	0.008	0.04
6527-1366	30.03.2001	Onkaparinga estuary sludge ponds	5.66	0.363	<0.005	0.48	0.368	1.63
6527-1363	30.03.2001	Onkaparinga estuary sludge ponds	32.2	0	<0.005	1.4	<0.005	0.02
6527-1367	30.03.2001	Onkaparinga estuary sludge ponds	193	0.016	<0.005	0.78	0.021	0.09
6627-1544	13.03.2001	Willunga effluent ponds	0.005	1.78	<0.005	0.01	1.79	7.93
6627-6174	14.03.2001	Willunga effluent ponds	0.013	1.88	<0.005	0.015	1.88	8.35
6627-6984	13.03.2001	Willunga effluent ponds	<0.005	3.26	<0.005	0.012	3.26	14.5
6627-8935	13.03.2001	Willunga effluent ponds	<0.005	1.45	<0.005	0.012	1.46	6.46
6627-3671	12.03.2001	Kuitpo Forest		0.003	<0.005	0.037	0.008	0.04
6627-5163	12.03.2001	Kuitpo Forest		0.189	<0.005	0.022	0.194	0.86
6627-7482	27.03.2001	Kuitpo Forest		0	<0.005	0.006	<0.005	0.02

Microbiological

Well unit number	*Sample date*	Land use	FeB (/mL)	FC (/100mL)	E.coli (/100ml)	FS (/100mL)	Enterococcus spp. (/100mL)
6527-1017	13.03.2001	Aldinga effluent pond	20	0	0	0	0
6527-1023	20.03.2001	Aldinga effluent pond	<10	0	0	7	7
6527-1077	13.03.2001	Aldinga effluent pond	3200	0	0	0	0
6527-1189	13.03.2001	Aldinga effluent pond	110	0	0	0	0
6527-559	13.03.2001	Aldinga unsewered	<10	0	0	0	0
6527-1111	13.03.2001	Aldinga unsewered	240 000	1600	550	520	520
6527-1183	20.03.2001	Aldinga unsewered	10	4	4	0	0
6527-1184	20.03.2001	Aldinga unsewered	200	2	2	12	12
6527-1197	20.03.2001	Aldinga unsewered	2700	5	5	>100	>100
6627-2362	14.03.2001	McLaren Vale wineries	40	–	–	–	–
6627-3834	14.03.2001	McLaren Vale wineries	<10	–	–	–	–
6627-6363	14.03.2001	McLaren Vale wineries	<10	–	–	–	–
6627-7436	14.03.2001	McLaren Vale wineries	30	–	–	–	–
6627-9625	14.03.2001	McLaren Vale wineries	2200	–	–	–	–
6627-9731	20.03.2001	McLaren Vale wineries	<10	–	–	–	–
6627-10034	20.03.2001	Old Noarlunga abattoir	<10	0	0	2	2
6527-1350	14.03.2001	Old Noarlunga unsewered	700	>1800	>1800	>4800	>4800
6527-1096	14.03.2001	Old Noarlunga unsewered	10 000	0	0	0	0
6627-3797	29.03.2001	Old Noarlunga unsewered	150	0	0	0	0
6527-1364	30.03.2001	Onkaparinga estuary sludge ponds	110 000	1000	1000	200 000	200000
6527-1365	30.03.2001	Onkaparinga estuary sludge ponds	<10	0	0	560	560
6527-1366	30.03.2001	Onkaparinga estuary sludge ponds	1100	0	0	74	74
6527-1363	30.03.2001	Onkaparinga estuary sludge ponds	2300	10	10	2200	2200
6527-1367	30.03.2001	Onkaparinga estuary sludge ponds	260	0	0	610	610
6627-1544	13.03.2001	Willunga effluent ponds	30	0	0	0	0
6627-6174	14.03.2001	Willunga effluent ponds	170	0	0	0	0
6627-6984	13.03.2001	Willunga effluent ponds	20	0	0	0	0
6627-8935	13.03.2001	Willunga effluent ponds	50	0	0	2	2
6627-3671	12.03.2001	Kuitpo Forest	–	–	–	–	–
6627-5163	12.03.2001	Kuitpo Forest	–	–	–	–	–
6627-7482	27.03.2001	Kuitpo Forest	–	–	–	–	–

Pesticides

Well unit number	Sample date	Land use	Simazine (ug/L)	Atrazine (ug/L)	Azinphos-Methyl (ug/L)	Diazinon (ug/L)	Fenitrothion (ug/L)	Hexazinone (ug/L)	Malathion (ug/L)	Parathion (ug/L)	Parathion -methyl (ug/L)	Prometryne (ug/L)
6627-3671	12.03.2001	Kuitpo Forest	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5
6627-5163	12.03.2001	Kuitpo Forest	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5
6627-7482	27.03.2001	Kuitpo Forest	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5

3 NORTHERN OCWMB AREA — RESULTS OF CHEMICAL ANALYSIS

General data, cations and anions

Well unit number	*Sample date*	Land use	TDS (by EC) (mg/L)	TOC (mg/L)	Electrical conductivity (*u*S/cm)	Potassium cation (mg/L)	Sulphate anion (mg/L)
6628-6704	29.03.2001	Bridgewater chicken shed	250	<0.3	464	–	–
6628-13802	29.03.2001	Bridgewater chicken shed	210	<0.3	920	–	–
6627-6395	9.03.2001	Echunga effluent pond	2400	0.6	4290	–	–
6627-6399	9.03.2001	Echunga effluent pond	2700	1.1	4830	–	–
6628-10476	9.03.2001	Lobethal abattoir	630	0.7	1140	–	–
6628-10489	9.03.2001	Lobethal abattoir	690	0.5	1250	–	–
6628-10514	9.03.2001	Lobethal abattoir	1000	1.1	1830	–	–
6627-2803	8.03.2001	Mylor unsewered	260	0.3	476	–	–
6627-2806	8.03.2001	Mylor unsewered	160	<0.3	285	–	–
6627-2807	12.03.2001	Mylor unsewered	230	<0.3	426	–	–
6627-4206	8.03.2001	Mylor unsewered	340	0.4	621	–	–
6627-6016	8.03.2001	Mylor unsewered	610	0.8	1110	–	–
6627-6052	8.03.2001	Mylor unsewered	970	0.4	1750	–	–
6627-7212	8.03.2001	Mylor unsewered	270	<0.3	492	–	–
6627-7302	30.03.2001	Mylor unsewered	520	1.9	949	–	–
6627-7335	8.03.2001	Mylor unsewered	570	0.5	1040	–	–
6627-7356	8.03.2001	Mylor unsewered	180	0.5	333	–	–
6627-8687	12.03.2001	Mylor unsewered	1700	0.9	3010	–	–
6628-6583	7.03.2001	Piccadilly FIB	100	0.6	185	–	–
6628-6742	9.03.2001	Piccadilly FIB	210	<0.3	375	–	–
6628-6776	7.03.2001	Piccadilly FIB	370	<0.3	671	–	–
6628-12429	7.03.2001	Piccadilly FIB	410	<0.3	749	–	–
6628-6711	19.03.2001	Piccadilly wineries	320	0.8	589	1.1	40.5
6628-6844	9.03.2001	Piccadilly wineries	340	<0.3	623	3.1	13.3
6628-6854	19.03.2001	Piccadilly wineries	510	0.4	930	4.4	41.6
6628-12023	9.03.2001	Piccadilly wineries	260	<0.3	470	2.3	9.9
6627-6091	15.03.2001	Southern Mount Lofty FIB	300	0.4	548	–	–
6627-7005	15.03.2001	Southern Mount Lofty FIB	400	<0.3	732	–	–
6628-10244	15.03.2001	Southern Mount Lofty FIB	870	0.4	1570	–	–
6628-10285	16.03.2001	Southern Mount Lofty FIB	650		1180	–	–

Well unit number	*Sample date*	Land use	TDS (by EC) (mg/L)	TOC (mg/L)	Electrical conductivity (*u*S/cm)	Potassium cation (mg/L)	Sulphate anion (mg/L)
6628-10361	16.03.2001	Southern Mount Lofty FIB	620	0.5	1120	–	–
6628-10366	16.03.2001	Southern Mount Lofty FIB	710	0.4	1290	–	–
6628-10626	16.03.2001	Southern Mount Lofty FIB	980	1.2	1780	–	–
6628-14504	15.03.2001	Southern Mount Lofty FIB	1100	2.4	2000	–	–
6628-15950	16.03.2001	Southern Mount Lofty FIB	270	0.9	490	–	–
6627-2482	6.03.2001	Stirling unsewered	470	0.9	858	–	–
6627-2554	5.03.2001	Stirling unsewered	320	0.6	588	–	–
6627-2695	5.03.2001	Stirling unsewered	390	0.6	708	–	–
6627-6097	5.03.2001	Stirling unsewered	340	0.6	619	–	–
6628-6677	19.03.2001	Stirling unsewered	230	1	418	–	–
6628-6693	6.03.2001	Stirling unsewered	530	0.8	960	–	–
6627-7985	6.03.2001	Stirling unsewered	380	0.5	695	–	–
6627-8170	6.03.2001	Stirling unsewered	460	2.2	843	–	–
6627-8296	5.03.2001	Stirling unsewered	370	0.7	665	–	–
6627-9853	6.03.2001	Stirling unsewered	420	0.3	767	–	–
6627-10379	12.03.2001	Stirling unsewered	290	<0.3	520	–	–
6628-11171	6.03.2001	Stirling unsewered	170	0.5	317	–	–
6628-6755	7.03.2001	Summertown unsewered	290	<0.3	534	–	–
6628-6777	7.03.2001	Summertown unsewered	400	<0.3	727	–	–
6628-6793	7.03.2001	Summertown unsewered	210	0.3	387	–	–
6628-6796	6.03.2001	Summertown unsewered	380	<0.3	692	–	–
6628-6813	9.03.2001	Summertown unsewered	390	0.4	713	–	–
6628-6815	7.03.2001	Summertown unsewered	390	<0.3	701	–	–
6628-6826	7.03.2001	Summertown unsewered	400	<0.3	736	–	–
6628-6828	8.03.2001	Summertown unsewered	380	<0.3	694	–	–
6628-6862	8.03.2001	Summertown unsewered	240	<0.3	432	–	–
6628-12141	7.03.2001	Summertown unsewered	230	<0.3	425	–	–
6628-12539	6.03.2001	Summertown unsewered	380	0.3	697	–	–

Nutrients

Well unit number	*Sample date*	Land use	NH_3 as N (mg/L)	NO_3 as N (mg/L)	NO_2 as N (mg/L)	PO_4 total as P (mg/L)	NO_3+NO_2 as N (mg/L)	NO_3+NO_2 as NO_3 (mg/L)
6628-6704	29.03.2001	Bridgewater chicken shed	<0.005	7.29	<0.005	0.14	7.29	32.3
6628-13802	29.03.2001	Bridgewater chicken shed	<0.005	4.06	<0.005	0.308	4.07	18
6627-6395	9.03.2001	Echunga effluent pond	0.005	2.26	<0.005	0.025	2.26	10
6627-6399	9.03.2001	Echunga effluent pond	0.011	0.552	<0.005	0.022	0.557	2.47
6628-10476	9.03.2001	Lobethal abattoir	<0.005	0.531	<0.005	0.088	0.5836	2.38
6628-10489	9.03.2001	Lobethal abattoir	<0.005	0	<0.005	0.082	<0.005	0.02
6628-10514	9.03.2001	Lobethal abattoir	<0.005	0.074	<0.005	0.6	0.079	0.35
6627-2803	8.03.2001	Mylor unsewered	0.006	0	<0.005	<0.005	<0.005	0.02
6627-2806	8.03.2001	Mylor unsewered	0.005	0.379	<0.005	0.058	0.384	1.7
6627-2807	12.03.2001	Mylor unsewered	0.005	0.338	<0.005	0.017	0.343	1.52
6627-4206	8.03.2001	Mylor unsewered	0.005	0.023	0.007	<0.005	0.03	0.13
6627-6016	8.03.2001	Mylor unsewered	0.036	0	<0.005	0.021	<0.005	0.02
6627-6052	8.03.2001	Mylor unsewered	0.009	0.02	<0.005	0.018	0.025	0.11
6627-7212	8.03.2001	Mylor unsewered	<0.005	0.166	<0.005	0.056	0.171	0.76
6627-7302	30.03.2001	Mylor unsewered	0.031	0.02	<0.005	0.089	0.025	0.11
6627-7335	8.03.2001	Mylor unsewered	0.012	0.144	0.011	<0.005	0.155	0.69
6627-7356	8.03.2001	Mylor unsewered	<0.005	1.13	0.01	0.017	1.14	5.04
6627-8687	12.03.2001	Mylor unsewered	0.016	0.013	<0.005	0.024	0.018	0.08
6628-6583	7.03.2001	Piccadilly FIB	<0.005	0.667	<0.005	0.016	0.672	2.98
6628-6742	9.03.2001	Piccadilly FIB	0.005	6.84	<0.005	0.037	6.85	30.3
6628-6776	7.03.2001	Piccadilly FIB	<0.005	1.99	<0.005	0.079	2	8.84
6628-12429	7.03.2001	Piccadilly FIB	0.007	3.5	<0.005	0.05	3.51	15.5
6628-6711	19.03.2001	Piccadilly wineries	0.01	0.388	0.128	0.105	0.515	2.28
6628-6844	9.03.2001	Piccadilly wineries	0.01	0	<0.005	0.16	<0.005	0.02
6628-6854	19.03.2001	Piccadilly wineries	0.01	0.014	<0.005	0.174	0.019	0.08
6628-12023	9.03.2001	Piccadilly wineries	0.01	1.26	<0.005	0.28	1.26	5.6
6627-6091	15.03.2001	Southern Mount Lofty FIB	0.005	0.225	0.006	0.02	0.23	1.02
6627-7005	15.03.2001	Southern Mount Lofty FIB	<0.005	0.655	<0.005	0.029	0.66	2.92
6628-10244	15.03.2001	Southern Mount Lofty FIB	0.012	0.004	<0.005	0.886	0.009	0.04
6628-10285	16.03.2001	Southern Mount Lofty FIB	0.006	0.008	<0.005	0.03	0.013	0.06
6628-10361	16.03.2001	Southern Mount Lofty FIB	0.019	0	<0.005	0.02	<0.005	0.02
6628-10366	16.03.2001	Southern Mount Lofty FIB	0.014	0.06	<0.005	0.058	0.065	0.29
6628-10626	16.03.2001	Southern Mount Lofty FIB	0.017	0	<0.005	0.092	<0.005	0.02

Well unit number	*Sample date*	Land use	NH_3 as N (mg/L)	NO_3 as N (mg/L)	NO_2 as N (mg/L)	PO_4 total as P (mg/L)	NO_3+NO_2 as N (mg/L)	NO_3+NO_2 as NO_3 (mg/L)
6628-14504	15.03.2001	Southern Mount Lofty FIB	0.06	0	<0.005	0.01	<0.005	0.02
6628-15950	16.03.2001	Southern Mount Lofty FIB	0.005	0	<0.005	0.176	<0.005	0.02
6627-2482	6.03.2001	Stirling unsewered	0.011	0	<0.005	0.216	0.005	0.02
6627-2554	5.03.2001	Stirling unsewered	0.006	1.14	<0.005	0.302	1.14	5.07
6627-2695	5.03.2001	Stirling unsewered	0.006	0.009	<0.005	0.047	0.014	0.06
6627-6097	5.03.2001	Stirling unsewered	0.005	0.281	<0.005	0.077	0.236	1.27
6628-6677	19.03.2001	Stirling unsewered	0.068	2.23	0.012	0.055	2.24	9.92
6628-6693	6.03.2001	Stirling unsewered	0.019	0.003	<0.005	0.031	0.008	0.03
6627-7985	6.03.2001	Stirling unsewered	0.007	0.132	0.016	0.166	0.148	0.66
6627-8170	6.03.2001	Stirling unsewered	0.006	0	<0.005	0.301	<0..005	0.02
6627-8296	5.03.2001	Stirling unsewered	0.011	0.001	<0.005	0.053	0.006	0.03
6627-9853	6.03.2001	Stirling unsewered	<0.005	0.255	0.011	0.139	0.266	1.18
6627-10379	12.03.2001	Stirling unsewered	<0.005	0.256	<0.005	0.032	0.261	1.16
6628-11171	6.03.2001	Stirling unsewered	<0.005	2.36	<0.005	0.078	2.37	10.5
6628-6755	7.03.2001	Summertown unsewered	0.006	1.2	<0.005	<0.005	1.2	5.32
6628-6777	7.03.2001	Summertown unsewered	0.011	7.38	0.067	0.04	7.44	33
6628-6793	7.03.2001	Summertown unsewered	<0.005	3.1	<0.005	0.096	3.11	13.8
6628-6796	6.03.2001	Summertown unsewered	<0.005	0.091	<0.005	0.008	0.096	0.43
6628-6813	9.03.2001	Summertown unsewered	<0.005	1.46	0.008	0.052	1.47	6.52
6628-6815	7.03.2001	Summertown unsewered	<0.005	2.59	<0.005	0.059	2.6	11.5
6628-6826	7.03.2001	Summertown unsewered	<0.005	1.63	<0.005	0.049	1.64	7.26
6628-6828	8.03.2001	Summertown unsewered	<0.005	3.2	<0.005	0.048	3.21	14.2
6628-6862	8.03.2001	Summertown unsewered	<0.005	0.857	0.017	0.01	0.874	3.87
6628-12141	7.03.2001	Summertown unsewered	0.037	2.52	0.019	<0.005	2.54	11.2
6628-12539	6.03.2001	Summertown unsewered	<0.005	101	<0.005	0.069	0.106	0.47

Microbiological

Well unit number	*Sample date*	Land use	FeB (/mL)	FC (/100mL)	E.coli (/100ml)	FS (/100mL)	Enterococcus spp. (/100mL)
6628-6704	29.03.2001	Bridgewater chicken shed	<10	0	0	0	0
6628-13802	29.03.2001	Bridgewater chicken shed	20	3	1	1	1
6627-6395	9.03.2001	Echunga effluent pond	<10	0	0	72	72
6627-6399	9.03.2001	Echunga effluent pond	<10	0	0	0	0
6628-10476	9.03.2001	Lobethal abattoir	<10	0	0	9	9
6628-10489	9.03.2001	Lobethal abattoir	<10	0	0	0	0
6628-10514	9.03.2001	Lobethal abattoir	<10	0	0	0	0
6627-2803	8.03.2001	Mylor unsewered	40	0	0	4	4
6627-2806	8.03.2001	Mylor unsewered	150	18	18	33	33
6627-2807	12.03.2001	Mylor unsewered	<10	0	0	0	0
6627-4206	8.03.2001	Mylor unsewered	<10	0	0	–	0
6627-6016	8.03.2001	Mylor unsewered	<10	0	0	5	5
6627-6052	8.03.2001	Mylor unsewered	<10	0	0	0	0
6627-7212	8.03.2001	Mylor unsewered	<10	0	0	8	8
6627-7302	30.03.2001	Mylor unsewered	10	0	0	4	0
6627-7335	8.03.2001	Mylor unsewered	<10	0	0	0	0
6627-7356	8.03.2001	Mylor unsewered	<10	0	0	4	4
6627-8687	12.03.2001	Mylor unsewered	<10	0	0	0	0
6628-6583	7.03.2001	Piccadilly FIB	700	0	0	8	8
6628-6742	9.03.2001	Piccadilly FIB	<10	0	0	10	10
6628-6776	7.03.2001	Piccadilly FIB	10	0	0	8	8
6628-12429	7.03.2001	Piccadilly FIB	<10	0	0	0	0
6628-6711	19.03.2001	Piccadilly wineries	<10	–	–	–	–
6628-6844	9.03.2001	Piccadilly wineries	<10	–	–	–	–
6628-6854	19.03.2001	Piccadilly wineries	10	–	–	–	–
6628-12023	9.03.2001	Piccadilly wineries	10	–	–	–	–
6627-6091	15.03.2001	Southern Mount Lofty FIB	10	0	0	0	0
6627-7005	15.03.2001	Southern Mount Lofty FIB	<10	0	0	0	0
6628-10244	15.03.2001	Southern Mount Lofty FIB	<10	0	0	0	0
6628-10285	16.03.2001	Southern Mount Lofty FIB	90	0	0	4	4
6628-10361	16.03.2001	Southern Mount Lofty FIB	<10	0	0	0	0

Well unit number	*Sample date*	Land use	FeB (/mL)	FC (/100mL)	E.coli (/100ml)	FS (/100mL)	Enterococcus spp. (/100mL)
6628-10366	16.03.2001	Southern Mount Lofty FIB	20	0	0	0	0
6628-10626	16.03.2001	Southern Mount Lofty FIB	50	1	1	>200	>200
6628-14504	15.03.2001	Southern Mount Lofty FIB	<10	0	0	0	0
6628-15950	16.03.2001	Southern Mount Lofty FIB	10	0	0	3	3
6627-2482	6.03.2001	Stirling unsewered	500	0	0	6	6
6627-2554	5.03.2001	Stirling unsewered	880	0	0	0	0
6627-2695	5.03.2001	Stirling unsewered	<10	0	0	0	0
6627-6097	5.03.2001	Stirling unsewered	280	0	0	9	9
6628-6677	19.03.2001	Stirling unsewered	10	20	20	>100	>100
6628-6693	6.03.2001	Stirling unsewered	30	0	0	0	0
6627-7985	6.03.2001	Stirling unsewered	10	0	0	0	0
6627-8170	6.03.2001	Stirling unsewered	<10	1	1	3	3
6627-8296	5.03.2001	Stirling unsewered	<10	0	0	0	0
6627-9853	6.03.2001	Stirling unsewered	<10	0	0	0	0
6627-10379	12.03.2001	Stirling unsewered	<10	0	0	0	0
6628-11171	6.03.2001	Stirling unsewered	1100	28	28	220	220
6628-6755	7.03.2001	Summertown unsewered	40	0	0	1	1
6628-6777	7.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6793	7.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6796	6.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6813	9.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6815	7.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6826	7.03.2001	Summertown unsewered	<10	0	0	0	0
6628-6828	8.03.2001	Summertown unsewered	3500	0	0	0	0
6628-6862	8.03.2001	Summertown unsewered	20	16	16	1	1
6628-12141	7.03.2001	Summertown unsewered	<10	0	0	0	0
6628-12539	6.03.2001	Summertown unsewered	<10	0	0	0	0

4 GRAPHED ANALYTE RESULTS, OCWMB AREA MONITORING PROGRAM, SAMPLED 2001

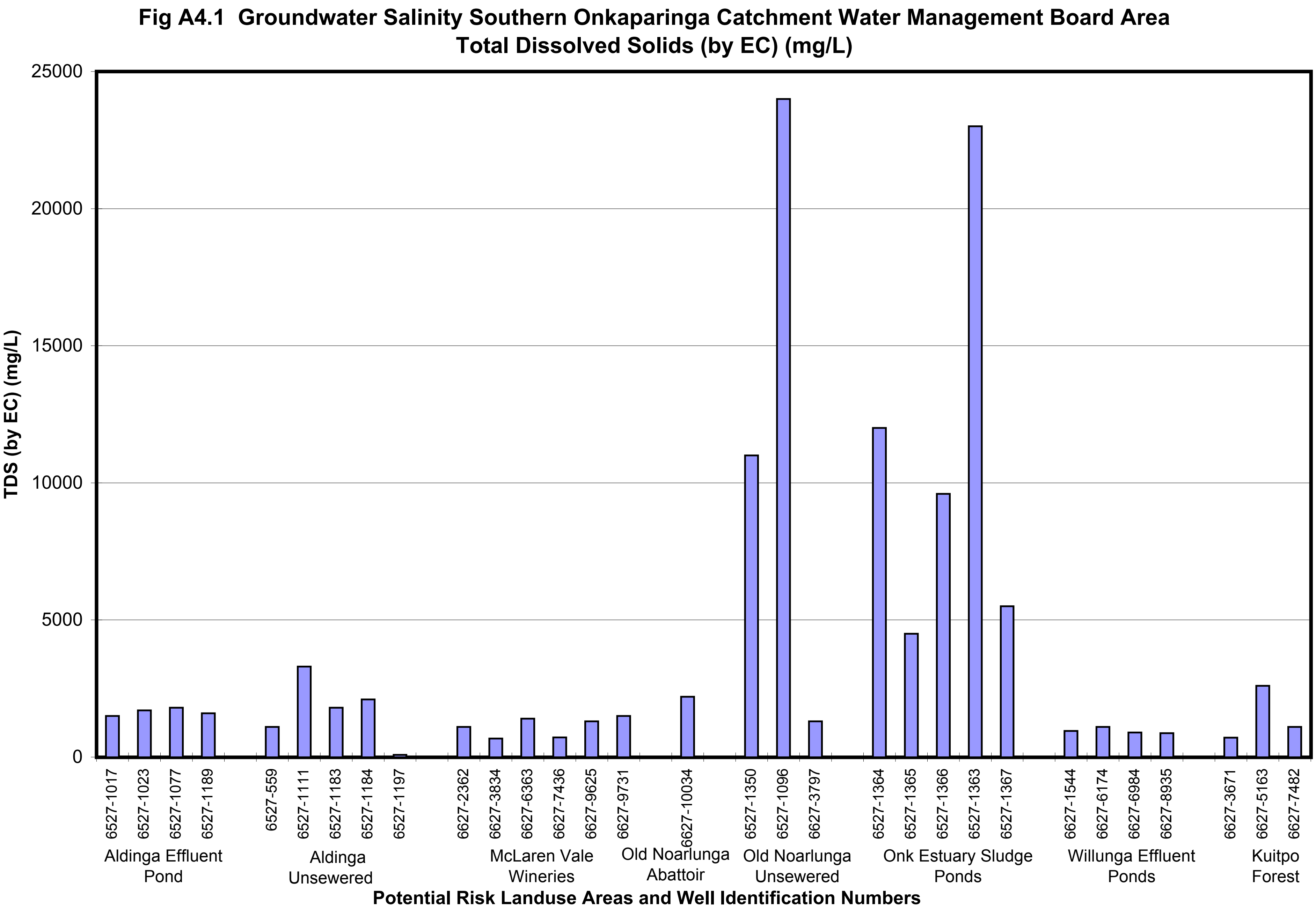


Fig A4.1 Groundwater Salinity Southern Onkaparinga Catchment Water Management Board Area
Total Dissolved Solids (by EC) (mg/L)
TDS (by EC) (mg/L)
25000
20000
15000
10000
5000
0
6527-1017
6527-1023
6527-1077
6527-1189
6527-559
6527-1111
6527-1183
6527-1184
6527-1197
6627-2362
6627-3834
6627-6363
6627-7436
6627-9625
6627-9731
6627-10034
6527-1350
6527-1096
6627-3797
6527-1364
6527-1365
6527-1366
6527-1363
6527-1367
6627-1544
6627-6174
6627-6984
6627-8935
6627-3671
6627-5163
6627-7482
Aldinga Effluent Pond
Aldinga Unsewered
McLaren Vale Wineries
Old Noarlunga Abattoir
Old Noarlunga Unsewered
Onk Estuary Sludge Ponds
Willunga Effluent Ponds
Kuitpo Forest
Potential Risk Landuse Areas and Well Identification Numbers

Fig A4.2 Groundwater Salinity Northern Onkaparinga Catchment Water Management Board Area
Total Dissolved Solids (by EC) (mg/L)

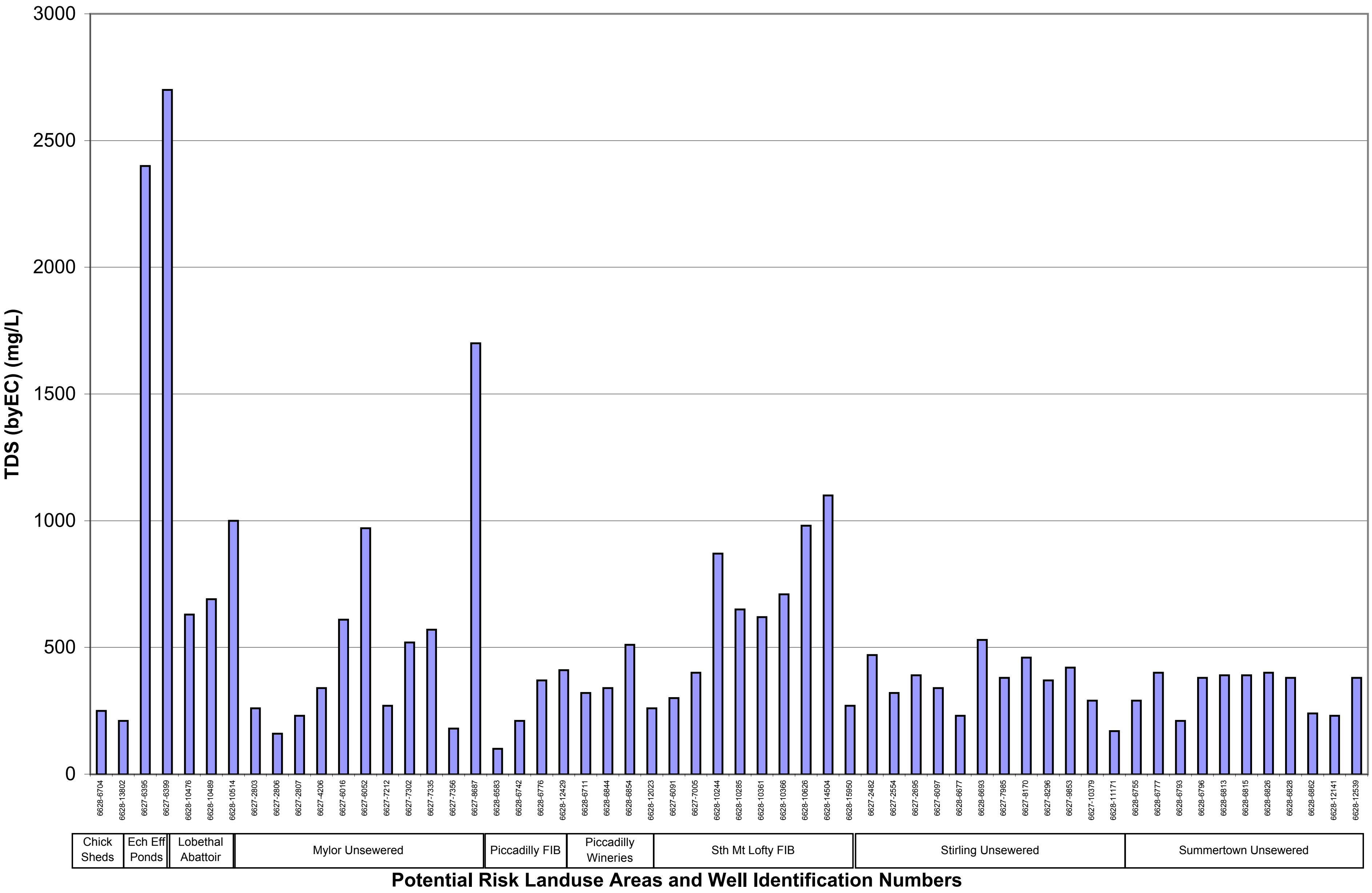


Fig A4.3 Potassium (K) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

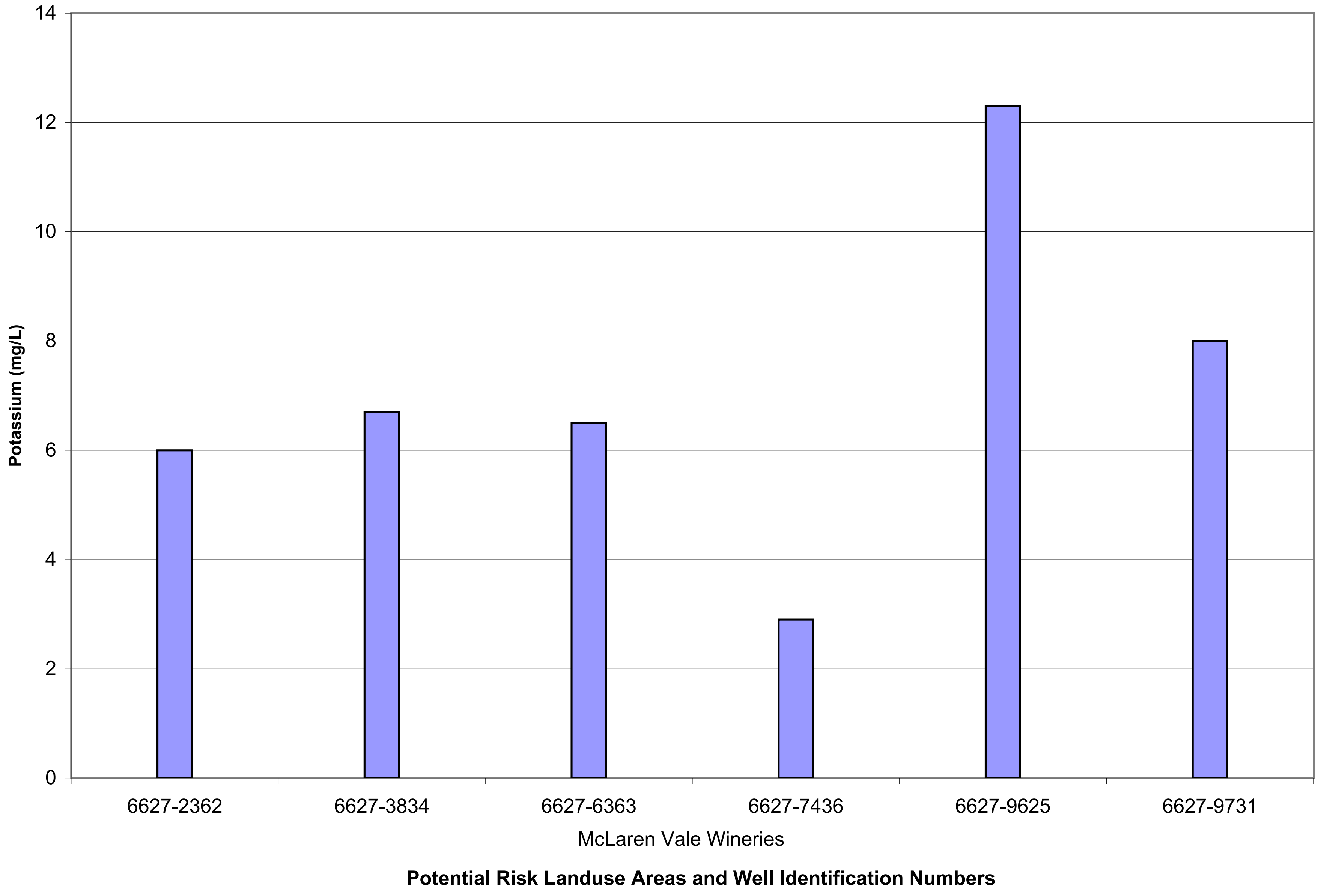


Fig A4.4 Potassium (K) (mg/L) of Groundwater Northern Onkaparinga Catchment Water Management Board Area

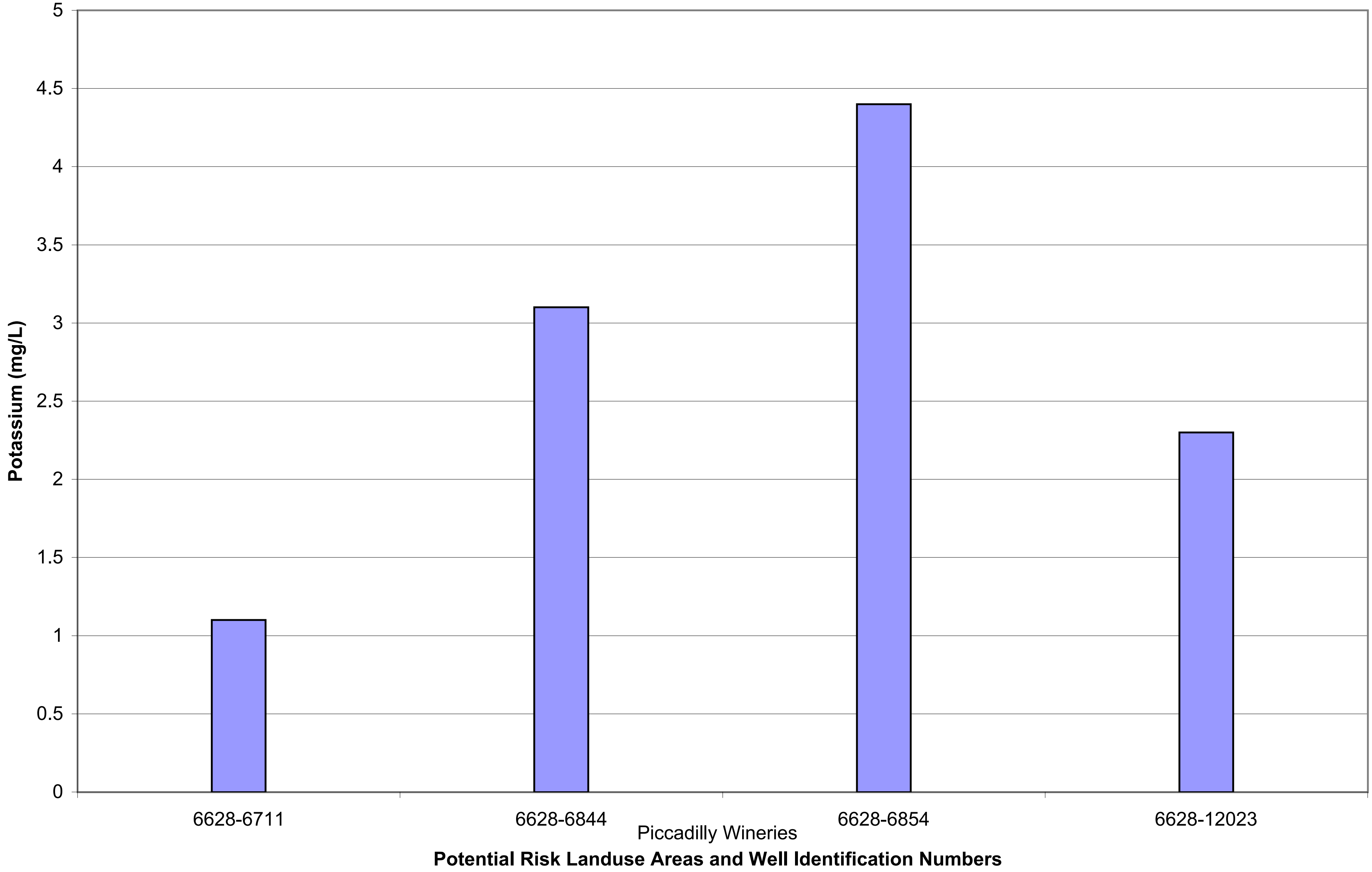


Fig A4.5 Sulphate (S) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

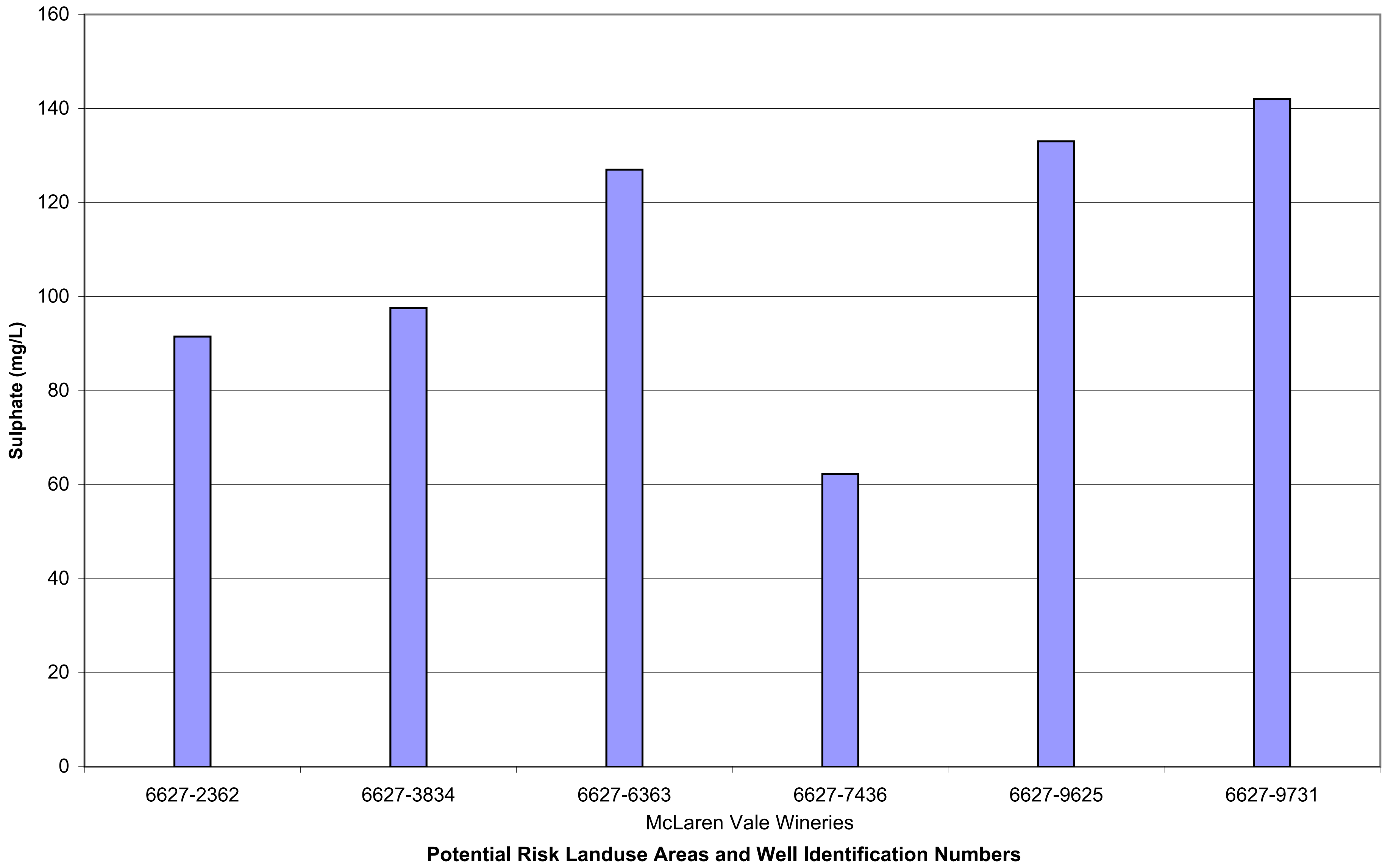


Fig A4.6 Sulphate (S) (mg/L) of Groundwater Northern Onkaparinga Catchment Water Management Board Area

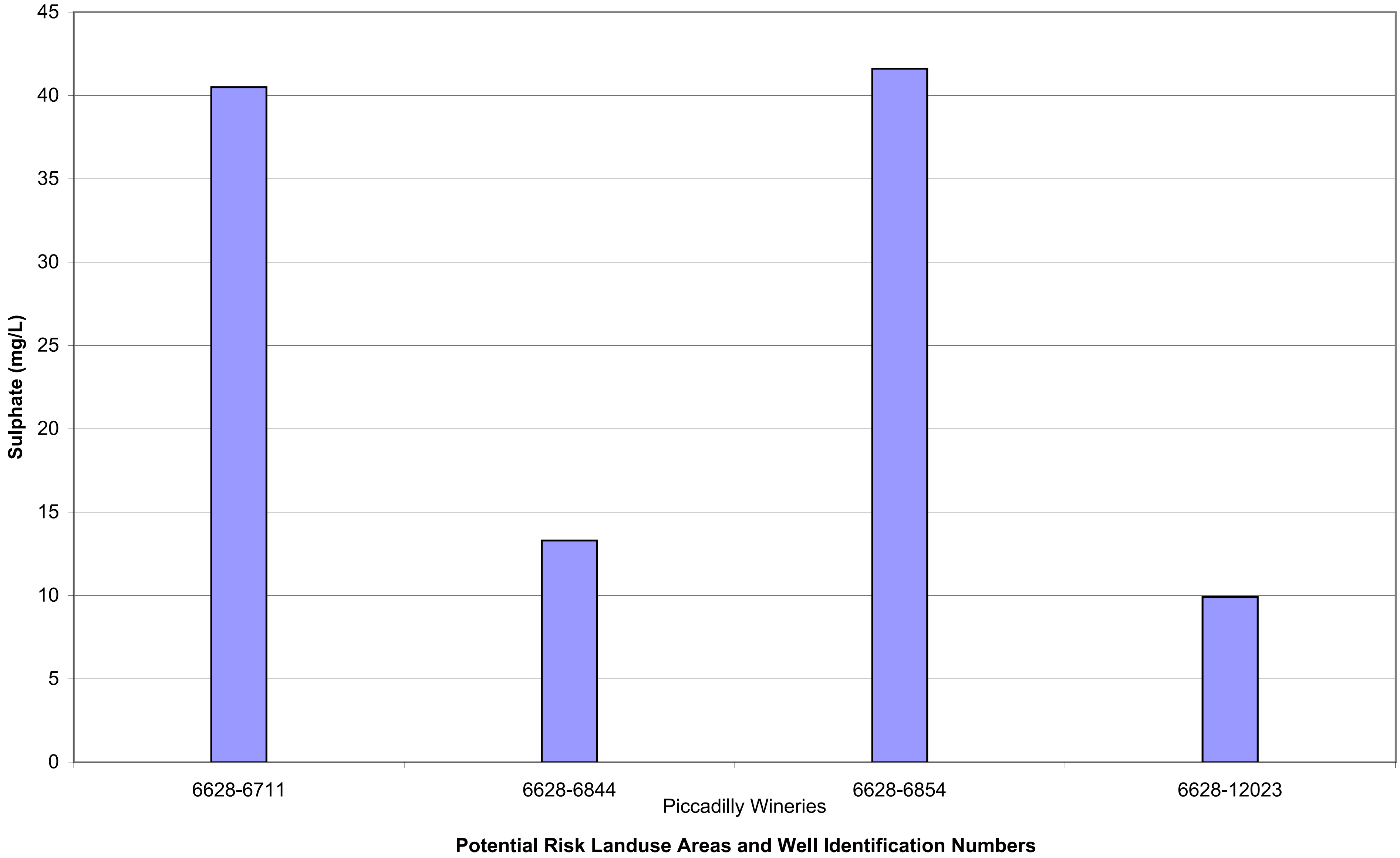


Fig A4.7 Ammonia as Nitrogen (NH_3 as N) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

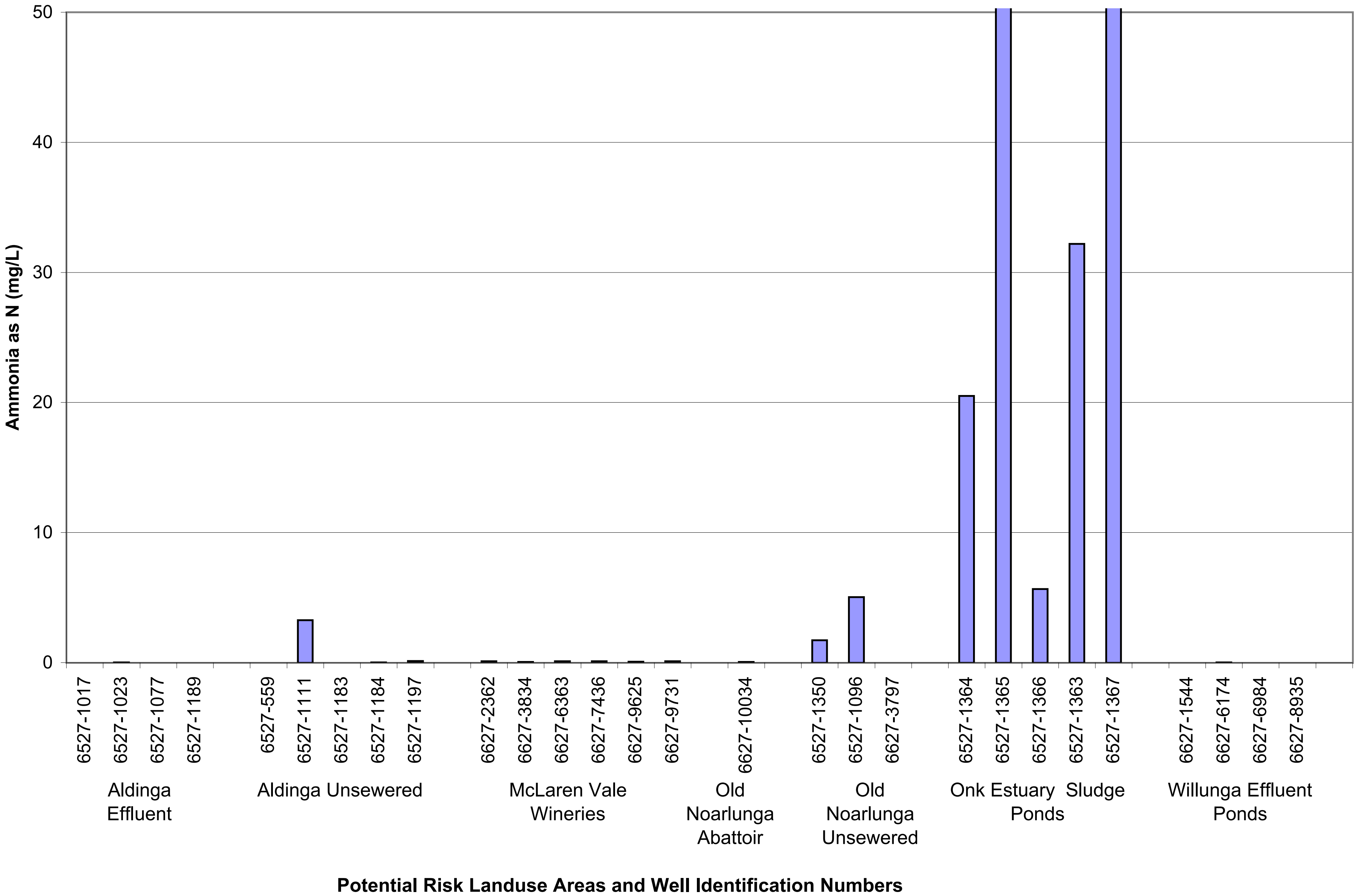


Fig A4.8 Ammonia as Nitrogen (NH_3 as N) (mg/L) of Groundwater in the Northern Onkaparinga Catchment Water Management Board Area

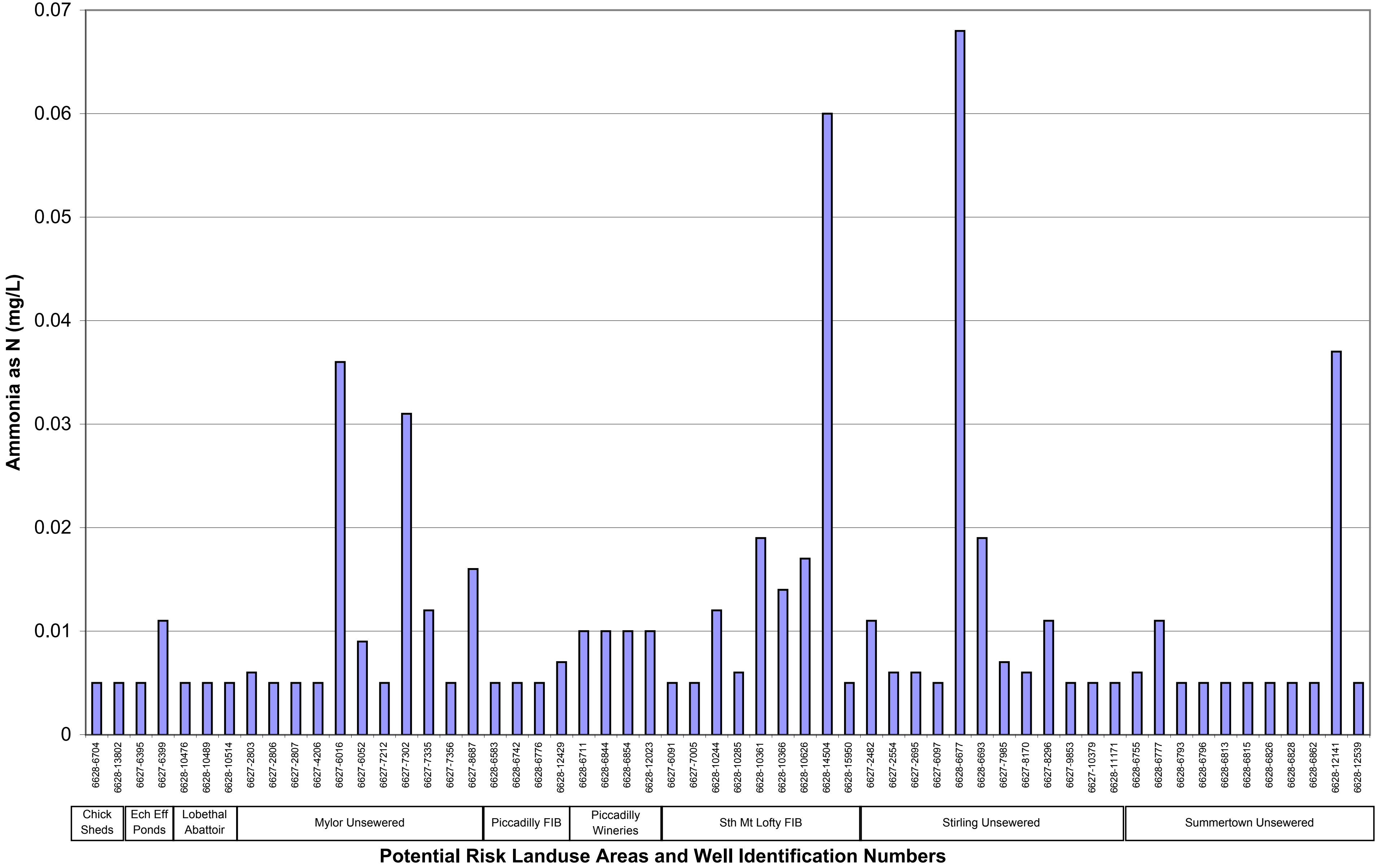


Fig A4.9 Nitrite as Nitrogen (NO_2 as N) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

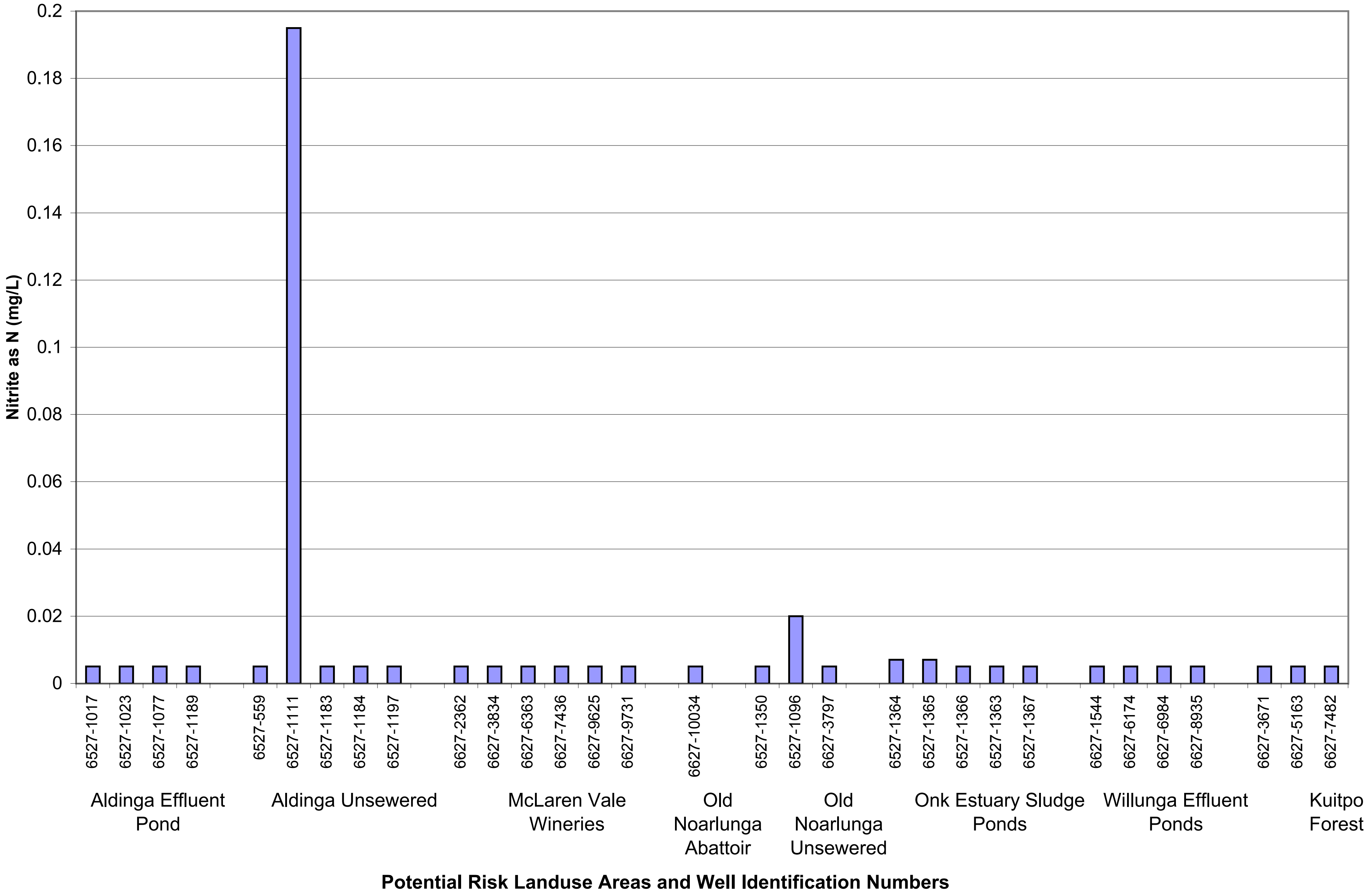


Fig A4.10 Nitrite as Nitrogen (NO_2 as N) (mg/L) of in the Groundwater Northern Onkaparinga Catchment Water Management Board Area

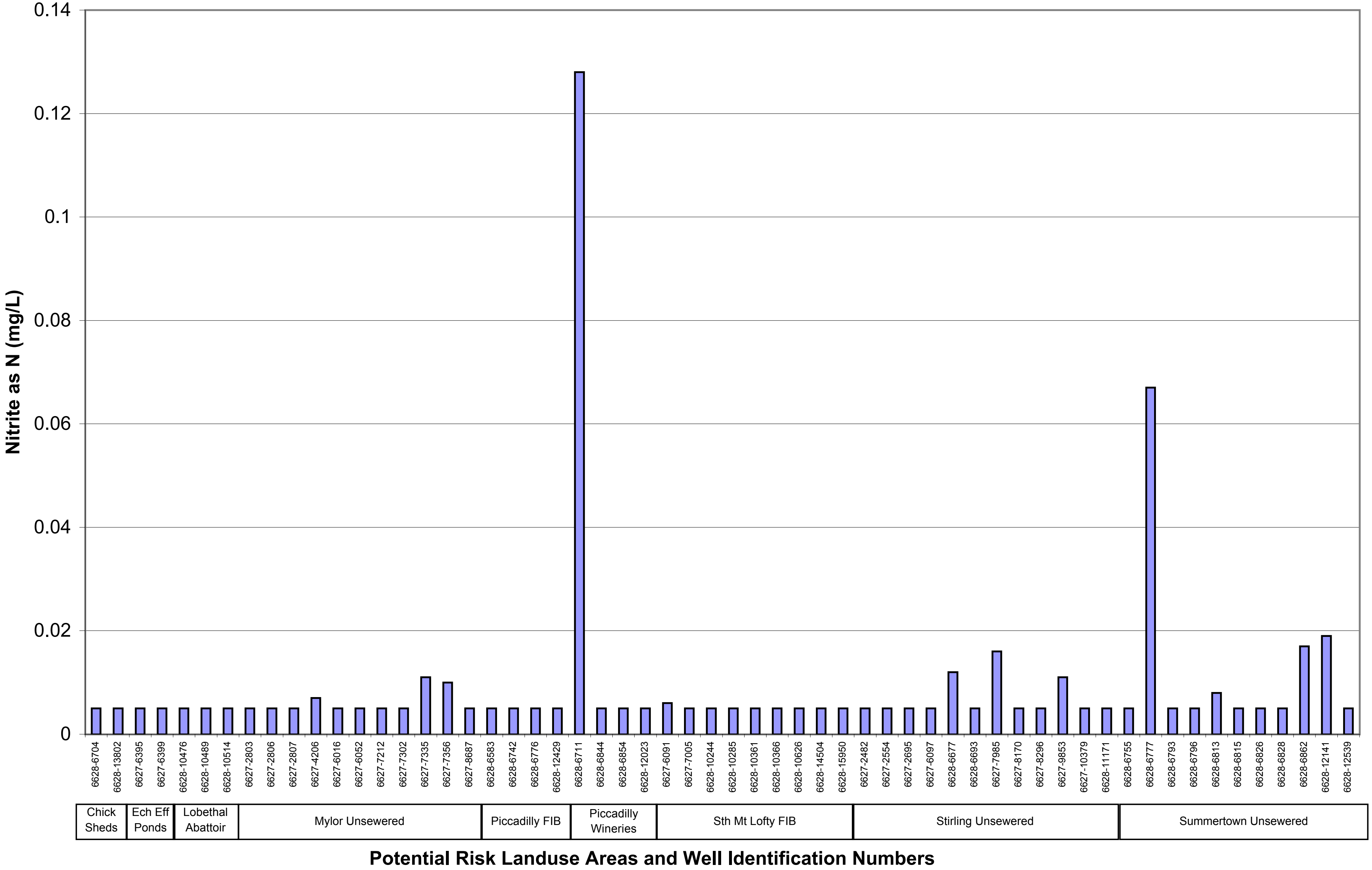


Fig A4.11 Nitrate as Nitrogen (N0_3 as N) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

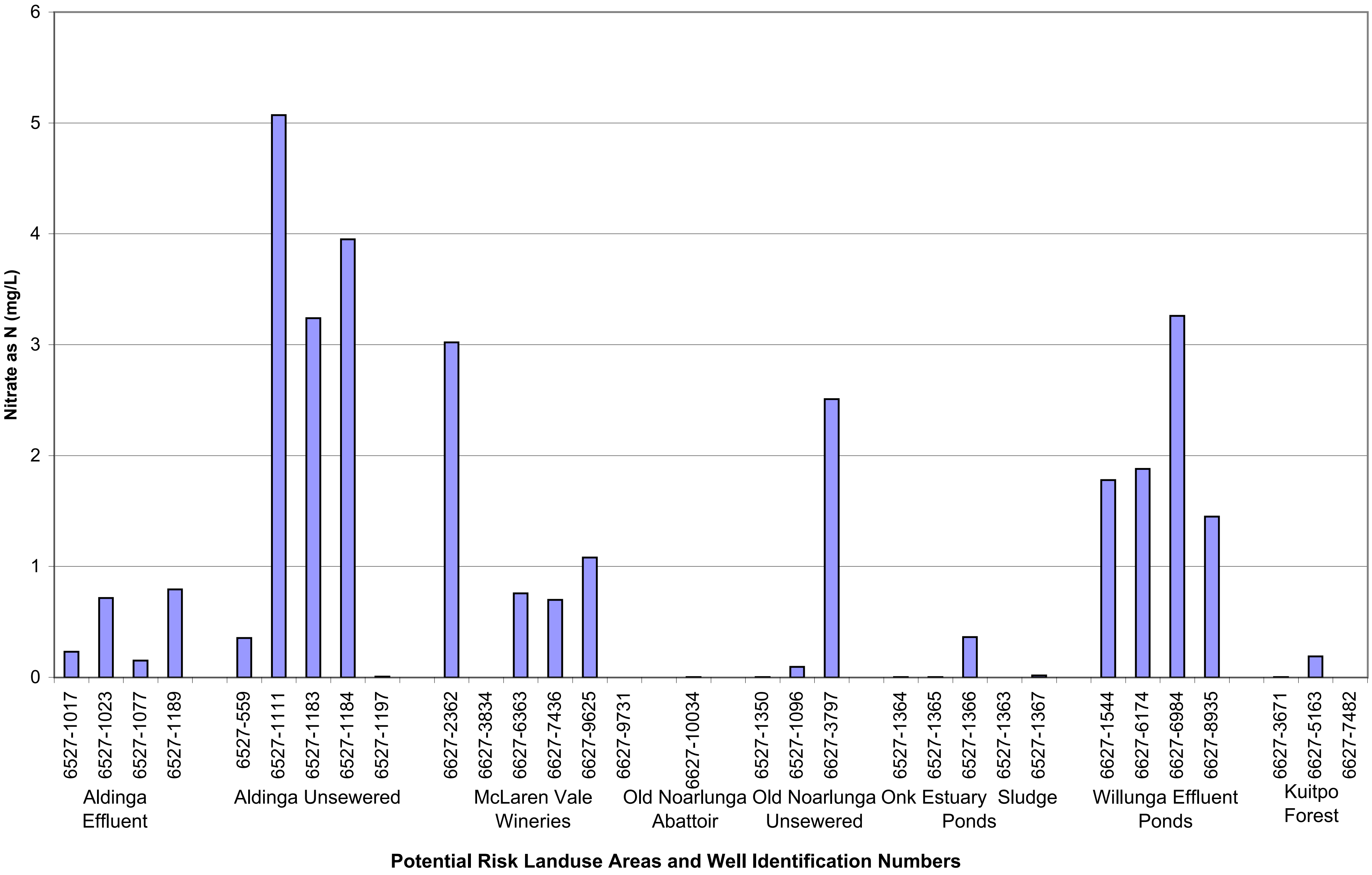


Fig A4.12 Nitrate as Nitrogen (NO_3 as N) (mg/L) of Groundwater in the Northern Onkaparinga Catchment Water Management Board Area

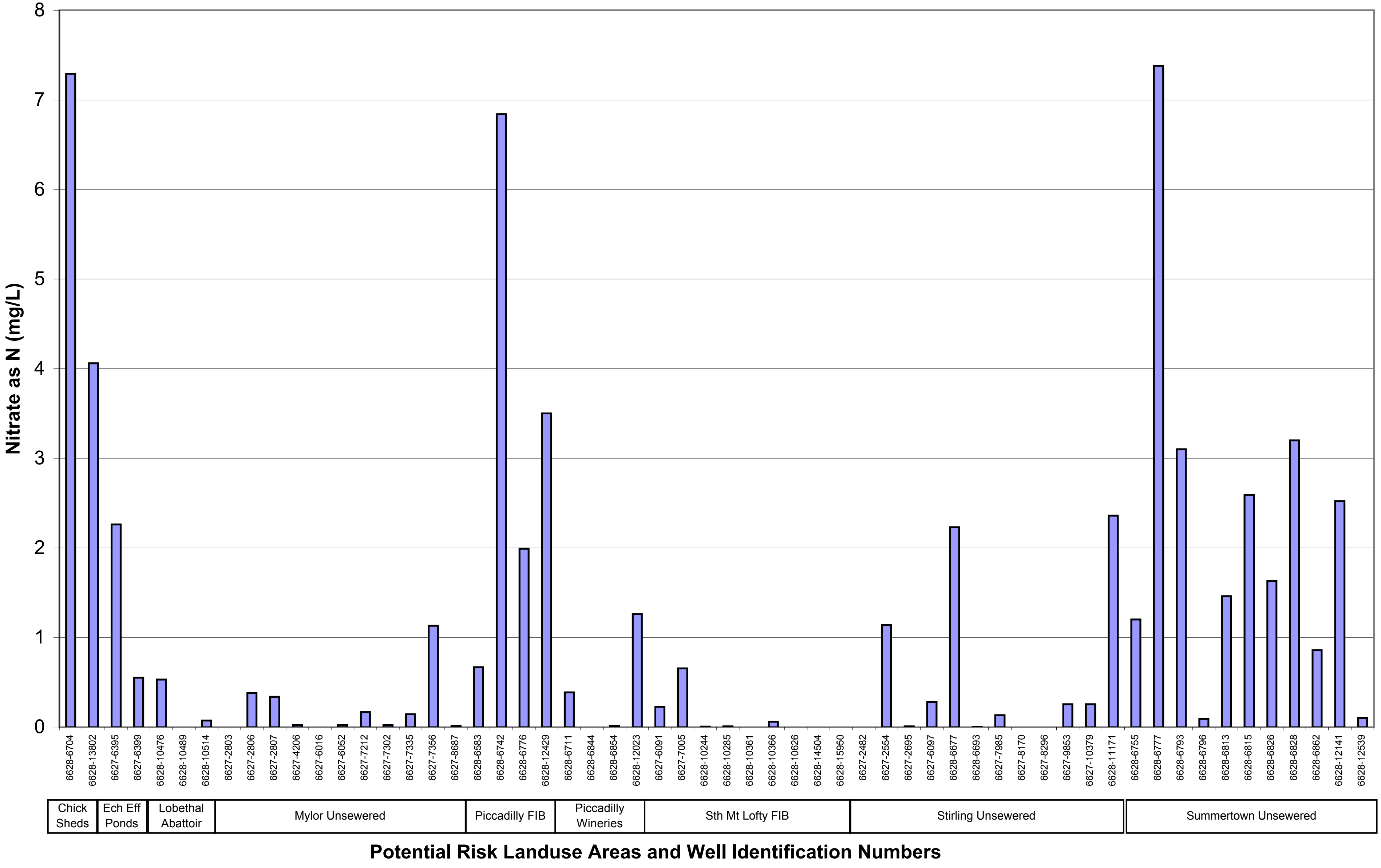


Fig A4.13 Total Organic Carbon (TOC) (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

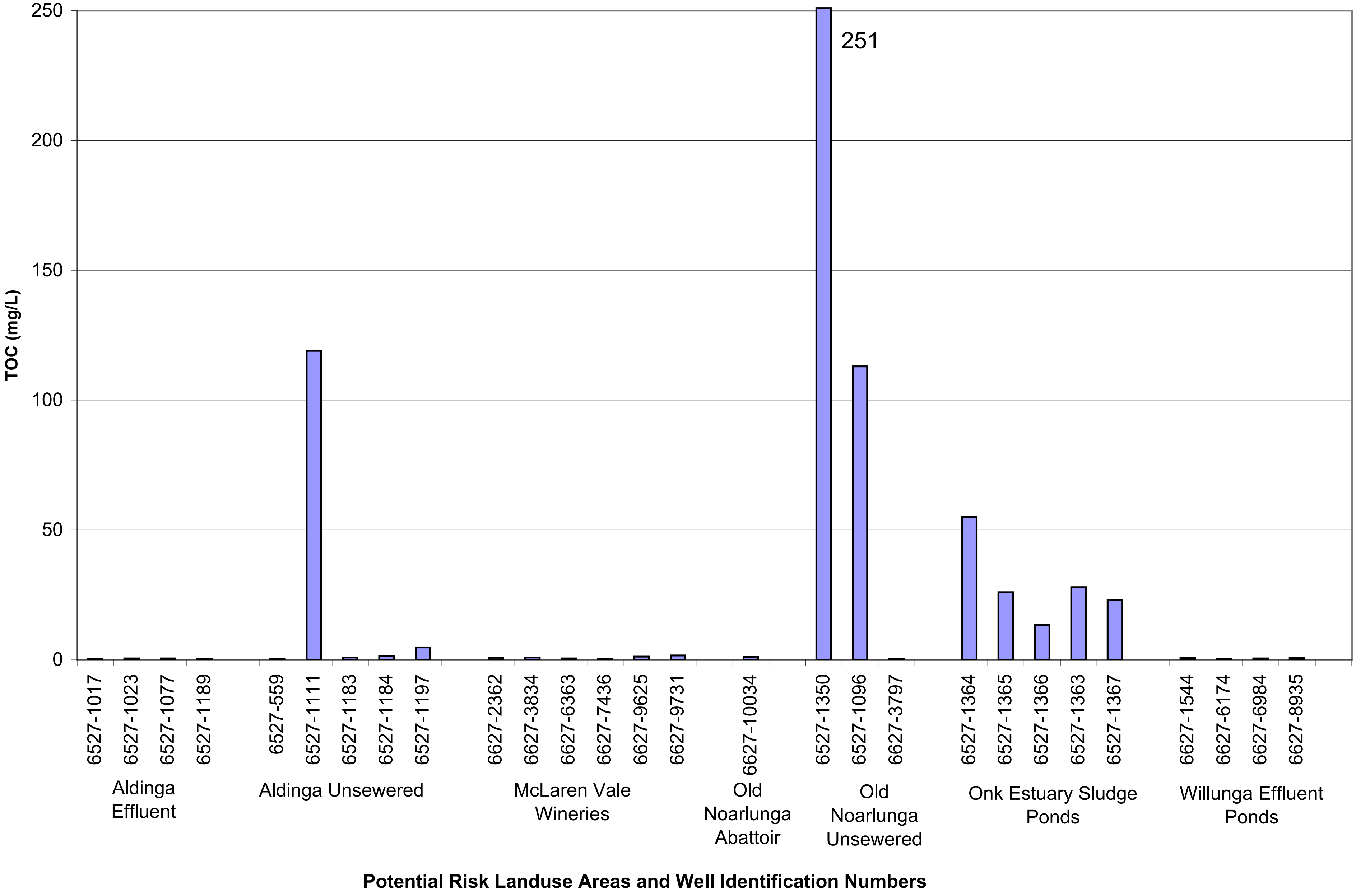


Fig A4.14 Total Organic Carbon (TOC) (mg/L) of Groundwater Northern Onkaparinga Catchment Water Management Board Area

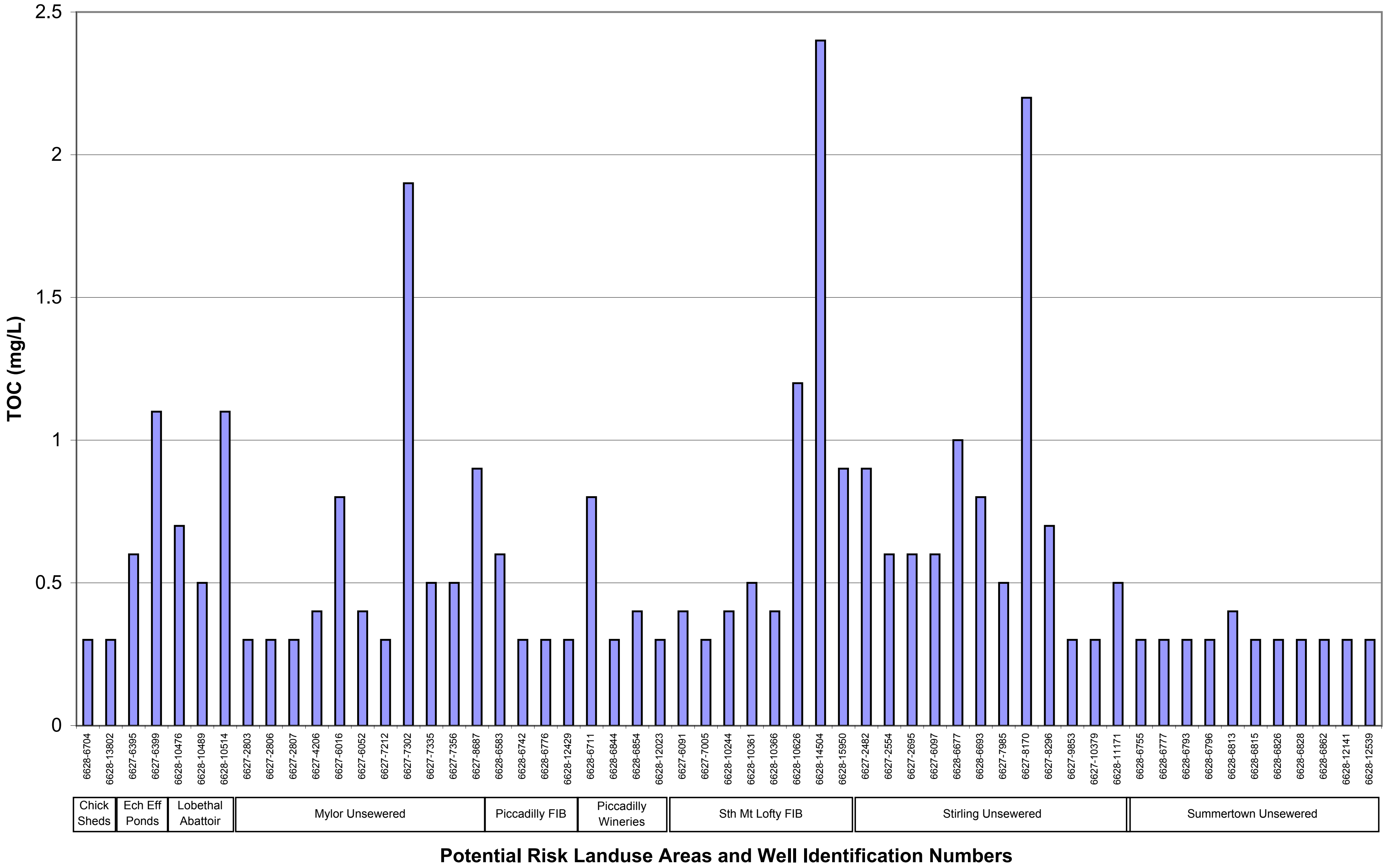


Fig A4.15 Phosphorus - Total as P (mg/L) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

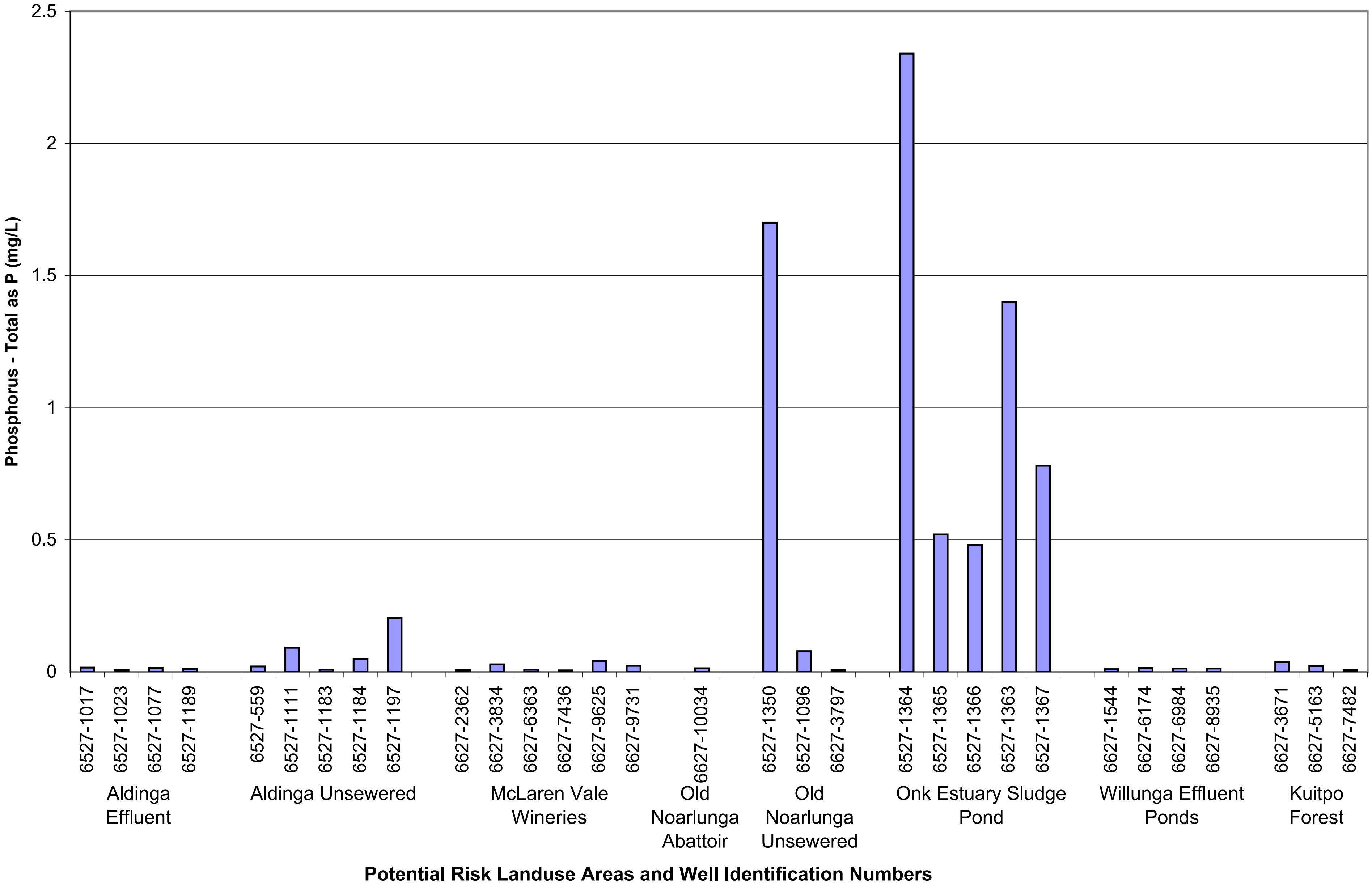


Fig A4.16 Phosphorus - Total as P (mg/L) of Groundwater Northern Onkaparinga Catchment Water Management Board Area

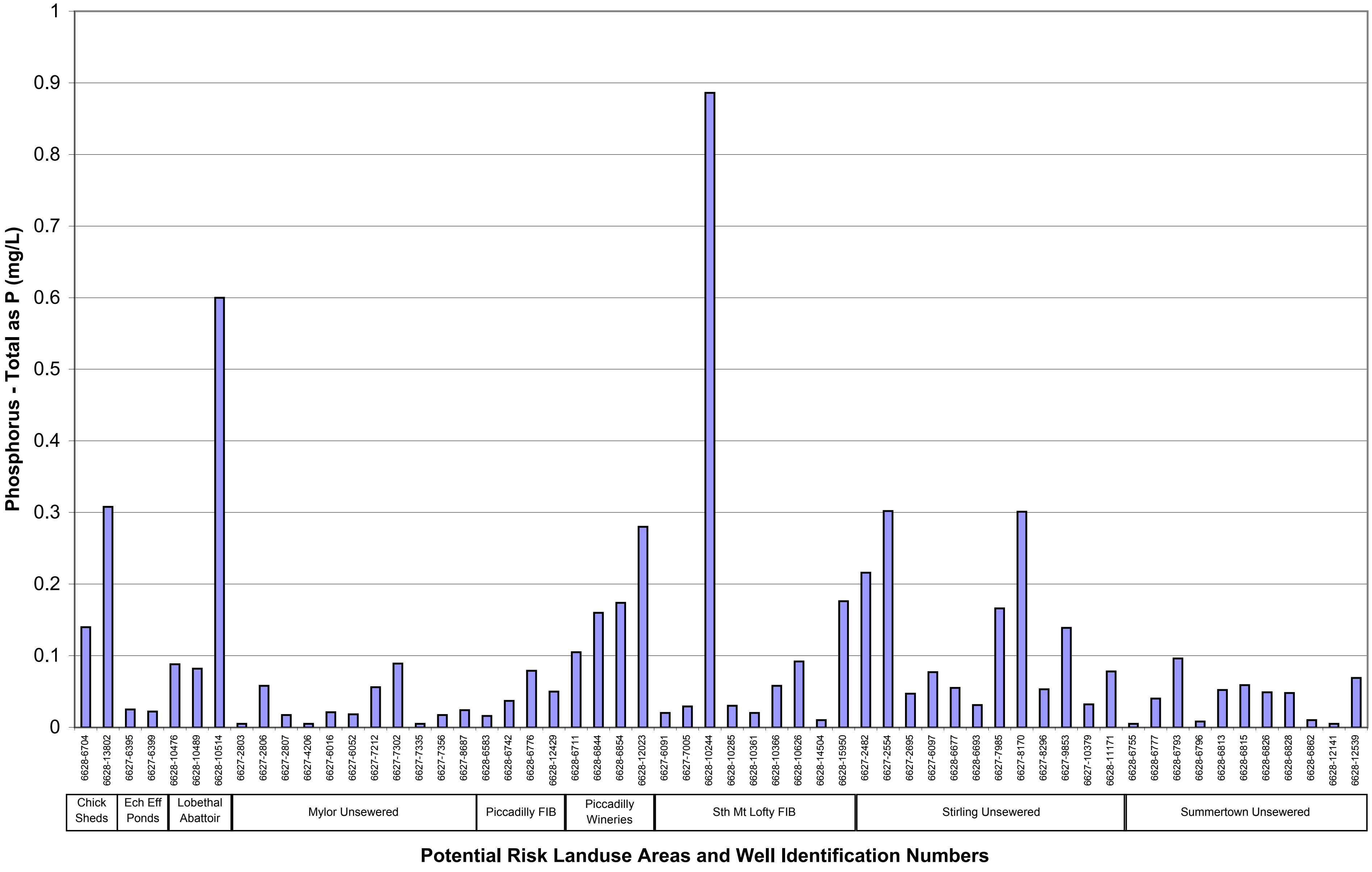


Fig A4.17 Faecal Coliform (/100mL) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

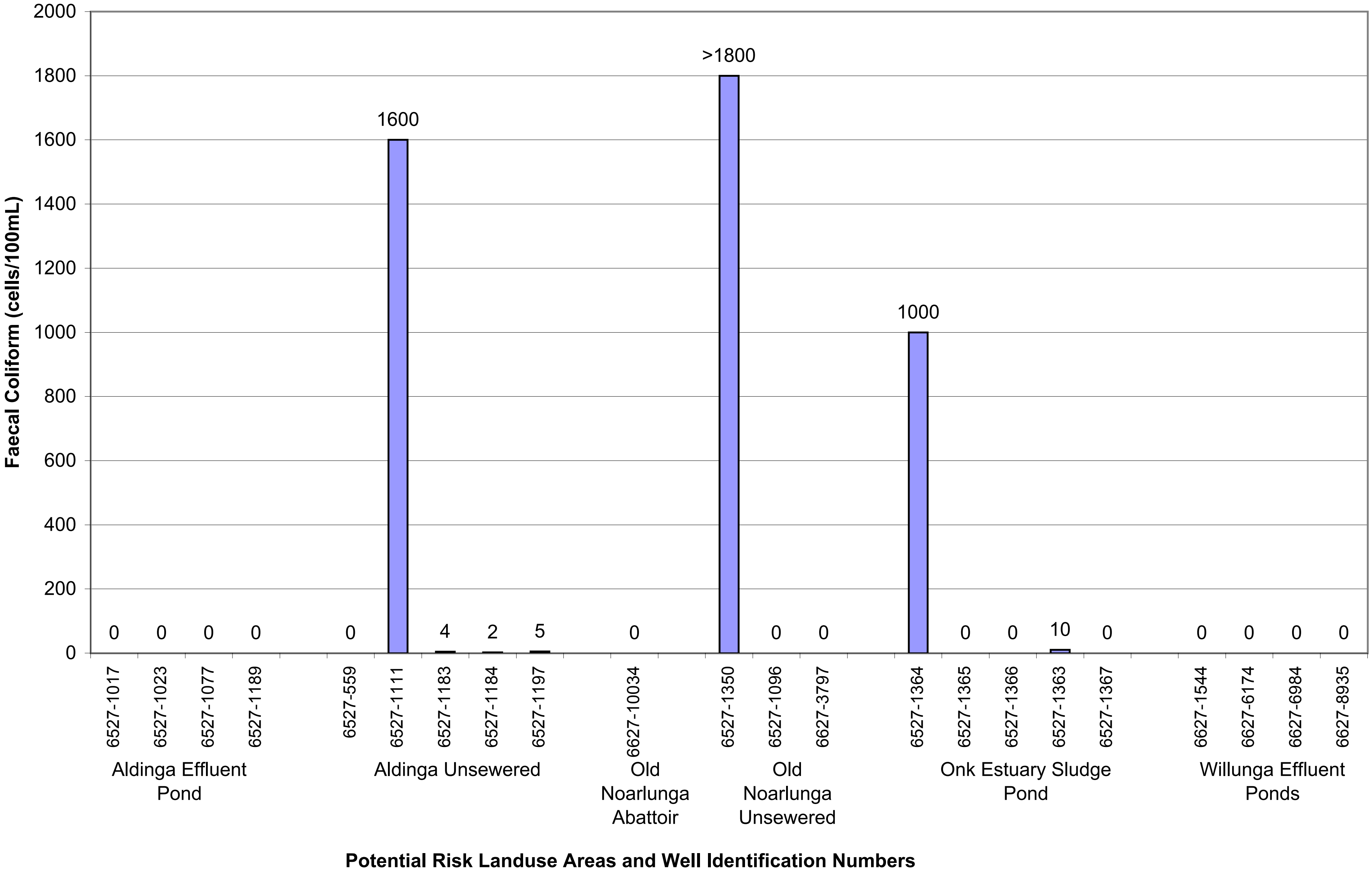


Fig A4.18 Faecal Coliform (/100mL) of Groundwater Northern Onkaparinga Catchment

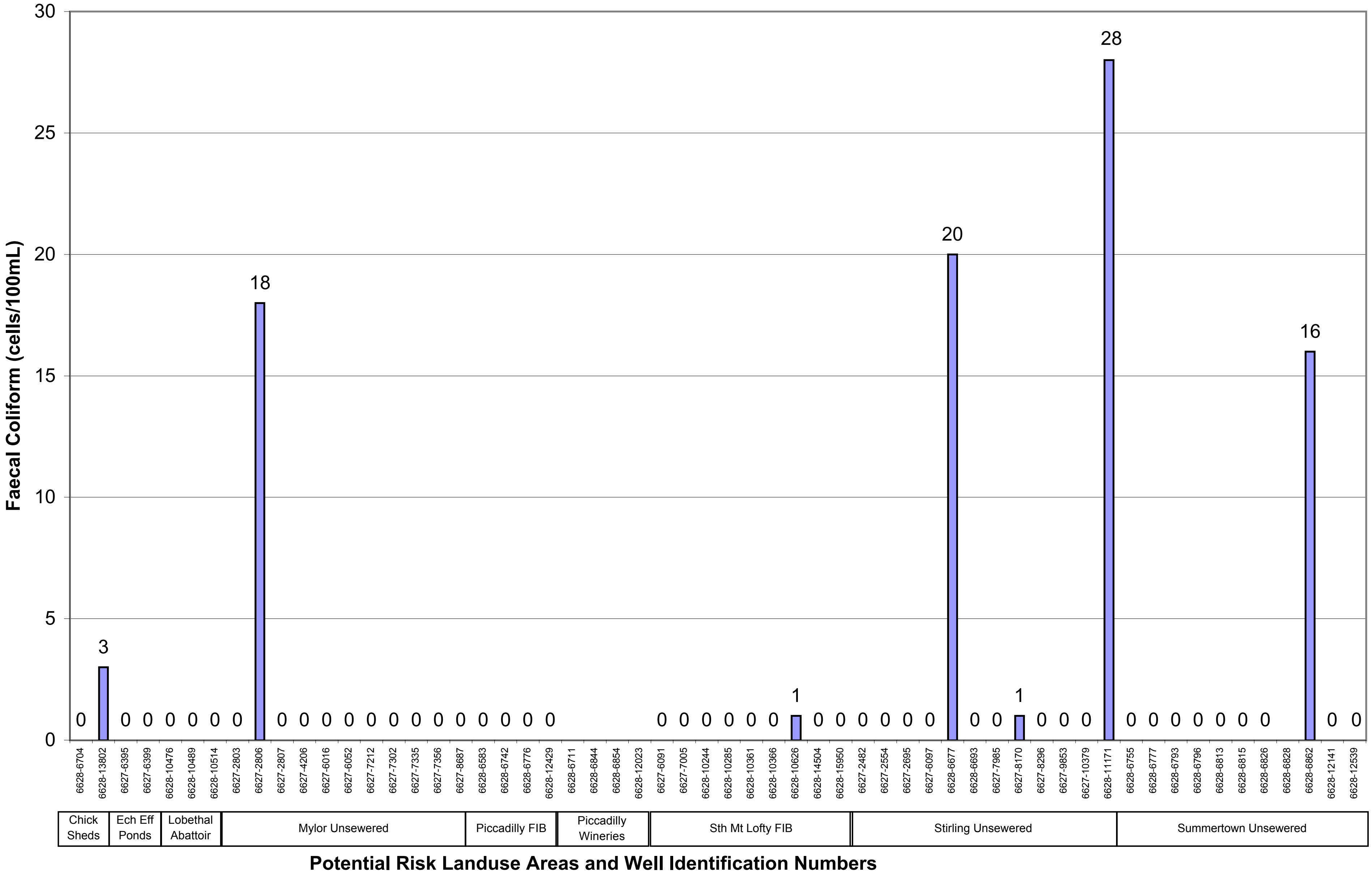
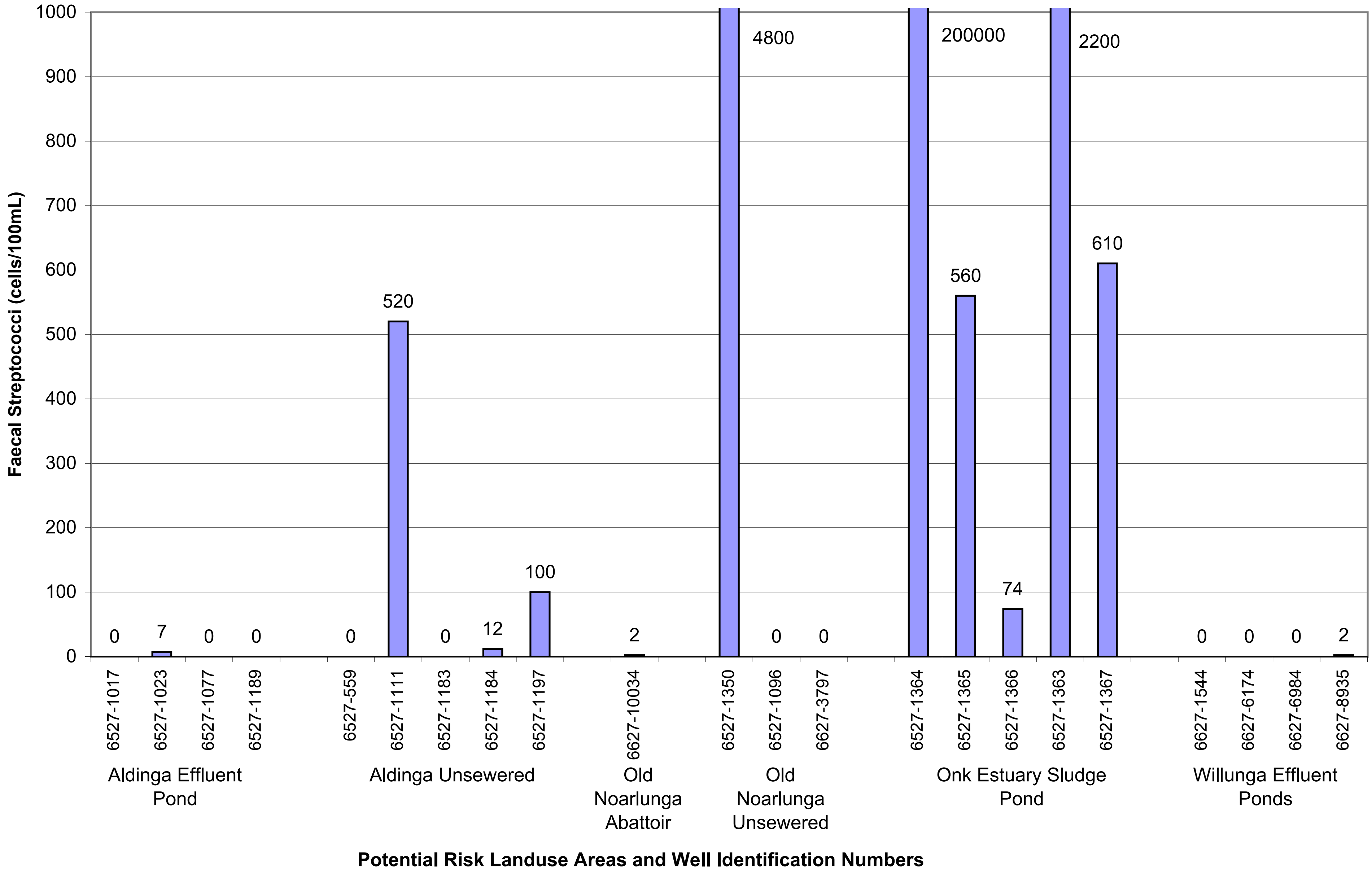


Fig A4.19 Faecal Streptococci (/100mL) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area



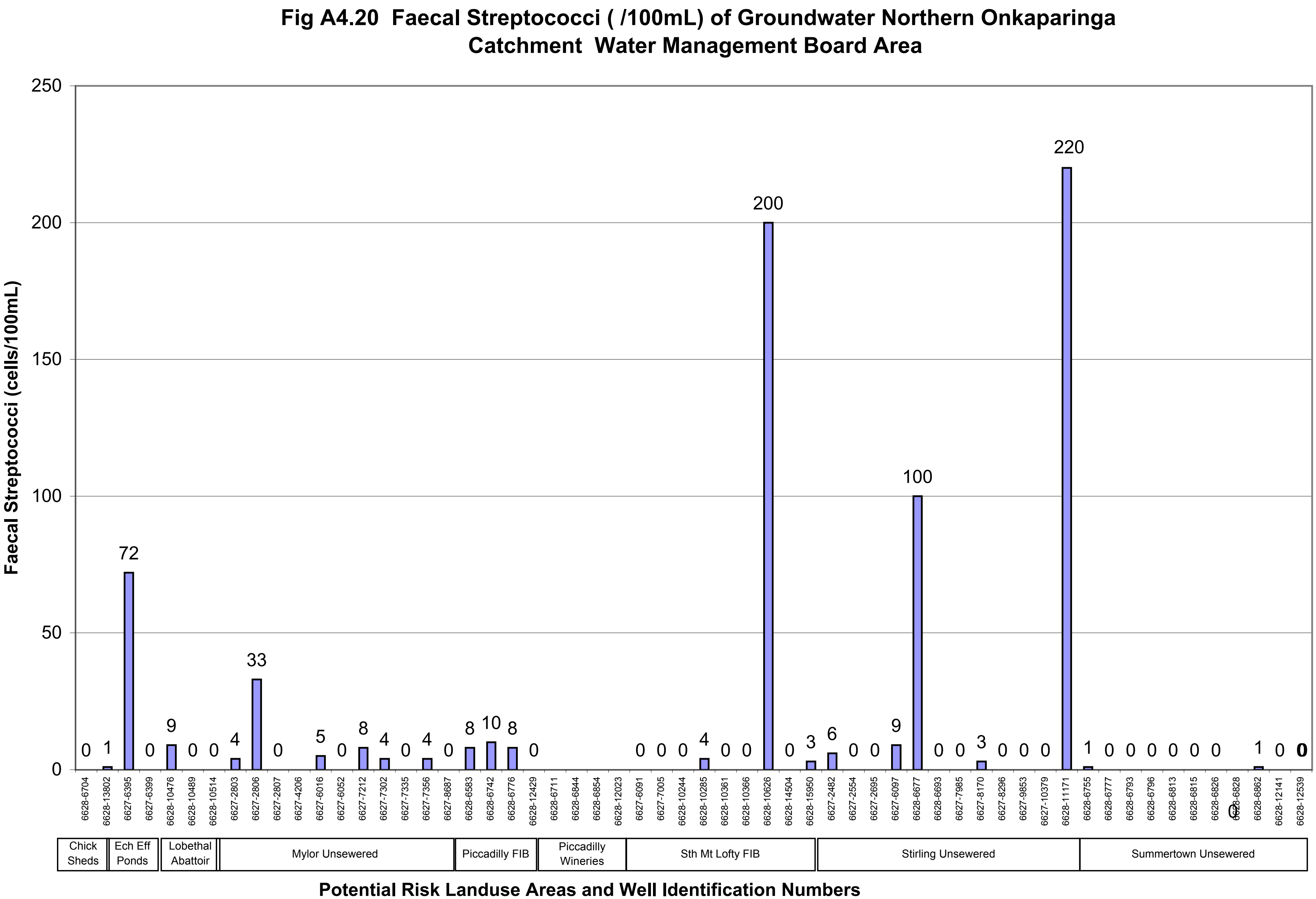


Fig A4.20 Faecal Streptococci (/100mL) of Groundwater Northern Onkaparinga Catchment Water Management Board Area
Faecal Streptococci (cells/100mL)
Potential Risk Landuse Areas and Well Identification Numbers
Chick Sheds
Ech Eff Ponds
Lobethal Abattoir
Mylor Unsewered
Piccadilly FIB
Piccadilly Wineries
Sth Mt Lofty FIB
Stirling Unsewered
Summertown Unsewered

Fig A4.21 Heterotrophic Iron Bacteria (/mL) (culture) of Groundwater in the Southern Onkaparinga Catchment Water Management Board Area

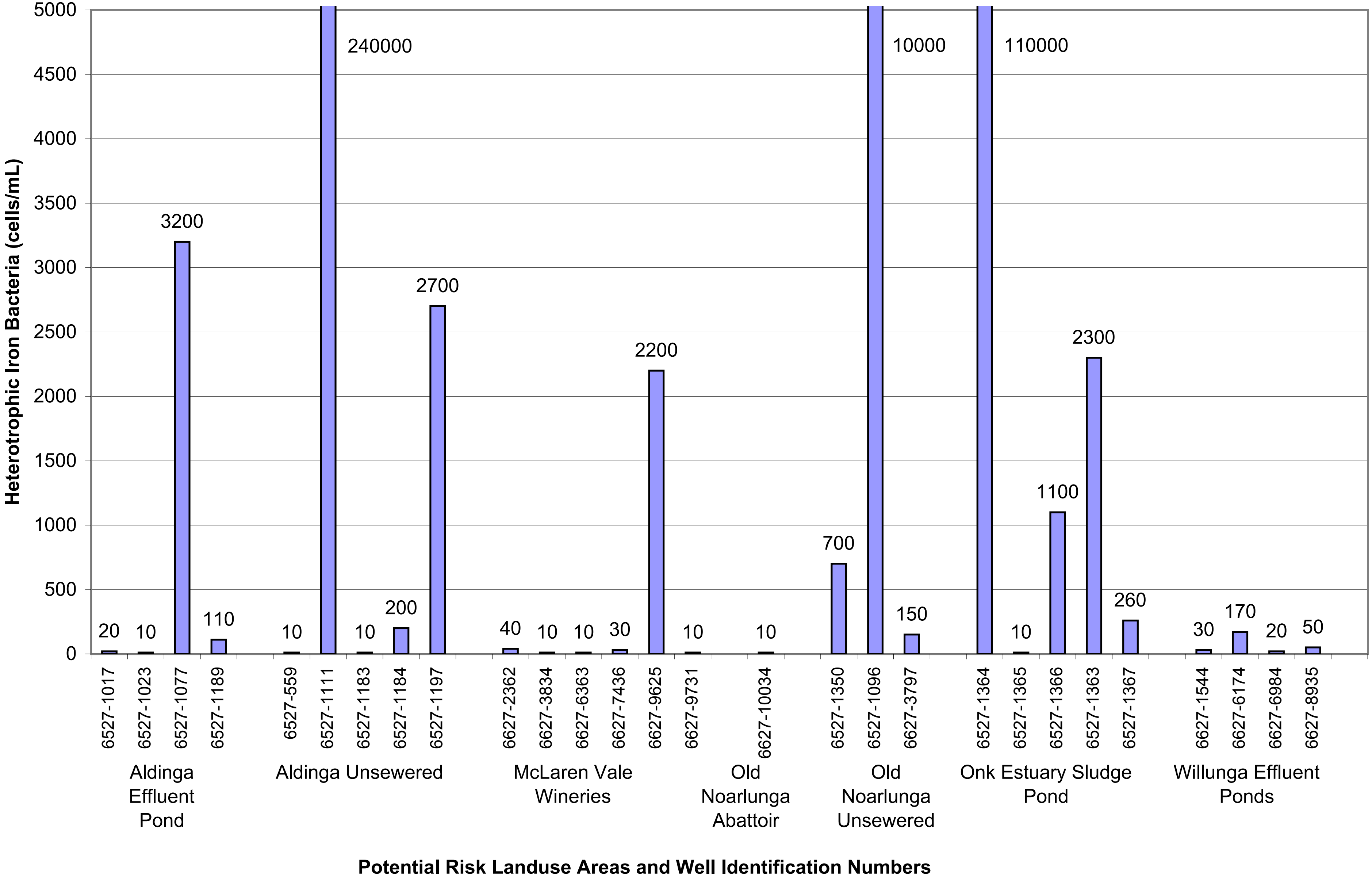
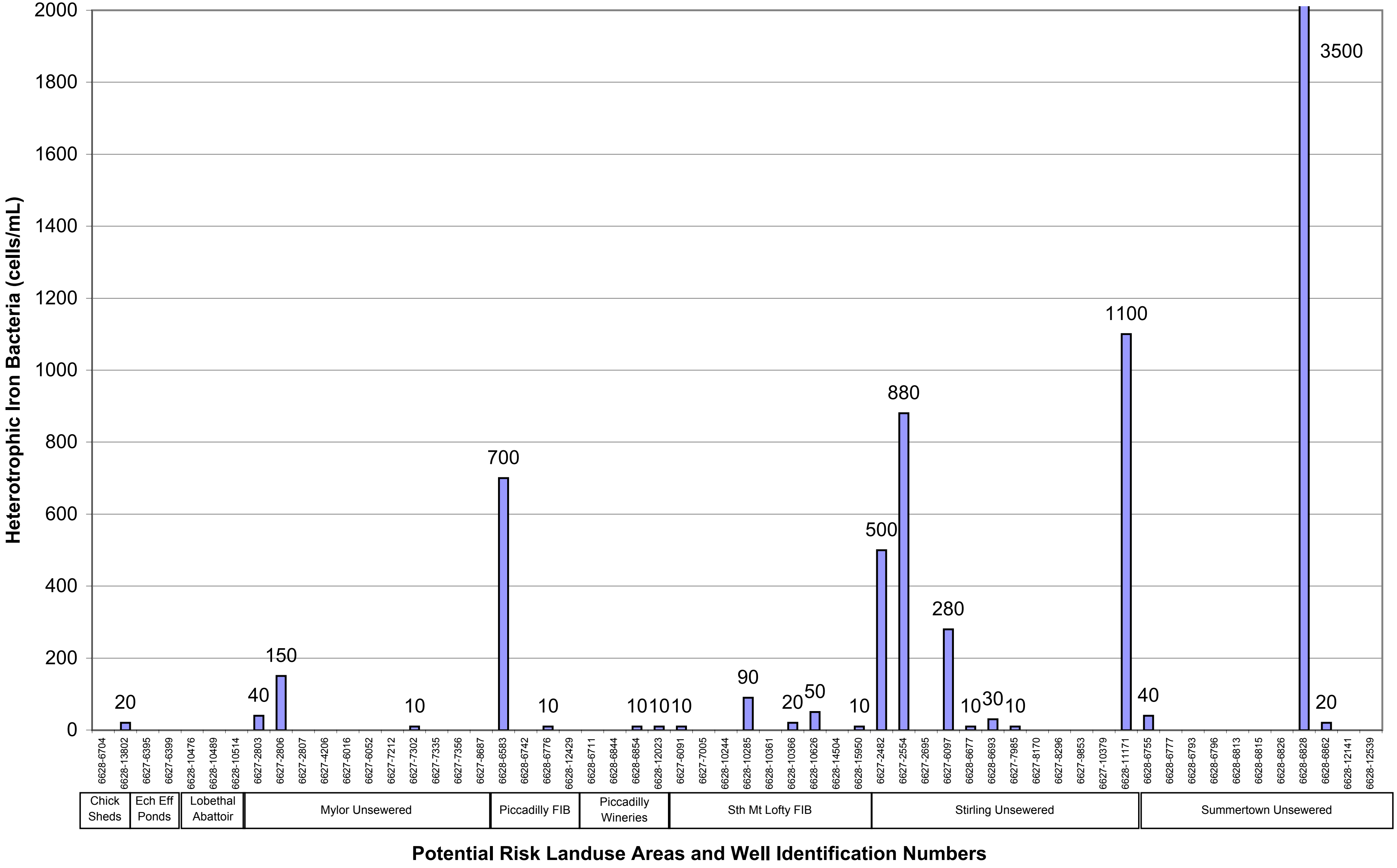


Fig A4.22 Heterotrophic Iron Bacteria (/mL) (culture) of Groundwater Northern Onkaparinga Catchment Water Management Board Area



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