Government of **Western Australia**
Department of **Water**

Looking after all our water needs

Hydrogeochemical assessment of the Superficial aquifer

Perth metropolitan area

Hydrogeological record series

Report no. HG37
August 2010

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Cover photograph Lake Muckenburra, 68 km north of Perth CBD (Photo courtesy of the Water Resource Assessment Branch, Department of Water)

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Summary

The Department of Water carried out a hydrogeochemical study of groundwater in the Perth metropolitan area from Gingin to Mandurah. The study involved the compilation and assessment of data collected before 2003 and groundwater chemical analyses obtained by sampling and testing the Superficial aquifer from 2003 to 2007. The chemical analyses provide baseline data for future comparison. Data is from 226 Superficial aquifer monitoring bores, 17 permanent wetlands, and 18 rainfall sampling sites. Water quality data were studied for 65 different chemical and physical parameters, and calculated and modelled parameters. The study provides a basis for understanding changes in groundwater quality due to variations in climate, land use and groundwater abstraction.

The objective of the study was to gather the hydrogeochemical information needed to:

- identify the probable physical processes and chemical reactions occurring within the Superficial aquifer
- the significant parameters needed to measure mineralogical controls
- the source of groundwater and its flow pattern.

Chemical analyses were used to prepare hydrochemical maps and diagrams to show the spatial and stratigraphical distribution of the chemical constituents. These allowed us to interpret the relationship between chemical constituents and hydrogeological parameters.

Groundwater in Bassendean Sand at the crest of the Gnangara and Jandakot Groundwater Mounds enters and interacts with carbonate rocks while flowing westwards through the Tamala Limestone, aggressive waters start to dissolve the calcite in the Spearwood system that gradually becomes saturated by calcite along the groundwater flow line towards the ocean. Heterogeneity in the distribution of saturation indices for calcite indicates there is a conduit flow in addition to Darcy flow in Tamala Limestone. Conduit flows are common in highly karstic carbonate aquifers and occur in the cave system within the Yanchep National Park.

The results of this study indicate an overall salinity increase of up to 225 mg/L in some areas near the crest of the Gnangara Groundwater Mound since 1986. Similarly, there is a trend of increasing salinity in the Mirrabooka, Wanneroo, Gwelup, and Perth groundwater areas. A similar increase in salinity can also be seen in the southern Perth area including Jandakot, Cockburn and Stakehill groundwater areas.

The nitrate data indicates that the application of fertilisers in agriculture have increased concentrations of nitrates in the Superficial aquifer in the Perth metropolitan area, especially in the intensively irrigated horticultural areas. These increased concentrations have become more widespread since 1992. Maximum nitrate concentrations were 292 mg/L in the Carabooda area, 280 mg/L north-east of Lake Wilgarup, 280 mg/L in the Lake Neerabup area, 266 mg/L in the Coogee Swamp area and 53 mg/L in the Lake Nowergup area.

Acidification of the Superficial aquifer groundwater is evident from sulfate concentrations higher than 100 mg/L around the Mirrabooka, Wanneroo and Lake Pinjar borefields. Sulfate is also high around Lake Joondalup, Lake Mariginiup, Lake Bindiar and the Yeal Swamp area in the northern Perth metropolitan region.

Groundwater with higher SO_4/Cl ratios also has high Fe and As concentrations, and low pH, indicating that groundwater acidification mostly results from the oxidation of iron sulfide and/or other sulfidic minerals. This is due to the lowering of groundwater levels, resulting from abstraction, that has exposed the sulfide minerals in the soils to oxidation. These have then been leached, causing the groundwater to acidify. Areas affected by sulfide oxidation are Mirrabooka, Wanneroo and Gwelup Groundwater Areas, east of Lake Goollelal, east of Lake Joondalup, Jandabup Lake, Lake Mariginiup and Lake Wilgarup areas. Increased SO_4/Cl ratios in the Yeal area and bores PM3 and PM4 close to wetlands are the result of oxidation of exposed sulfidic sediments due to water level decline resulting from reduced rainfall since 1969.

In the study area, only one spot sample was taken from each wetland, which provides only limited data on salinity, pH and major anions and cations to compare to the underlying groundwater. Wetlands that are part of the Spearwood Lake system are very well connected with the groundwater beneath and interact accordingly. These wetlands include Lake Loch McNess, Lake Yonderup, Lake Nowergup, Lake Joondalup and Lake Goollelal. They are considered as groundwater windows of the Superficial aquifer. Jandabup Lake, Gnangara Lake, Lake Monger and Lake Herdsman are also groundwater throughflow lakes showing a high correlation between up-gradient and down-gradient groundwater chemistry. Lake Mariginiup, Pipidinny Swamp numbers 1 and 2, Gwelup Lake, North Lake, Bibra Lake, and Forestdale Lake are considered to have limited connection with the underlying groundwater but they are not perched wetlands. These wetlands have similar chemistry to the surrounding groundwater. Some of these have a high correlation with up-gradient groundwater chemistry, while others have better correlation with down-gradient groundwater chemistry.

The chloride ratio method (CRM) is used to estimate the areal distribution of recharge into superficial aquifers in the Perth metropolitan area. The approach spatially integrates recharge over areas up-gradient from the measurement point. Spatial scales range from about 200 m to several kilometres and time scales range from years to thousands of years. Results could be improved in future studies by closer spacing sampling of groundwater at the watertable. The results from this analysis show that the average recharge from rainfall into the Superficial aquifer is about 11% of rainfall, and ranges from over 30% in Whiteman Park, Ballajura and Bindiar Lake to about 2% in the Lake Mariginiup and Lake Jandabup areas. The average rainfall recharge to the superficial aquifer in the southern Perth area is about 5.5% of rainfall, ranging from 2% at the eastern and western margins to 15% and 28% in the Jandakot and Success areas.

1 Introduction

Lower than average annual rainfall since the early 1970s has reduced groundwater recharge and increased the dependence on groundwater for scheme supplies and private use. This trend has led to declines in the groundwater levels over the entire Gnangara Groundwater Mound, with local areas being more affected by nearby influences such as private abstraction near Gwelup and Wanneroo, public abstraction near the Pinjar and Wanneroo borefields, and the pine plantations particularly in the north-eastern part of the Mound (Yesertener 2008).

Changes in land use and water use in addition to reduced rainfall can create significant detrimental effects on both the surface and groundwater environments. Due to this it is imperative that the state of the groundwater resource is closely monitored and understood.

There are significant gaps in our understanding of aspects of the Perth Basin aquifer system. For example, the recharge characteristics of some parts of the system are poorly understood. The water chemistry of the groundwater in the Superficial aquifer has not been investigated on a basin-wide scale. Without an in-depth, spatially extensive and continuous hydrogeochemical survey of the metropolitan area’s groundwater, we will not know what effects have been occurring due to past and present groundwater consumption patterns.

The objective of the study was to gather the hydrogeochemical information needed to:

- identify the probable physical processes and chemical reactions occurring within the Superficial aquifer
- the significant parameters needed to measure mineralogical controls
- the source of groundwater and its flow pattern.

Chemical analyses were used to prepare hydrochemical maps and diagrams to show the spatial and stratigraphical distribution of the chemical constituents. These allowed us to interpret the relationship between chemical constituents and hydrogeological parameters.

In particular, the information was used to explain:

- the concentrations, distribution and sources of solutes
- the development of geomorphic features
- the hydrogeochemical controls on hydraulic conductivity and flow paths
- the spatial changes in water quality over time and the rate of these changes
- the functioning of the hydrological system and how it relates to water quality problems and their solutions.

The hydrogeochemical survey was carried out within the Perth metropolitan area between Gingin in the north and Mandurah in the south, as shown in Figure 1.

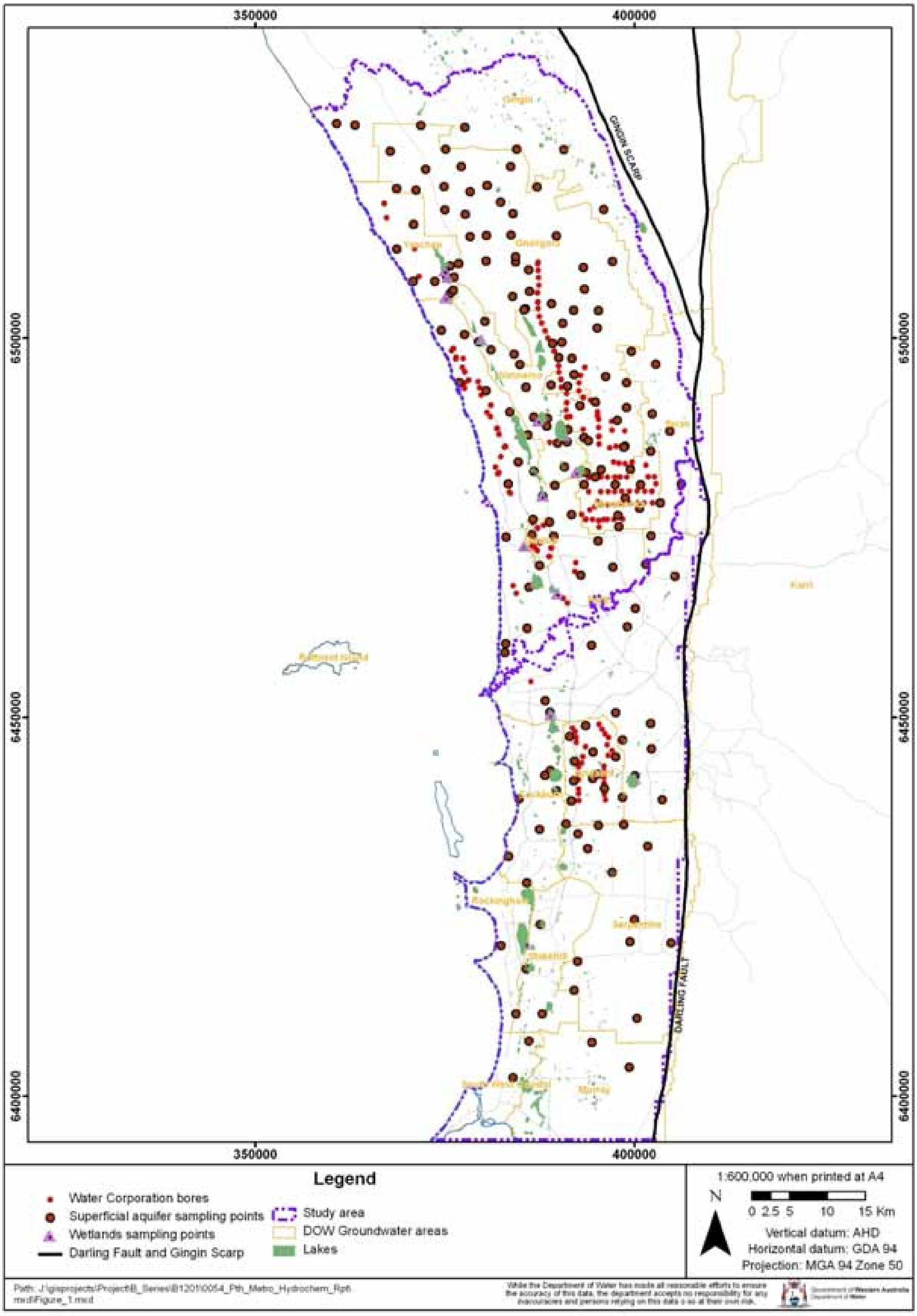


Figure 1 Location of study area

2 Physiography and land use

2.1 Climate

The Perth metropolitan region has a Mediterranean climate with hot, dry summers and mild, wet winters. The hot, dry summers are caused by a belt of high pressure that passes over the region between October and March. During the cool winter months, rainfall accompanied by strong wind results from sub-polar, low pressure cells that cross the region as cold fronts (Davidson 1995).

The long-term average rainfall ranges from about 715 mm in the north to about 810 mm in the centre and about 865 mm in the southern coastal area of the Perth metropolitan region. The rainfall pattern has been evaluated using the cumulative deviation from the mean (CDFM) technique, which has determined a wet period between 1915 and 1968, and a dry period following 1969, as seen in Figure 2 (Yesertener 2008).

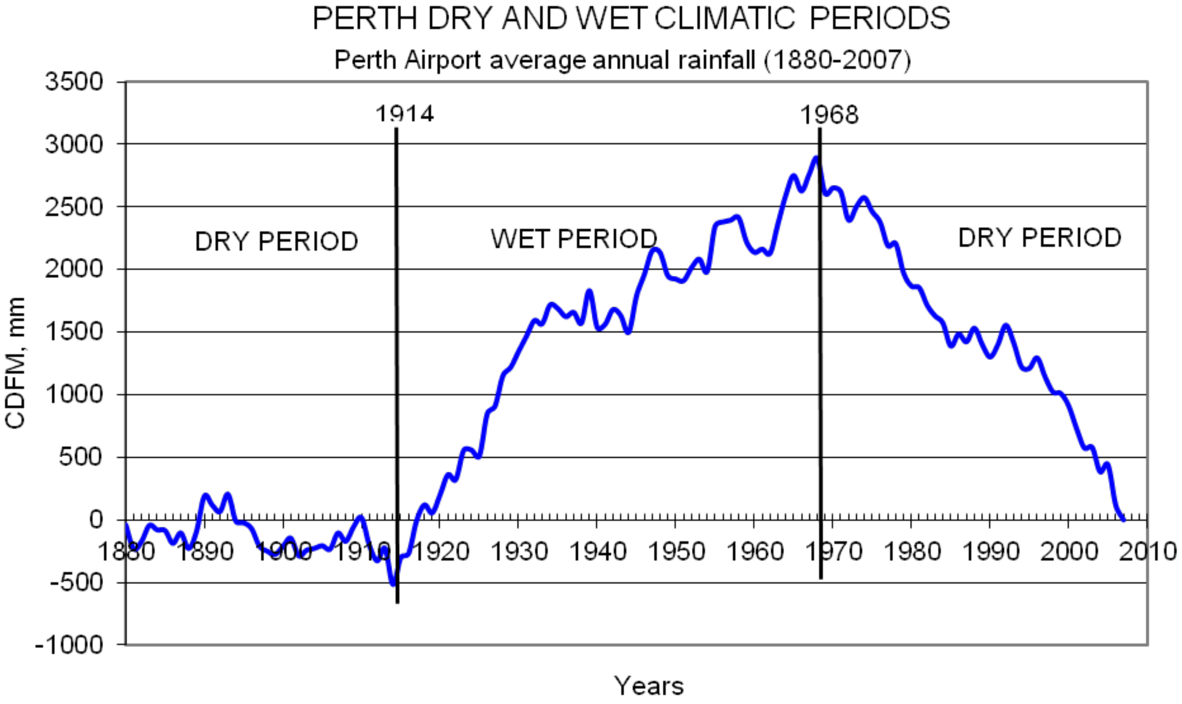


Figure 2 Perth dry and wet climatic periods

The reduction in rainfall for Perth Airport meteorological station can be also seen in Figure 3, which compares the long-term, wet period, and dry period annual mean rainfall values.

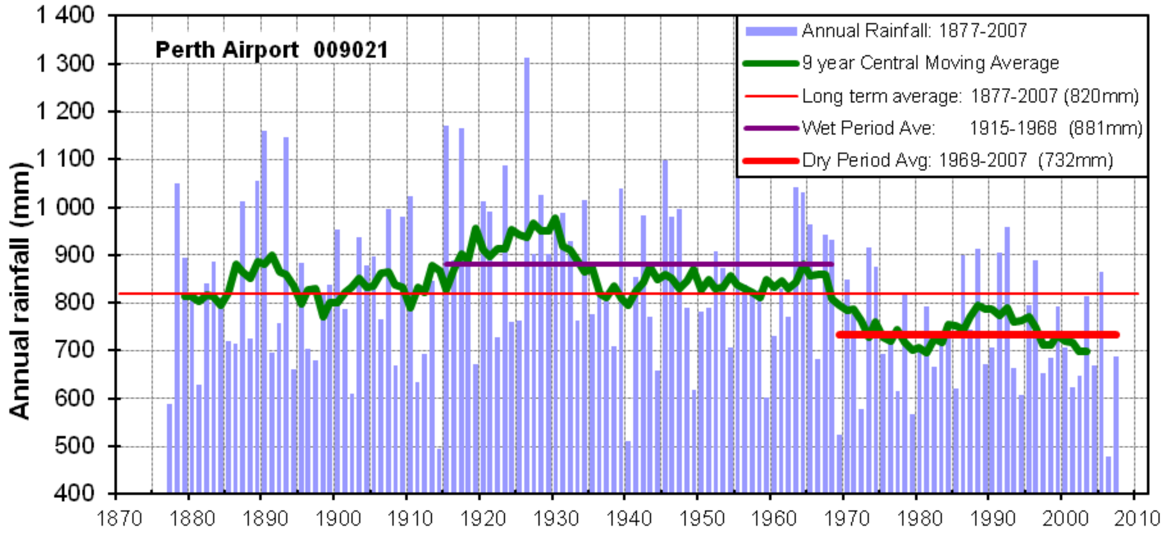


Figure 3 Perth Airport (9021) long-term, wet period and dry period mean precipitation

2.2 Geomorphology

In the Perth region, the Swan Coastal Plain is about 36 km wide in the north and about 23 km wide in the south. It is bounded by the Gingin Scarp and Darling Fault in the east (Figure 4).

The plain is made up of sedimentary materials that originated as a result of river, wind or marine activity. The distribution pattern of the sediments is striking, constituting a series of geomorphic elements, which are sub-parallel to the present coastline (McArthur and Bettenay 1960, Table 1). The most easterly element is the Ridge Hill Shelf, a narrow strip of the colluvial slopes 2 to 3 km wide, which forms the foothills of the Darling Scarp. Extending westward from the foot of the Ridge Hill Shelf is the relatively flat Pinjarra Plain consisting of unconsolidated alluvial sediments. It is up to 12 km wide and is terminated sharply on its western edge by a series of coastal dunes. The most easterly and oldest of these is the Bassendean System which consists of hills of siliceous sand interspersed with poorly drained areas. West of the Bassendean System is the Spearwood System of yellow or brown calcareous aeolian sand, remnant from leaching of the underlying limestone. The Quindalup System of windblown lime and quartz beach sand borders the present coastline.

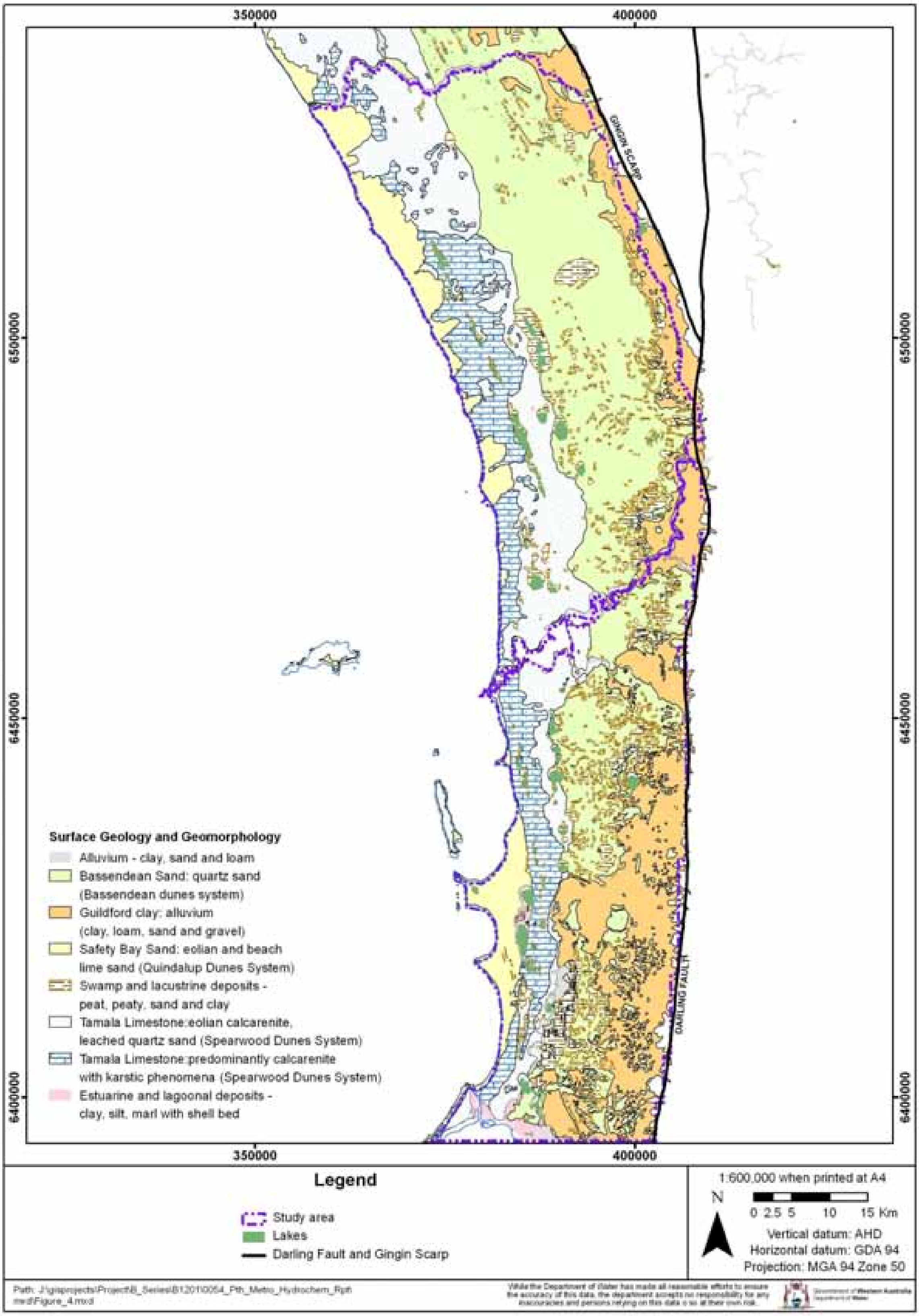


Figure 4 Generalised geomorphology and surface geology (revised from Department of Water GIS spatial database)

2.3 Wetlands

Numerous wetlands (including lakes, rivers, swamps and sumplands) of diverse origin are located in the Perth region. The location of the wetlands is controlled by a combination of geological, climatic and topographical factors that affect the watertable and in turn the extent and persistence of the various wetlands (see Figure 1).

There are four major types of wetlands from a hydrogeological perspective within the Perth region. These are perched wetlands, groundwater recharge lakes, groundwater discharge wetlands and groundwater throughflow wetlands. The relationship between some of these wetlands and the groundwater system has been investigated by Allen (1980), Davidson (1983), Hall (1985), Townley et al. (1993) and Rockwater (2003).

2.4 Land use

The population of Perth in 2006 was about 1 445 000. Most of the population of the region live in suburban areas adjacent to the Swan River estuary, along the coast, and within the south-east corridor south to Armadale. Small urban areas have also developed to the north and south and lie mostly within rural land cleared for agriculture. The remaining bushland comprises mostly state forest and Crown land or reserves, and undeveloped private land adjacent to the coast (Figure 5). Market gardens (horticulture) are located mainly in depressions within the Spearwood Dunes and within low lying areas between the Spearwood and Bassendean dune systems where the soil is commonly peaty. Pine plantations have been developed over large tracts of sandy soil within the Spearwood and Bassendean dunes. Vineyards (viticulture) are located on the loamy soils of the Pinjarra Plain, particularly within the Swan Valley. Fruit trees, including olive groves, have been established on the Dandaragan Plateau and form a rapidly growing industry. Elsewhere, cleared agricultural land is used mainly for grazing.

In recent years, significant residential developments have been taking place along the coastal strip and Perth’s north-east corridor, including Ellen Brook. Extensive urbanisation has also been taking place in Gwelup, Joondalup, Wanneroo, and Lansdale, where market gardens have been subdivided into small residential lots.

Major heavy industrial developments have been established in the Kwinana district. Many smaller industries and commercial areas are located throughout the region.

The more significant centres are shown in Figure 5.

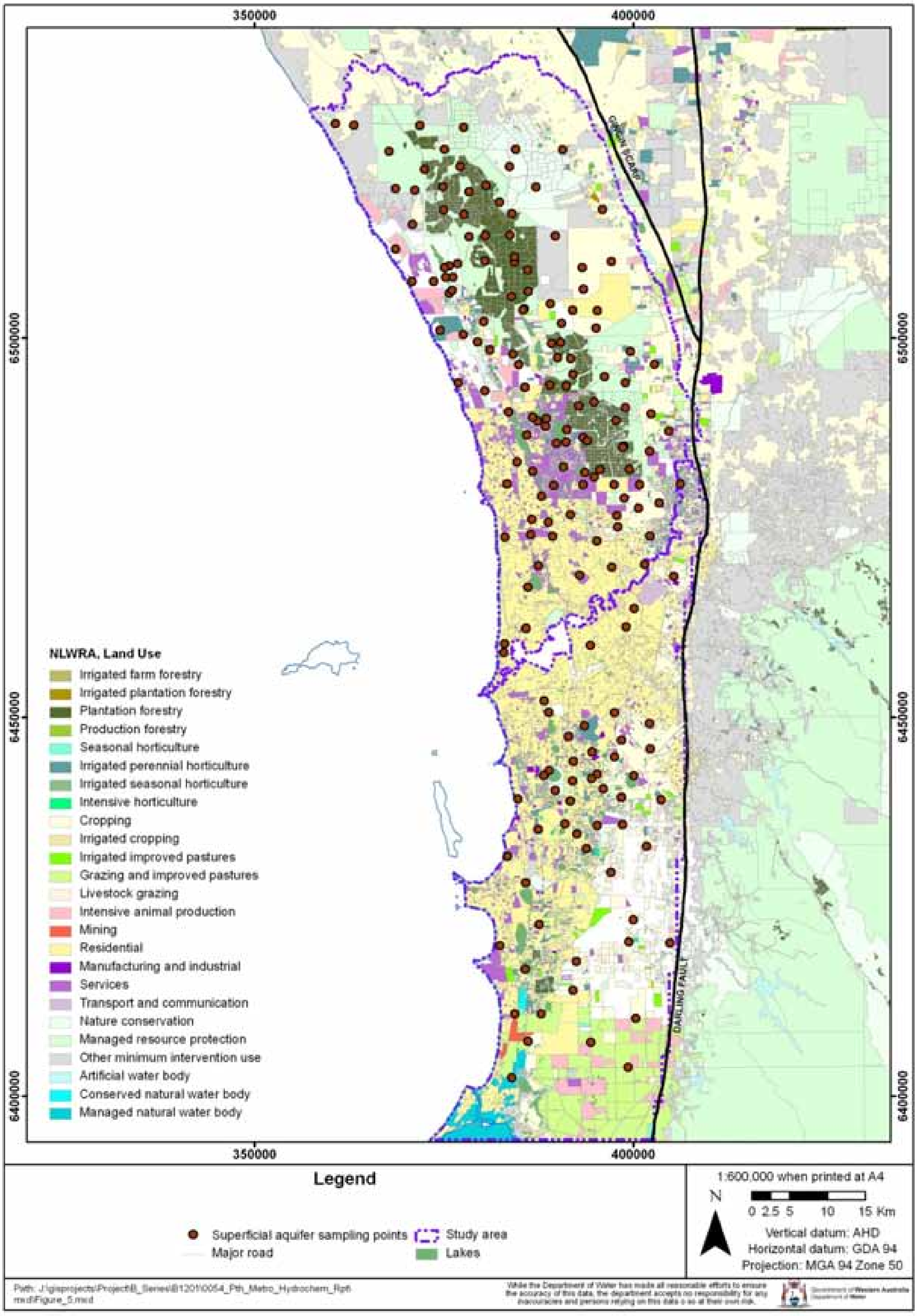


Figure 5 Land use (revised from DoW GIS spatial database)

3 Geology and hydrogeology

3.1 Geology

The study area is covered by late Tertiary to Quaternary superficial formations. These formations unconformably overlie older Mesozoic – Early Tertiary formations. In this study only those superficial formations of hydrogeological significance to the Perth region are described.

The geology of the late Tertiary – Quaternary sediments of the Perth Basin has been described by Playford et al. (1976) and Davidson (1995). These sediments were named as 'superficial formations' by Allen (1976a). The term embraces Safety Bay Sand, Becher Sand, Tamala Limestone, Bassendean Sand, Gnangara Sand, Guildford Clay, Yoganup Formation, and Ascot Formation. These formations consist of up to 90 m thick, laterally and vertically variable sequences of sand, limestone, silt, and clay. Near the coast, the sediments consist of calcareous marine sands and coastal limestone (Tamala Limestone and Safety Bay Sand). Inland, they consist of variable sequences of fine and medium sand with minor silt and limestone (mainly Bassendean Sand) that interfinger with a sequence of clay and clayey sand towards the foothills of the Gingin and Darling scarps (Guildford Clay). The Guildford Clay has also been deposited along river valleys (Davidson & Yu 2007) (See Figure 4).

Ascot Formation

The Ascot Formation consists of hard to friable calcarenite with thinly interbedded sand commonly containing shell fragments, glauconitic and phosphatic nodules near the base of the formation. The sand is fine to coarse grained, very poorly sorted. To the south of Perth thick beds of shelly, silty clay, and thinly bedded glauconitic clay occurs in places near the base of the formation.

The Ascot Formation has a maximum thickness of about 30 m in the northern Perth area and is up to 20 m thick south of Perth, and is known to occur over wide areas at the base of the superficial formations (Figure 6).

Guildford Clay

The Guildford Clay refers to the clayey sediments for the type area in the Swan River valley around Guildford.

The Guildford Clay consists of mostly brown, silty and slightly sandy clay, which interfingers to the west with the Bassendean Sand and Gnangara Sand. It is up to 35 m thick and commonly contains lenses of fine to coarse grained, very poorly sorted conglomeratic and sometimes shelly sand at its base, particularly in the Swan Valley area.

The Guildford Clay is predominantly of fluvial origin. It unconformably overlies Early Tertiary and Mesozoic sediments, and outcrops over much of the eastern Perth region (Figure 6), where it forms the Pinjarra Plain of McArthur and Bettenay (1960) (Davidson 1995).

Gnangara Sand

The Gnangara Sand consists of fine to very coarse grained, very poorly sorted quartz sand and abundant feldspar. This unit is predominantly of fluvial origin.

The Gnangara Sand extends over most of the central Perth region and is readily identifiable from bore logs by the common occurrence of well rounded very coarse grains, sub angular fine to medium grains and feldspar. It has a maximum known thickness of about 30 m.

Bassendean Sand

The Bassendean Sand covers most of the central Perth region (Playford & Low 1972). It consists of leached predominantly medium grained, moderately sorted, quartz sand.

The Bassendean Sand varies in thickness, and has a maximum known thickness of about 80 m. The Bassendean Sand unconformably overlies the Tertiary and Cretaceous sediments. This unit interfingers to the east with the Guildford Clay and conformably overlies the Gnangara Sand. To the west, it is unconformably overlain by the Tamala Limestone (Figure 6). The interfingering stratigraphical relationships of the Bassendean Sand with the Gnangara Sand and Guildford Clay indicate that the formation was deposited under a changing, and at times alternating, fluvial, estuarine and shallow marine environment.

Tamala Limestone

The Tamala Limestone occurs along the coastal strip and consists of calcareous aeolianite (Playford et al. 1976). The Tamala Limestone contains carbonate cemented, predominantly medium grained quartz sand, shell fragments and minor clayey lenses. The limestone contains numerous solution channels and cavities, particularly in the zone where the watertable fluctuates, and in some areas has karstic structures.

Along the coastal strip, the Tamala Limestone varies in thickness, and has a maximum known thickness of about 110 m.

Safety Bay Sand

The Safety Bay Sand consists of white, calcareous medium grained quartz sand and shell fragments with traces of fine grained heavy minerals (Passmore 1967, 1970). The Safety Bay Sand is up to 24 m thick. It lies along the coastal margin as beach sand and mobile dunes (Quindalup Dune System of McArthur and Bettenay 1960).

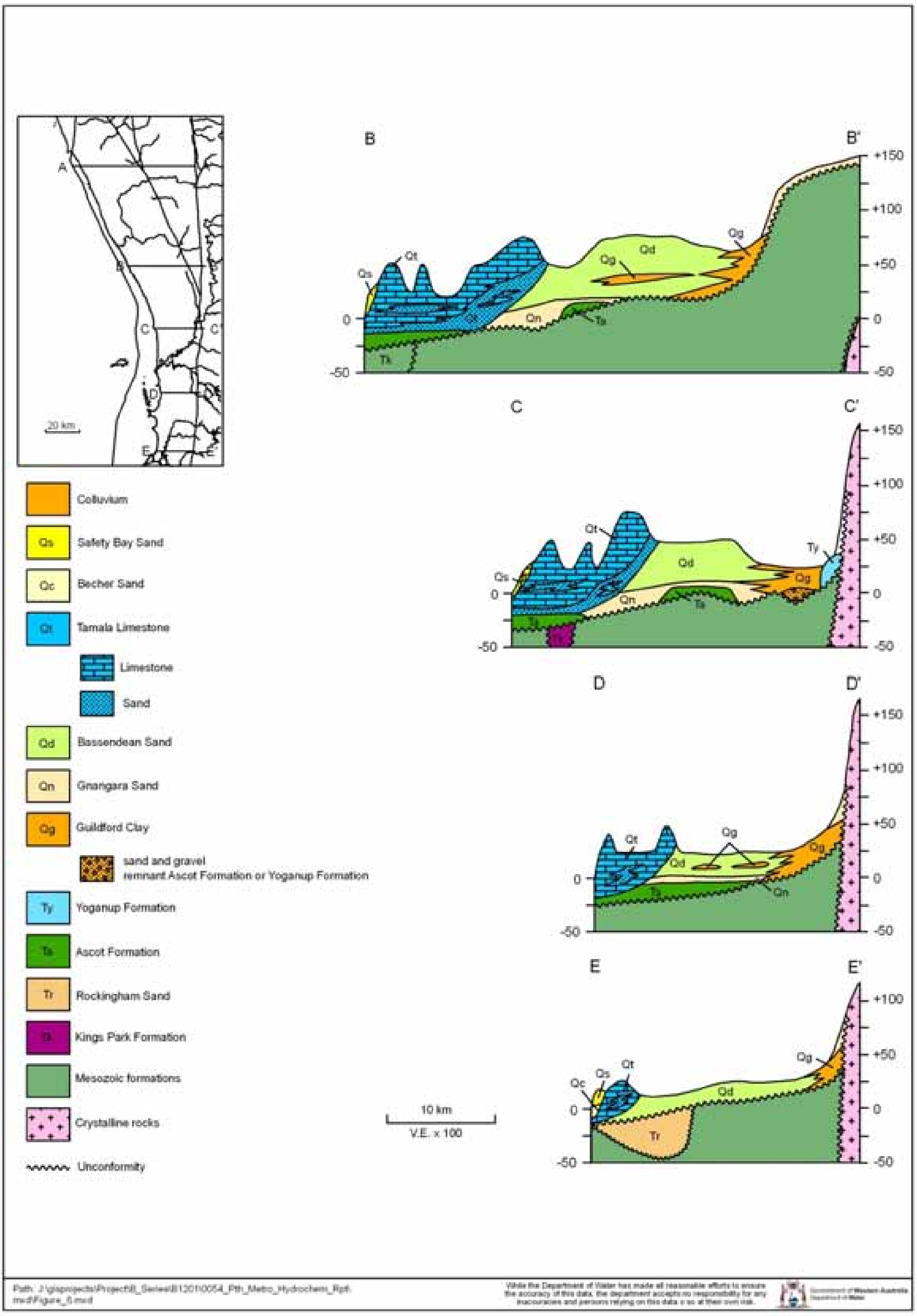


Figure 6 Geological sections showing stratigraphical relationships of superficial formations (revised from Davidson & Yu 2007)

3.2 Hydrogeology

The superficial formations underlying the coastal plain that contain groundwater are referred to as the Superficial aquifer. The Superficial aquifer is bounded to the east by the Gingin Scarp and Darling Scarp and to the west by the Indian Ocean shoreline (Figure 7).

A regional watertable occurs within the aquifer and two major bodies of groundwater; the Gnangara Groundwater Mound to the north of Perth and the Jandakot Groundwater Mound to the south. Other small groundwater areas which form discrete flow systems are also recognised. The groundwater originates from infiltration of winter rainfall across the coastal plain. It moves from the crests of the mounds and elevated parts of the groundwater areas to discharge into low lying areas occupied by lakes and wetlands, into drainage lines, and along the coast where it discharges into the ocean across a saltwater interface. The groundwater in the Superficial aquifer is unconfined and over large areas is in hydraulic continuity with the underlying Mesozoic sediments. In some areas, downward groundwater flow from the Superficial aquifer recharges the Mesozoic sediments, and in other areas upward groundwater flow discharges from the Mesozoic sediments into the Superficial aquifer.

The Superficial aquifer of the Perth region has been divided into discrete hydrogeological areas on the basis of topography, geology, and the discharge boundaries formed by the rivers and the ocean. The Swan River divides the Superficial aquifer into two parts and is a discharge boundary to the system.

The hydraulic properties of the Superficial aquifer vary significantly depending on lithological specifications. The Guildford Clay consists of clayey sediments and has a low hydraulic conductivity of less than 0.4 m/day, although some basal sandy lenses have a hydraulic conductivity of up to 10 m/day. The average hydraulic conductivity is about 15 m/day for the Safety Bay Sand and about 8 m/day for the Ascot Formation (Davidson 1995).

The Bassendean and Gnangara sands represent highly permeable sandy materials. Over the entire area of the Bassendean Sand, hydraulic conductivities for the Bassendean Sand vary between 10 and 50 m/day, with an average of 15 m/day. In the Jandakot area, where the ‘coffee rock’ is generally thicker than elsewhere, the limonite cement may reduce the hydraulic conductivity to less than 10 m/day (Davidson & Yu 2007).

The hydraulic properties of the Tamala Limestone are highly variable. Hydraulic conductivities are estimated between 100 and 1000 m/day where the limestone contains numerous solution channels and cavities (Davidson 1995). Hydraulic conductivity values of up to 1800 m/day were indicated by test pumping in the Yanchep and Two Rocks area (Rockwater 1974). However, the average horizontal hydraulic conductivity is influenced mostly by the low conductivity beds or sandy facies and may be about 50 m/day (Davidson & Yu 2007).

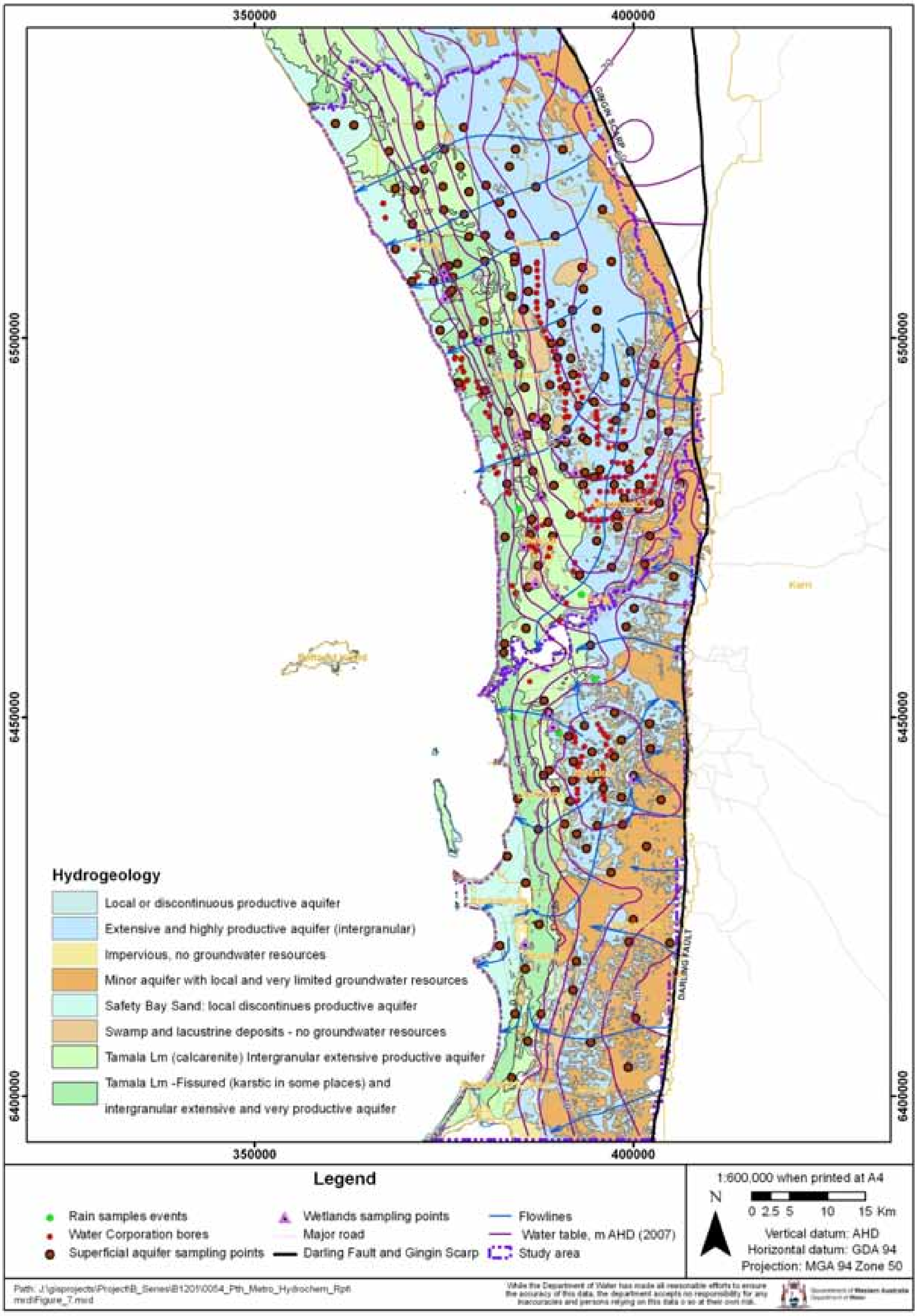


Figure 7 Hydrogeology of the Perth metropolitan area

Groundwater in the Superficial aquifer flows by gravity down the hydraulic gradient, away from the crests of the groundwater mounds and foothills of the Dandaragan and Darling plateaus. The direction of flow is indicated in Figure 7 by the arrows on the flowlines, which terminate at the discharge boundaries formed by the major drainages and the ocean, and locally by some of the wetlands.

The hydraulic gradients vary across the coastal plain mainly because of the variations in hydraulic conductivities, but also because of areal variations in rainfall recharge and the location of groundwater discharge boundaries. In the eastern area of clayey sediments, the hydraulic gradients are relatively steep in comparison with those in the central sandy area of the coastal plain. In the central sandy area, the hydraulic gradients are relatively uniform. In the western area, at about the contact between the lower permeable Bassendean Sand and the more highly permeable Tamala Limestone (Figure 4), and roughly coinciding with the north–south trending linear chain of lakes, the hydraulic gradients are relatively steep. This is also partly due to the high hydraulic conductivities (50 to 1000 m/day) of the Tamala Limestone to the west, which facilitates groundwater flow in this direction, resulting in a draining effect of the groundwater from the east and the steeper gradients (Davidson & Yu 2007).

Wetlands also affect the configuration of the watertable. Some wetlands, for instance Lake Mariginiup, Lake Nowergup and Lake Wilgarup, have limited hydraulic connection with underlying groundwater because of intervening clayey sediments, therefore lake levels can be higher or lower than surrounding groundwater levels. Lake Loch McNess, Lake Yonderup, Lake Wilgarup, Pipidinny Swamp, Coogee Swamp, Lake Carabooda, Lake Nowergup, Lake Neerabup, Lake Joondalup Goollelal, occur within interdunal depressions with prominent karstic phenomena. Wetlands on the Spearwood Dunes (e.g. Lake Loch McNess, Lake Yonderup, Pipidinny Swamp, Lake Nowergup, Lake Joondalup and Lake Goollelal) are permanent lakes, which are surface expressions of the watertable (Rockwater 2003).They are also considered as groundwater throughflow lakes

Recharge to the unconfined aquifer is mainly from rainfall percolation, even though some limited recharge from direct rainfall occurs through the lake system. Rainfall recharge estimations were conducted in a number of studies since 1970 (Davidson 1995). Recharge rates estimated by different studies, which relate to the study area, are given in Table 1.

Some recharge to the Superficial aquifer also occurs by upward leakage from underlying aquifers where confining beds are absent and where piezometric head is higher than the watertable.

Table 1 Estimated recharge to the Superficial aquifer in Perth metropolitan area

Study	**Rainfall recharge estimated**	**Comments**
Bestow 1971	7.3% of the mean annual rainfall over the Gnangara area	From Davidson (1995)
Allen 1976a	8.5% of the rainfall in the northern area, 5.5% in the southern area	From Davidson (1995)
Sharma and Pionke 1984	12% of rainfall over native bushland, 0% beneath a mature pine plantation	From Davidson (1995)
Davidson 1984a 1987	14% of rainfall in the southern area, 13% in the northern Perth Area	From Davidson (1995)
Sharma et al 1988	50–60% of rainfall on land used for pasture	From Davidson (1995)
Thorpe 1989	21% of rainfall near the crest of the Gnangara Groundwater Mound	From Davidson (1995)
Farrington and Bartle 1989	20–22% of rainfall for Banksia woodland area	From Davidson (1995)
Sharma et al 1991b	40% of rainfall over the market garden area to the north of Perth	From Davidson (1995)
Cargeeg et al 1987	About 21% of rainfall beneath the urban area	From Davidson (1995)
Davidson 1995	About 11% of rainfall over the Gnangara Groundwater Mound (north), 15% of the annual rainfall beneath the relatively high limestone area	From Davidson (1995)
Hatton et al 2001	Waves model: banksia area 24%, pine mature 8–12%, pasture 50% of rainfall	Recharge estimated using WAVES model
Salama et al 2002	2–20% of rainfall (10–150 mm/yr) for the Spearwood Sand under Banksia, 12–25% (110–202 mm/yr) for Bassendean Sand under pine	Recharge has been estimated using short-term water level fluctuations for the 1998–99 season
Xu et al 2005	22% of rainfall in Banksia, 45% in pasture, 40% in market garden, 0–28% in pine areas depending on density, and ~55% in urban areas	PRAMS VFM module recharge estimation
Davidson and Yu 2007	The net recharge to the Superficial aquifer within the groundwater mounds is between 10% and 40% of the annual rainfall, with an average of about 20%	Figure 81 in the report is conflicting with the net recharge rate given in text
Yesertener 2009	About 28% of the rainfall over the Gnangara Groundwater Mound (25–30% reduction in net recharge in pine plantation area)	The annual net recharge rates calculated for different rainfall zones and the total net recharge to Gnangara Groundwater Mound since 1889 using the CDFM technique.

Groundwater hydrograph analysis showed that groundwater and wetland levels on the Gnangara and Jandakot groundwater mounds have been declining since 1969.

Yesertener (2002, 2009) studied the reason for this decline in groundwater levels, and quantified the effects of climate, land use and groundwater abstraction.

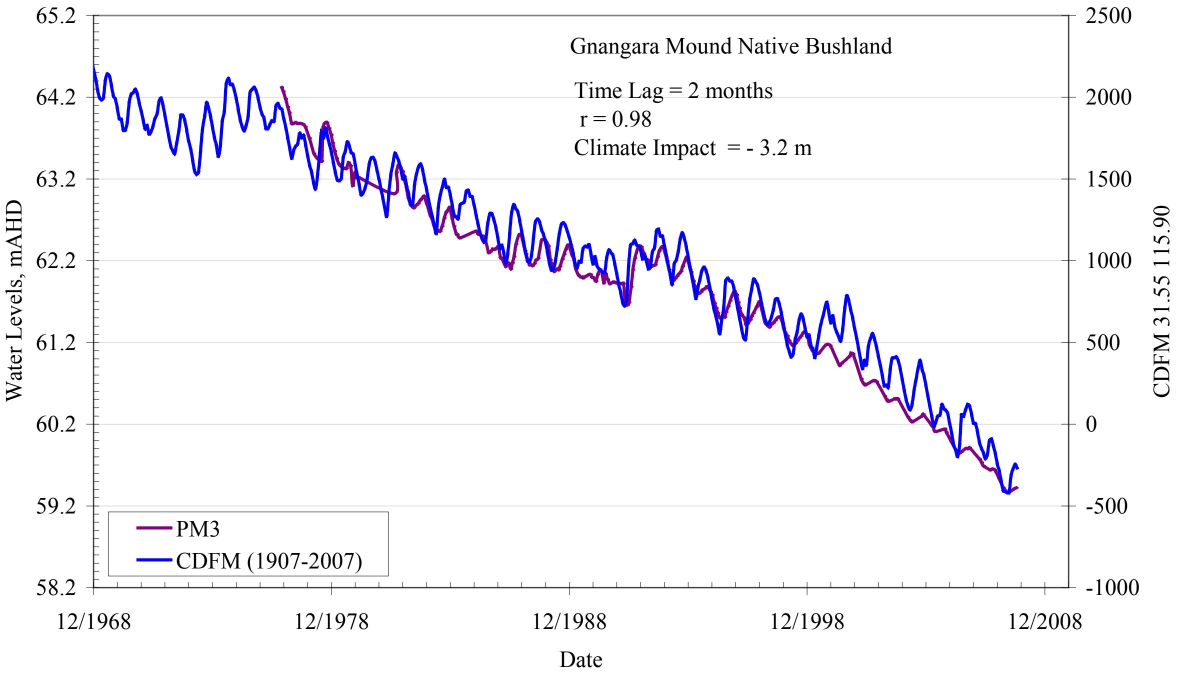


Figure 8 PM3 groundwater hydrograph evaluation using CDFM graph of Silo rainfall data next to the bore

This study concluded that the reduced rainfall is the major cause of the reduction of groundwater levels on the Gnangara Groundwater Mound since 1969, with falls of up to 4 m over the 1979–2005 period (Figure 8). The cumulative long-term impact of abstraction is centred on the Pinjar, Wanneroo, Gwelup and Mirrabooka borefields with maximum declines of 2.4, 2.0, 3.0 and 1.5 m, respectively. The Gnangara pine plantation has resulted in groundwater decline in the order of 3.5 m over the same period where pines are particularly dense. Impact areas of climate, abstraction and pine trees have been mapped (Yesertener 2009).

Groundwater moves very slowly through the Superficial aquifer and it is eventually discharged at the hydraulic boundaries formed by the rivers, the ocean and some of the lakes. Groundwater in the Superficial aquifer also discharges through natural and constructed drainages into wetlands and at springs. Some discharge takes place offshore from springs connected to solution channels within the Tamala Limestone.

At the end of its flow path, groundwater discharges into the ocean, Peel Inlet, and the Swan River estuary over a saltwater wedge that forms the interface between land- and ocean-derived groundwater. The elevation of the watertable near the coast is controlled by the ocean level and the prevailing climatic conditions over the recharge area to the east.

4 Hydrogeochemistry

Bores and wetlands sampled between 2003 and 2007 within the Perth metropolitan area between Gingin in the north and south to Mandurah are shown in Figure 1. This is the first in depth, spatially extensive and continuous hydrogeochemical survey of the metropolitan area’s groundwater on a basin-wide scale since Davidson (1995). It was needed so we can assess what detrimental effects are or have been occurring, due to past and present groundwater consumption patterns, climate variations, and land-use changes.

The study was extended to cover environmental isotopes and groundwater dating, to better understand the recharge to the Superficial aquifer. Environmental isotopes and other tracers, including CFC and SF6 survey results, are the subject of a further report that covers the use of tracers to determine, groundwater age, and recent rates of recharge to the Superficial aquifer.

4.1 Previous studies

The published reports and documents that were reviewed and examined in this study are summarised in Table 2.

Yesertener (2006) evaluated the hydrogeochemistry of the Superficial aquifer for the Yanchep Caves, including the saturation indexes. The study clearly indicated that the groundwater is NaCl type within the Bassendean Sand towards the east and gradually mixes with a $CaHCO_3$ type of groundwater while passing through the Tamala Sands. The concentrations of Ca and HCO_3 ions gradually increased down hydraulic gradient within the Tamala Sands and become dominant westward within the Tamala carbonate aquifer. Examination of the Ca saturation indexes shows that groundwater within the calcareous sands is not saturated with calcite although groundwater within the limestone is saturated or close to saturation.

Barber (2003) also showed that the carbonate aquifer under and in the vicinity of the cave system is undersaturated with regard to calcite, except in some ponds in Crystal Cave.

Turner and Townley (2006) determined the groundwater flowthrough regimes of shallow lakes and wetlands from the numerical analysis of stable isotopes and chlorine tracer distribution patterns at three locations. The study of Lake Nowergup, Jandabup Lake and Thomson Lake concluded that no other technique is better than the use of isotopic and hydrogeochemical data in interpreting the interaction between lakes or wetlands and regional aquifers. This is because it is very difficult to make sufficient physical or hydraulic measurements at meaningful temporal and spatial scales in the field that allow an understanding of lake–aquifer interaction. In comparison, the natural isotopes of water (^2H and ^{18}O) and conservative solutes, such as chloride, provide clear evidence for groundwater flow pathways.

Bekele (2006) has completed a review and evaluation for the Water Corporation of water quality data for the Superficial aquifer. The study area of 550 km^2 was bounded to the west by the Indian Ocean, extending inland to east of Lake Pinjar, and from the northern end of Lake Joondalup in the south to the town of Two Rocks in the north. She has compiled water quality data for bores in the Superficial aquifer from a range of available sources, but primarily the Department of Water's water information database. The main outcome is the final database containing data from 15 431 water samples collected from four lakes and 571 bores in the Superficial aquifer. The database included data from the department's WIN database, from Townley et al. (1993a), the sampling data from the Water Corporation borefields, and various hardcopy reports acquired from Rock Water and the Water Corporation. The data review was focused on areas having potential for managed aquifer recharge.

The *Perth groundwater atlas* (2004) has been designed to encourage responsible use of groundwater through the use of garden bores in the Perth metropolitan area and gives brief general information on groundwater quality, including generalised groundwater salinity and potential acid sulphate soil risk.

Sharma and Craig (1989) evaluated the environmental tritium method as a tool for assessing total and net recharge rates to the Gnangara Groundwater Mound. The study area was located in Melaleuca Park. The average long-term net recharge was estimated over 28 years using the tritium interface method together with estimates based upon the chloride ratio method. Tritium depth profiles in the saturated zone have provided realistic estimates of long-term net recharge ranging from 13 to 43% of rainfall, similar to values estimated by the chloride ratio method.

Cargeeg et al. (1987b) conducted a study of the Perth urban water balance which included a synopsis of a PhD project undertaken by Bawden (1991) on groundwater quality transformations in the Perth region. Groundwater sampling within the unconfined aquifer was conducted between 1984 and 1986 from bores along a flow line that starts near the crest of the Gnangara Groundwater Mound and continues through the public water supply bores for Wanneroo, Mirrabooka and Gwelup.

Townley et al. (1993a, b) provided recommendations on management issues such as the rates of solute and nutrient transport into shallow lakes and groundwater pumping strategies for artificial maintenance of lake levels.

Townley et al. (1993c) studied the wetlands of the Swan Coastal Plain focusing on flowthrough lakes, which have an up-gradient capture zone for groundwater and which discharge lake water on their down-gradient side. The report used chemical and isotopic tracers to the outflow or release zones from Lake Nowergup, Lake Mariginiup, and Jandabup Lake. Moreover, their study revealed that outflow from Lake Pinjar becomes inflow to Lake Nowergup, located about 6 km down-gradient.

Davidson (1995) describes the variations in the groundwater quality of the Superficial aquifer relative to geological location and position within the groundwater flow system. He includes a table of water quality data obtained in 1992 for production bores on the Gnangara Groundwater Mound, including the Gwelup, Mirrabooka, Wanneroo, Two Rocks and Yanchep bores. However, the tabulated data are described as 'representative' and considerably more data was used to construct the water quality maps. Water quality data was interpreted and presented as contours for sulfate, phosphorus, turbidity, and nitrate concentrations in the Superficial aquifer.

Several publications have examined the water quality immediately surrounding wetlands on the Gnangara Groundwater Mound. These include a study on Jandabup Lake by Allen (1980) and another on Lake Mariginiup by Hall (1985). These studies examined groundwater salinity plumes extending down-gradient of the lakes due to high evapotranspiration losses from the wetlands.

Table 2 Summary of published documents related to study area (after Bekele 2006)

Data source	Description	Contribution
Allen 1980	Hydrogeology of Jandabup Lake	Standard groundwater analyses reported for 23 bores surrounding Jandabup Lake in 1978.
Hall 1985	Hydrogeology of Lake Mariginiup	Standard groundwater analyses reported for 21 bores surrounding Lake Mariginiup in 1979–80 and 1 lake sample.
Cargeeg et al 1987b	Perth urban water balance; Appendix summarises a PhD project by Bawden (1991)	Analysis of geological and land-use factors influencing water chemistry along a flow line connecting recharge on the Gnangara Groundwater Mound to discharge at the Indian Ocean.
Sharma 1989	Net recharge to Gnangara Groundwater Mound	Tritium depth profiles in the saturated zone have provided realistic estimates of long-term net recharge ranging from 13 to 43% of rainfall, similar to values estimated by the chloride ratio method.
Townley et al 1993a, b	Consultancy reports that describe hydrochemistry along transects through Lake Nowergup, Lake Pinjar, Jandabup Lake, and Lake Mariginiup	Hydrochemistry data, including oxygen-18 and deuterium isotope data for groundwater bores and Lake Nowergup. Recommendations on solute and nutrient transport into shallow lakes and artificial maintenance of lake levels
Davidson 1995	Summarises spatial trends in water quality sampled in 1992 from production bores in the Superficial aquifer	Contours showing trends in the concentrations of nitrate, sulfate, and phosphorus as well as groundwater turbidity.

Data source	Description	Contribution
Perth groundwater atlas 2004	Perth Groundwater Atlas has been designed to help and encourage responsible use of groundwater through the use of garden bores in Perth metropolitan area.	Gives generalised brief information on groundwater quality including generalised groundwater salinity and potential acid sulphate soil risk .
Bekele 2006	Compilation of water quality data for the Superficial aquifer bores from a range of available sources, but primarily the Department of Water's water information database	The main outcome is the final database containing data from 15 431 water samples collected from four lakes and 571 bores in the Superficial aquifer.

Hall (1985) provides water quality data for Lake Mariginiup sampled in May 1979, as well as 21 bores completed in the Superficial aquifer. The bores were sampled after development in May 1979 and again in April 1980. Standard water quality analyses are reported, including major ions, some metals and nutrients.

Allen (1980) studied Jandabup Lake and included data for 23 bores completed in the Superficial aquifer and standard groundwater analyses for samples collected in May 1978.

There are currently two Department of Water projects that involve the collection of groundwater samples for hydrochemical and isotope analysis. One of the projects has recently drilled and sampled bores in North Gnangara from which a comprehensive isotope and hydrochemistry report is being prepared. The other project focuses on the interactions between the shallow groundwater system and nearby wetlands within the Jandakot and Gnangara groundwater mounds. New bores were drilled and monthly groundwater samples collected for hydrochemical analysis. Data will be collected and evaluated for a complete year (McHugh 2009 pers. com.).

4.2 Sampling sites

The sampling program for this study included over 250 Superficial aquifer monitoring bores, 22 lakes and wetlands and 18 rainfall sites within the Perth metropolitan area between Gingin in the north and Mandurah in the south. The sampling program, which started in 2003, was extended till 2007. Some bores that were sampled in 2004 have been re-sampled because the laboratory results were not within acceptable accuracy limits. The sites whose chemical analysis had an acceptable accuracy are shown in Figures 9 and 10. Site details for the sampling points including the sampling date are provided in Appendix A.

Groundwater sampling

The chemical composition of groundwater depends on a number of factors including precipitation, biological and chemical reactions occurring on the land surface and in the soil zone, and the mineral composition of the aquifer and confining beds through which the water moves.

The most common dissolved mineral substances are silica (SiO_2) and the 'major ions' sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium(K^+), chloride (Cl^-), bicarbonate (HCO_3), and sulfate ($SO4^{2-}$) (Fetter 1994). All of these ions are usually present at concentrations greater than 1 mg/L. Routine chemical analyses of water samples report these constituents and sometimes secondary ions (minor ions) that can include iron (Fe^{2+}), nitrate (NO_3^-), ammonium (NH_4^+), phosphate (PO_4^{3+}), bromide (Br^-) and arsenic (As) (see Table 3).

Table 3 Sampling requirements for major and minor constituents for laboratory analysis

Ions	Sample volume	Preservation	Sample filtration
Major cations: Ca, Mg, Na, K NH_4, PO_4, SiO_2	500 mL plastic	Acidified with HNO_3 Store at 4 °C	Filtered in the lab or field
Major anions: HCO_3, CO_3, Cl, SO_4, NO_3	500 mL plastic	No preservation Store at 4 °C	No filtration
Minor constituents: Fe^{2+} Br As	125 mL plastic	Acidified with HNO_3 Store at 4 °C	Filtered in the field
Environmental isotopes: O-18 H_2 (deuterium)	125 mL tightly sealed with minimal headspace	No preservation Store at 4 °C	No filtration
Other tracers: CFC 11 and CFC 12 C13 and SF6	125 mL tightly sealed with no head space, glass bottle, submersible sample	No preservation	No filtration

Two steps were taken before collecting a water sample. Firstly, the depth to water and total depth of a bore was measured from the surveyed reference point. Secondly, the bore was evacuated to remove stagnant water, which may not have been representative of flowing groundwater in the aquifer. Bore evacuation is performed by removing three times the volume of water standing in the bore casing or the removal of enough water until the pH, electrical conductivity and T parameters become stable. The water level in an evacuated bore is allowed to recover to the original level before sampling. Details of groundwater purging and sampling procedures for monitoring bores have been given in reports HR 213, 219 and 227 (Yesertener 2003, 2004). Site information and physico-chemical characteristics of the Superficial aquifer bores sampled are given in Appendix A.

Wetlands sampling

Numerous wetlands (such as lakes and sumplands) of diverse origin are located on the Swan Coastal Plan. The location of the wetlands has been determined by a combination of geological, climatic and topographical factors that affect the watertable and in turn the extent and persistence of the various wetlands. Some wetlands are closed basins, while others such as Lake Herdsman have a surface outlet so that the lake acts as a holding and mixing basin for the surface water and groundwater. The detention time of water in a wetland provides an opportunity for slow reactions to come closer to completion than they can in the rapidly moving water of a river. Mixing, however, may not be complete, so at any given time the water in one part of the wetlands may be greatly different in composition and properties from that in other parts of the lake.

Water stored in lakes and reservoirs commonly is not uniformly mixed. Thermal stratification and associated changes in water composition are among the most frequently observed effects. Single samples from lakes or reservoirs can be assumed to represent only the spot within the water body from which they came.

The effect of stratification on water composition is noticeable in the concentrations of ions whose behaviour is influenced by oxidation and reduction, the reduced species commonly increasing in concentration with depth below the surface and assuming particulate form in oxidising shallower water. The components that are used by life forms in the water also are often considerably affected. In the study there are only single samples taken from wetlands that represent only the spot sampling point. However, they can give some overall information on salinity and pH to compare to groundwater beneath it.

Wetlands, of which only 17 have permanent water, have been sampled close to the water level monitoring points (Appendix B).

Rainfall sampling

Rainwater is the source of most groundwater and is a logical starting point for the study of groundwater geochemistry. The chemical makeup of rainwater is dominated by oceanic salts and it resembles strongly diluted seawater. In order to show the areal distribution of the composition of rainwater, rainfall samples were collected at the 19 sites shown in Figures 9 and 10. Rainfall analyses were mainly used in this study to estimate percentage recharge using chloride and to determine the sources of ions.

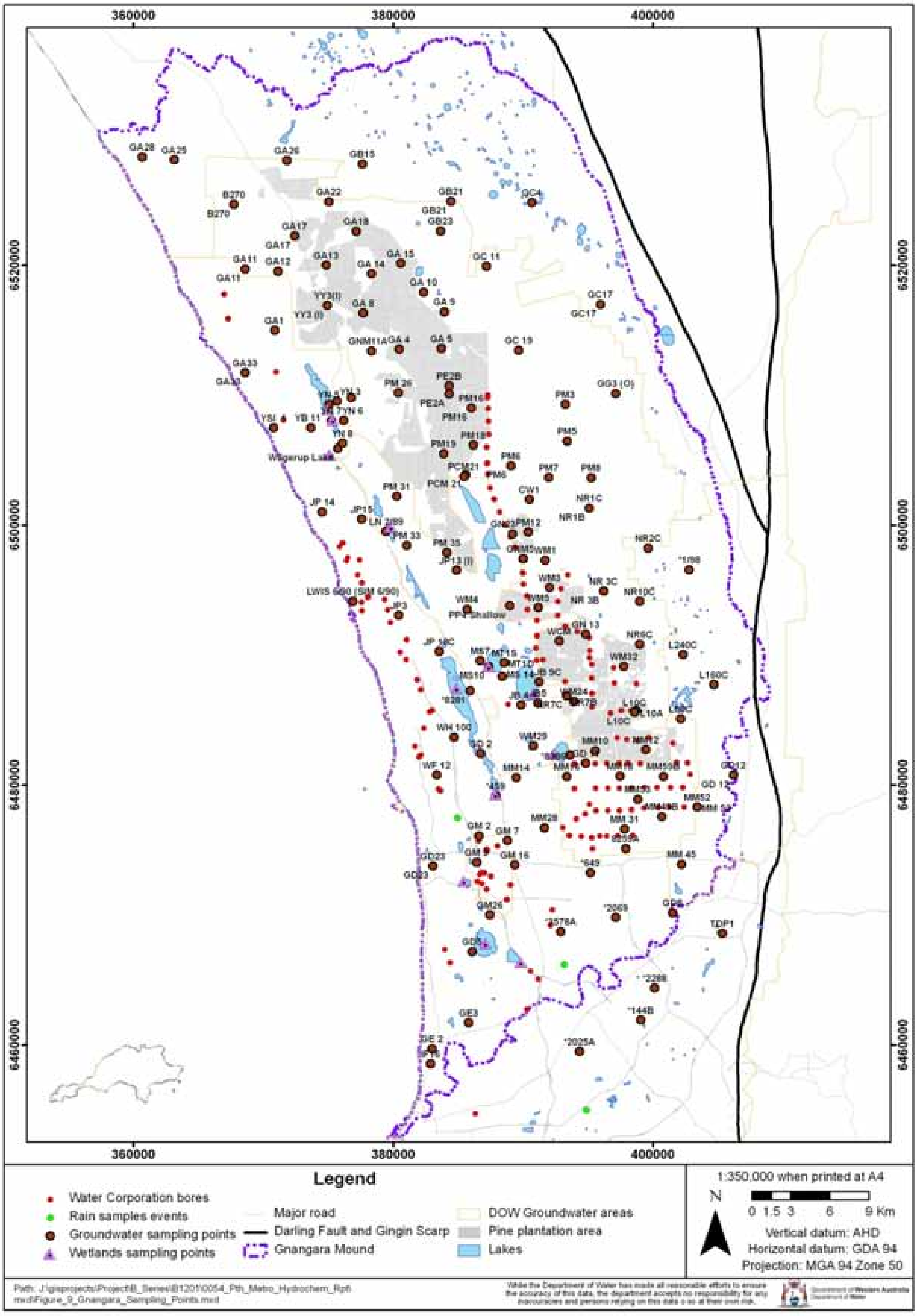


Figure 9 Superficial aquifer north sampling points

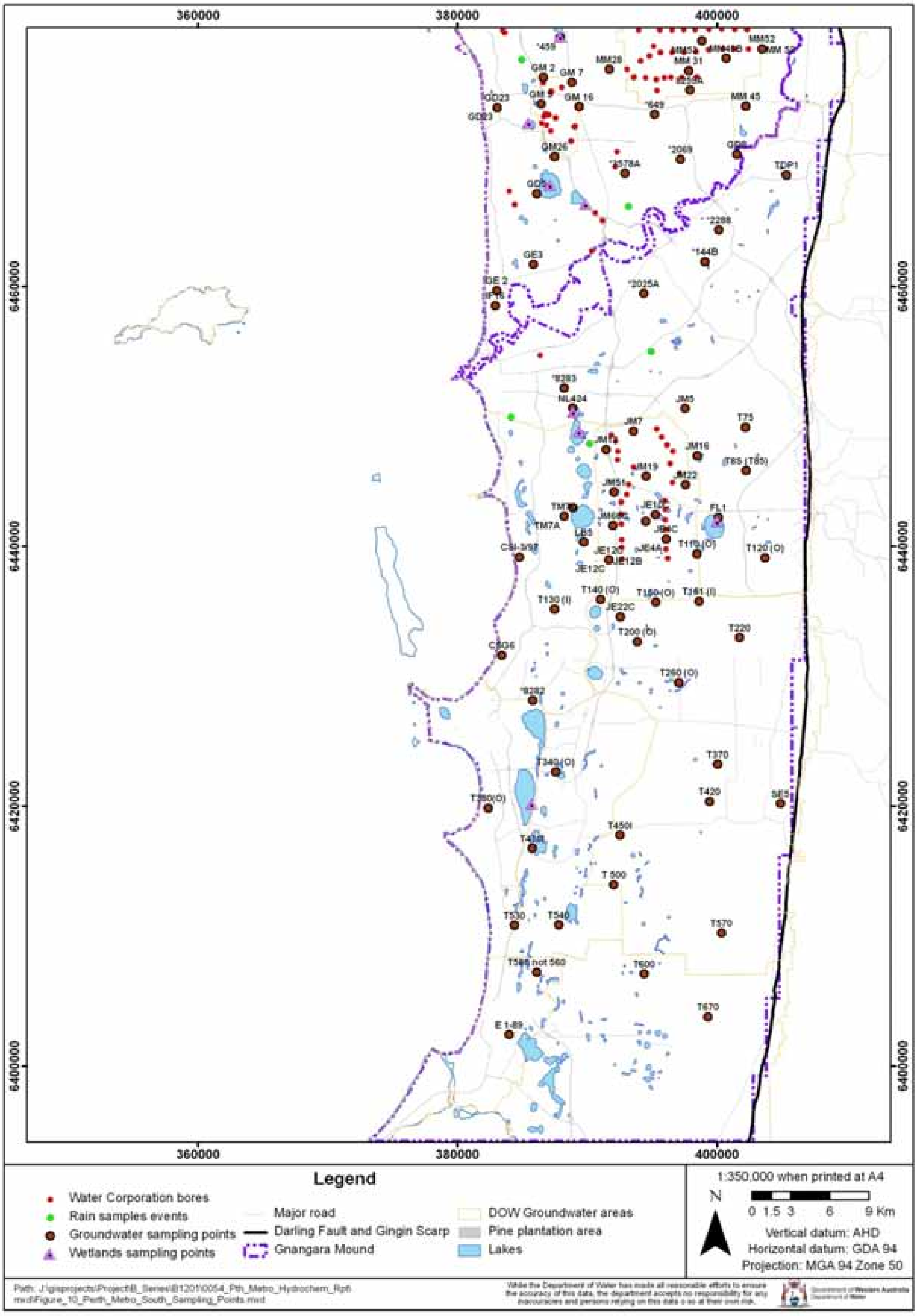


Figure 10 Superficial aquifer south sampling points

4.3 Analysis of water samples

The analysis of water for dissolved components for this study was undertaken by SGS Environmental, Curtin University and the National Measurement Institute. The standard methods used for the water analysis will not be discussed in this report. Comments will be made on some of the procedures for field testing and exploration.

Field testing of water and significance of properties

Testing of water in the field is an important part of hydrogeochemical studies. Field measurements were carried out for pH, electrical conductivity (EC), reduction potential (Eh), dissolved oxygen (DO) and temperature that are measured by electrode, and sometimes also for alkalinity (CO_3 and HCO_3).

Electrical conductivity (EC) measurements are particularly useful as a control on analysis and conservation of samples. EC values measured in the field and in the laboratory should agree within approximately 5 to 10%. Differences beyond this range indicate a chemical reaction following the collection of the water sample. The lower EC in the laboratory test can be related to the amount of material precipitated.

Eh measurements were not done with a flowthrough sampler, so they only give a qualitative indication of the redox conditions, and hence should not be related to anything quantitative (Appelo & Postma 2005).

The pH of a sample is so closely related to the environment of the water that it is likely to be altered by sampling and storage, and meaningful values can be obtained only in the field (Hem 1970, 1992).

Figure 11 compares pH measurements carried out immediately in the field with later laboratory measurements and shows substantial differences.

The results showed that field pH values were generally higher or lower than the laboratory pH values by as much as +/- 1 pH unit or more. Disagreement between field and laboratory pH measurements places a question mark over the reported concentrations of ions that are biologically involved, such as HCO_3, SO_4, NH_4 and Ca. In the same analysis the reported concentration of more conservative ions – Cl, Na, and K may be correct (Mazor 2004). Differences between field and laboratory measurements occur for numerous reasons. Field values of pH are commonly lower than laboratory values because collection, transport, or storage causes a release of dissolved carbon dioxide from the water into the head space of the sample container, and from there into the atmosphere when the container is opened. Lower laboratory pH values than field values can result from natural oxidation of dissolved ferrous ions to ferric ions forming hydroxide precipitates that can adsorb other metals. Oxidation typically lowers the pH through the formation and precipitation of hydroxides, thereby releasing hydronium ions into the water. The correlation coefficient between field and laboratory pH values is higher than $r = 0.80$, indicating that laboratory results are reasonably reliable, but some correction may be required when the difference is greater than +/- 1 pH unit.

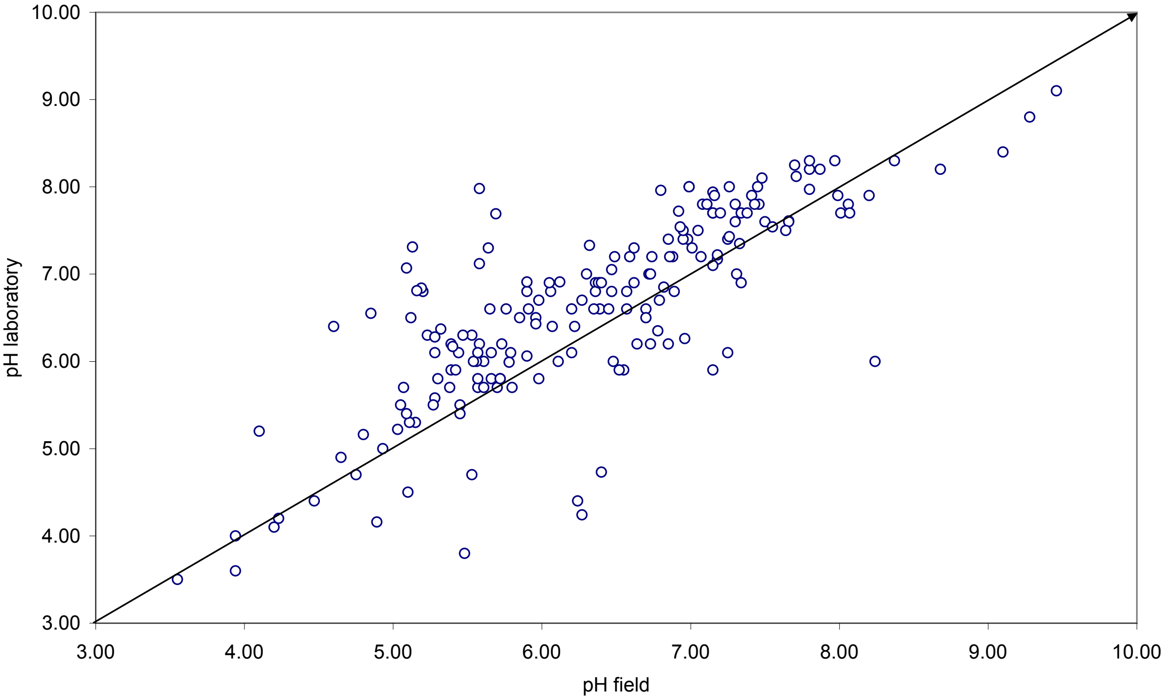


Figure 11 Comparison of field and laboratory measurement of pH

Field parameters measured on site are given in Appendices A and B. These values have been used to calculate missing of total dissolved solids (TDS) values, which a laboratory did not report at the time the sample was analysed.

The initial concentration of dissolved oxygen in groundwater can be computed for each study area (Mazor 2004). A figure showing the concentration at ocean level (1 atmosphere) as a function of the average annual temperature is given in Mazor (2004, p. 175). The average annual temperature for the Perth metropolitan area is about 19 ^{o}C. Air-saturated groundwater at ocean level at 19 ^{o}C contains 9.05 mg O_2/L. At an altitude of 100 m AHD, which is the average maximum recharge elevation for the Gnangara Groundwater Mound, it contains 9.05 x 0.985 = 8.91 mg O_2/L. Comparison of the calculated initial oxygen concentration with the value measured in the field reveals the fraction retained. The missing oxygen has been consumed by oxidation of rocks and biological activities. The rate of oxygen consumption depends on the aquifer lithology, occurrence of pyrite and other oxygen consuming minerals, and the availability of organic compounds and nutrients needed for oxygen consuming biological activities.

The consumption of dissolved oxygen serves also as a semi-quantitative age indicator. Older water tends to have lost most or all of its dissolved oxygen. Pollution by sewage effluent and other organic compounds can also result in consumption of the dissolved oxygen.

Accuracy of chemical analysis

During the hydrochemical survey undertaken for this study between 2003 and 2007, three different contractors were employed for sampling, and also three different laboratories used for analysis of the samples. Although the samples were delivered to the laboratories within the accepted time frame of 24 hours, some laboratory response times were longer than required turnaround of five days.

Measured chemical parameters values are not absolute, but are obtained with a certain degree of uncertainty. The uncertainty is caused by the combined effect of several error sources. In general, two types of errors are discerned in laboratory chemical analysis. Precision or statistical errors reflect random fluctuations in the analytical procedure while accuracy errors display systematic deviations due to faulty procedures or interferences during the analysis (Appelo & Postma 2005). The analytical error is a cumulative outcome of all errors involved in a measurement. The precision can be calculated by repeated analysis of the same sample.

The sum of cations equals the sum of anions in each solution. The deviation from such equality provides another way to assess data quality. The equation used is:

$$\text{Electrical balance (EB, \%)} = \frac{(\text{Sum cations} + \text{Sum anions})}{(\text{Sum cations - Sum anions})} \times 100$$

where cations and anions are expressed as milliequivalents per litre (meq/l).

The sums are taken over the cations Ca^{2+}, Na^{+}, Mg^{2+} and K^{+}, and the anions HCO_3^{-}, SO_4^{2-}, Cl^{-} and NO_3^{-}. Sometimes other elements contribute significantly, for example ferrous iron (Fe_2^{+}) or NH_4^{+} in reduced groundwater, or in acid water H^{+} and Al^{+3}. The electrical balance was calculated for each sample using AquaChem v5.1 software. Differences in EB of over 5% have been examined using the AquaChem software. This has often led to the HCO_3^{-} anion being recalculated because precipitation as calcite occurred when CO_2 escaped from the sample bottle due to delays in laboratory analysis. If the EB difference was greater than 20%, then the groundwater was re-sampled for additional analysis.

4.4 Interpretation of hydrochemical data

The sources of ions in groundwater are (Hem 1970; Freeze & Cherry 1979):

- oceanic salts in rainwater
- dissolution of minerals
- decomposition of organic material in the soil and phreatic zones by solution–precipitation
- sorption–desorption
- ion filtration
- organic degradation
- radioactive decay.

Sources of ions in groundwater are summarised in Table 4.

Table 4 Sources of ions in groundwater (revised from Back & Custodio 1995)

Major constituents > 5 mg/L	Source
Calcium, Ca^{++}	Primarily from carbonates, gypsum
Magnesium, Mg^{++}	Feldspars, mica, dolomites
Sodium, Na^{+}	Seawater, clays, feldspars, ion exchange, industrial waste
Potassium, K^{+}	Feldspar, fertilisers
Ammonia, $NH4^{+}$	Reduced NO3-, pollution
Bicarbonates, $HCO3^{-}$	Soil and atmospheric CO_2, carbonates, oxidation of organic materials
Sulfate, $SO4^{=}$	Dissolution of gypsum and anhydrite, oxidation of pyrite, sea water
Chloride, Cl^{-}	Rain water, sea water
Nitrate, $NO3^{-}$	Decay of nitrogen fixing plants, oxidation of ammonia or organic nitrogen fertilisers, contamination
Iron, Fe^{++}	Oxides and sulfides such hematite, pyrite, carbonates and clays
Phosphate, PO_4	Apatite, fertiliser, sewage
Strontium, Sr^{++}	Carbonates
Arsenic, As	Sulfidic sediments like pyrite, sulfide oxidation

Interpreting groundwater hydrochemistry data gives us an understanding of the sources and behaviour of ions, of water quality and of the origin of groundwater. The classical use of water analysis in hydrology is to show the regional distribution of water composition on a map. Such maps provide water resource managers and environmental authorities with a way of identifying aquifers, areas of good quality water, water types, possible risk areas for health, the effects of water use on groundwater quality and a means for assessing the relation between water bearing rock mineralogy and groundwater composition. Table 5 provides a summary of the criteria for identifying the sources of ions in groundwater.

The results of major and minor chemical analysis of samples from the Superficial aquifer, wetlands and rainfall are given in Appendices C to F.

Chemical characteristics of the Superficial aquifer

In order to identify the significant groundwater chemical characteristics of the Superficial aquifer the range of major ions have been given for each of the hydrogeological units. Additionally, hydrogeochemical classification diagrams and some graphical methods have been used to help in understanding the origin and evolution of groundwater chemistry in the aquifer flow system.

Table 5 Summary of criteria for identifying sources of ions (after Hounslow 1995)

Parameter	**Concentrations, mmol**	**Conclusion**
SiO_2	> 0.5	Volcanic glass or hydrothermal water possible
HCO_3-/SiO_2	> 10	Carbonate weathering
	> 5 and < 10	Ambiguous
	< 5	Silicate weathering
SiO_2/(Na+K-Cl)	< 1	Cation exchange
	> 1 and < 2	Albite weathering
	> 2	Ferromagnesian minerals
(Na+K-Cl)/(Na+K-Cl+Ca)	0.2 – 0.8	Plagioclase weathering possible
	< 0.2 or > 0.8	Plagioclase weathering unlikely
Na/(Na+Cl)	> 0.5	Sodium source other than halite – albite, ion exchange
	=0.5	Halite solution
	< 0.5 TDS > 500	Reverse softening, sea water
	< 0.5 TDS < 500 and > 50	Analysis error
	< 0.5 TDS < 50	Rain water
Mg/(Ca+Mg)	=0.5 and (HCO3/Si)> 10	Dolomite weathering
	< 0.5	Limestone–dolomite weathering
	> 0.5	Dolomite dissolution, calcite precipitation, or seawater
	< 0.5 and (HCO3/Si)< 5	Ferromagnesian minerals
Ca/(Ca+SO_4)	=0.5	Gypsum dissolution
	< 0.5 and pH< 5.5	Pyrite oxidation
	< 0.5 and pH neutral	Calcium removal – ion exchange or calcite precipitation
	> 0.5	Calcium source other than gypsum – carbonate or silicates
TDS	> 500	Carbonate weathering or brine or sea water
	< 500	Silicate weathering
Cl/Sum anions	> 0.8 and TDS> 500	Sea water or brine or evaporites
	> 0.8 and TDS< 100	Rain water
	< 0.8	Rock weathering
HCO_3/Sum anions	> 0.8	Silicate or carbonate weathering
	> 0.8 and SO4 > 20 meq/L	Gypsum dissolution
	< 0.8 and sulfate low	Sea water or brine
Calcite saturation index	> 0	Oversaturated with respect to calcite
	=0	Saturated with respect to calcite
	< 0	Undersaturated with respect to calcite

The physical and chemical characteristics of groundwater in the Superficial aquifer vary mainly with geological location and position within the groundwater flow system relative to recharge and discharge. These characteristics are derived from the dissolution of minerals and decomposition of organic material in the soil and phreatic zones by hydrogeochemical processes such as solution–precipitation, sorption–desorption, ion filtration, and organic degradation.

A standard groundwater chemical analysis will, as a minimum, have eleven variables comprising temperature, EC, pH, four major cations and four major anions. There are 226 groundwater analyses in the study area. To get an overview of this large amount of data, Piper and Stiff diagrams have been used. These display the main groundwater components at a glance and provide a basis for the descriptive classification of water type.

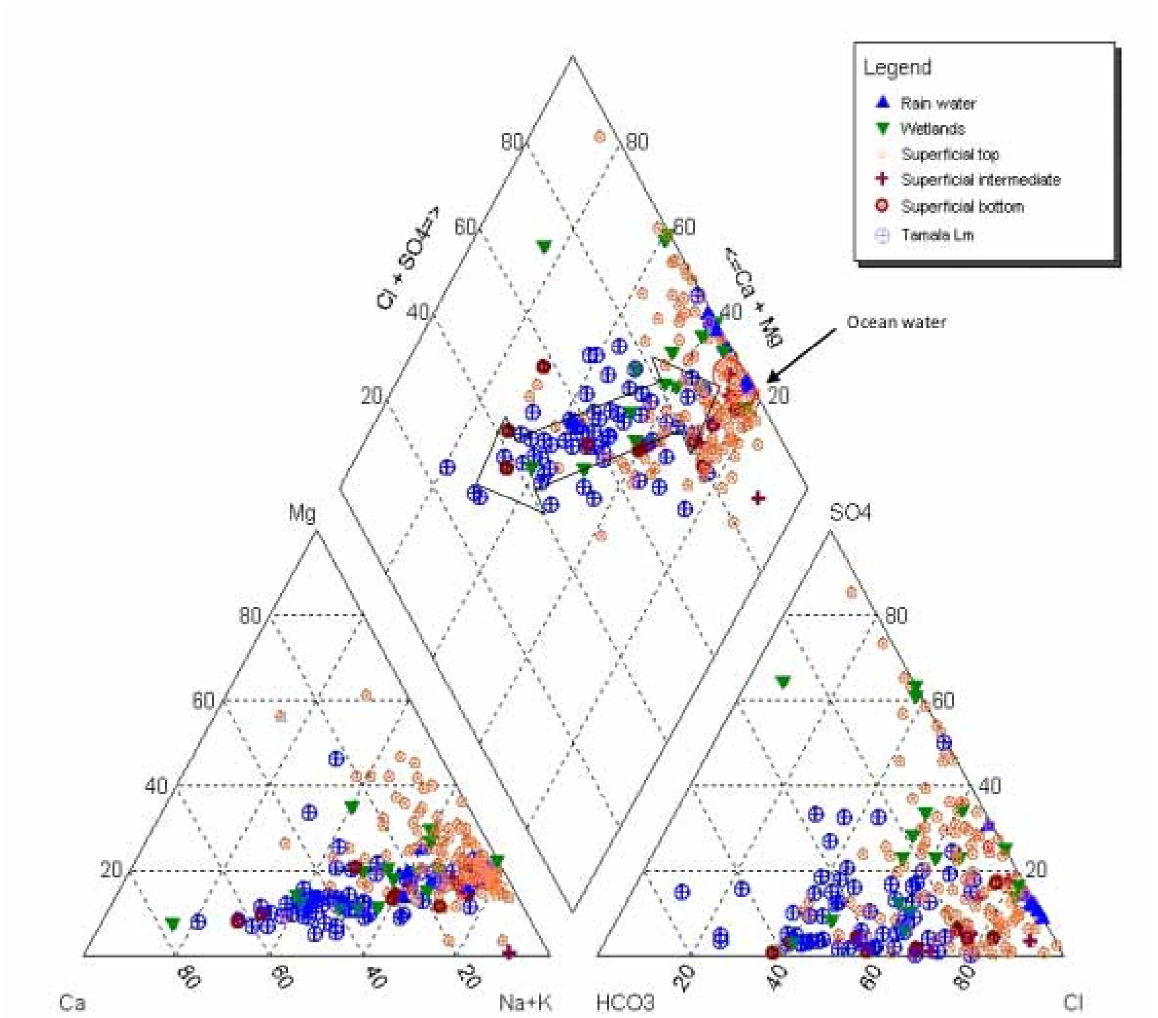


Figure 12 Piper diagram of water from the Superficial aquifer, rain and surrounding wetlands

The Piper diagram (Figure 12) displays the chemical composition in percentages of milliequivalents per litre for groundwater in the Superficial aquifer, permanent wetlands and rainfall in the Perth metropolitan area.

As seen from Figure 12, rainwater samples resemble highly diluted seawater because ocean water and rainwater are positioned in the same area at the right hand corner of the diamond diagram. The limestone, and calcarenite that derived from decomposed Tamala Limestone, produce a Ca-HCO_3 type of water. Groundwater in the Bassendean Sand contains Na-Cl type of water, which is similar to rainwater composition.

Examination of the Piper diagram clearly indicates that Na-Cl type groundwater within the Bassendean Sand at the crest of the Gnangara and Jandakot groundwater mounds gradually mixes with a Ca-HCO_3 type of groundwater while flowing westwards through the Tamala Sands towards the ocean. The concentrations of Ca and HCO_3 ions gradually increase westwards due to carbonate dissolution within the Tamala Sands, and become dominant within the Tamala carbonate aquifer. The change in water type along the flow lines from the crest of the Gnangara Groundwater Mound towards the ocean can be seen clearly in Figure 13.

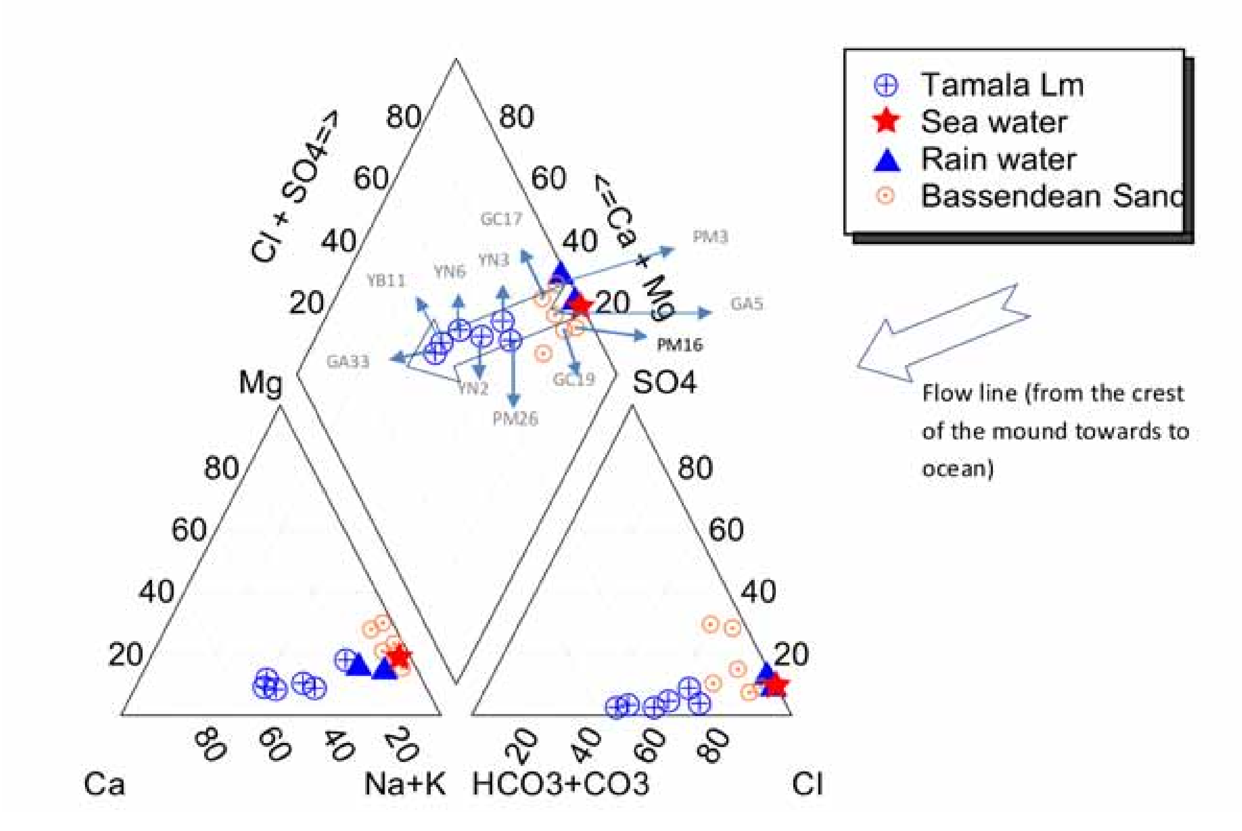


Figure 13 Piper diagram of groundwater along the flow line from the crest of the Gnangara Groundwater Mound towards the ocean

To see the relation between the aquifer materials and the chemical composition of the groundwater within the Superficial aquifer, Stiff diagrams of groundwater were plotted along groundwater flow lines from the recharge areas to discharge areas. They are shown together in Figures 14 and 15, together with the hydrogeology of the Perth metropolitan area.

The Stiff diagram presents the major groundwater chemical components in milliequivalents per litre. They consist of three horizontal axes displaying a cation to the left and a related anion to the right of the axis. The upper most axes have Na^+ to the left and Cl^- to the right, followed by Ca^{2+} and $HCO3^-$ pairs, and Mg^{2+} and $SO4^{2-}$ pairs.

Figures 14 and 15 show that groundwater at the crest of the mounds has Na-Cl type water with a low concentration of all the components. The groundwater gradually adds Ca and HCO_3 ions, as it flows down-gradient towards the ocean, by the dissolution of carbonates and becomes Ca-HCO_3 type of water with higher ion concentrations (Map 5). Along the coastline, Stiff diagrams from bores YS11 in the Yanchep groundwater area and GD5 to the west of Lake Herdsman in Perth show evidence for seawater intrusion by becoming dominated by Na and Cl and having a much higher concentration of all components than other coastal monitoring bores in vicinity. The Stiff diagrams show that groundwater around the wetlands areas within the Bassendean Sand including the Yeal Swamp area, Mirrabooka borefield area, and Wanneroo groundwater area east of Lake Joondalup have high SO_4 concentrations, which indicates additional SO_4 sources other than sea water.

As mentioned earlier, the groundwater HCO_3 concentration increases as a result of carbonate dissolution within the Tamala Limestone. HCO_3 concentrations of the groundwater in the Superficial aquifer have been mapped in Map 2, which shows that the HCO_3 distribution correlates very well with the calcareous Tamala Limestone.

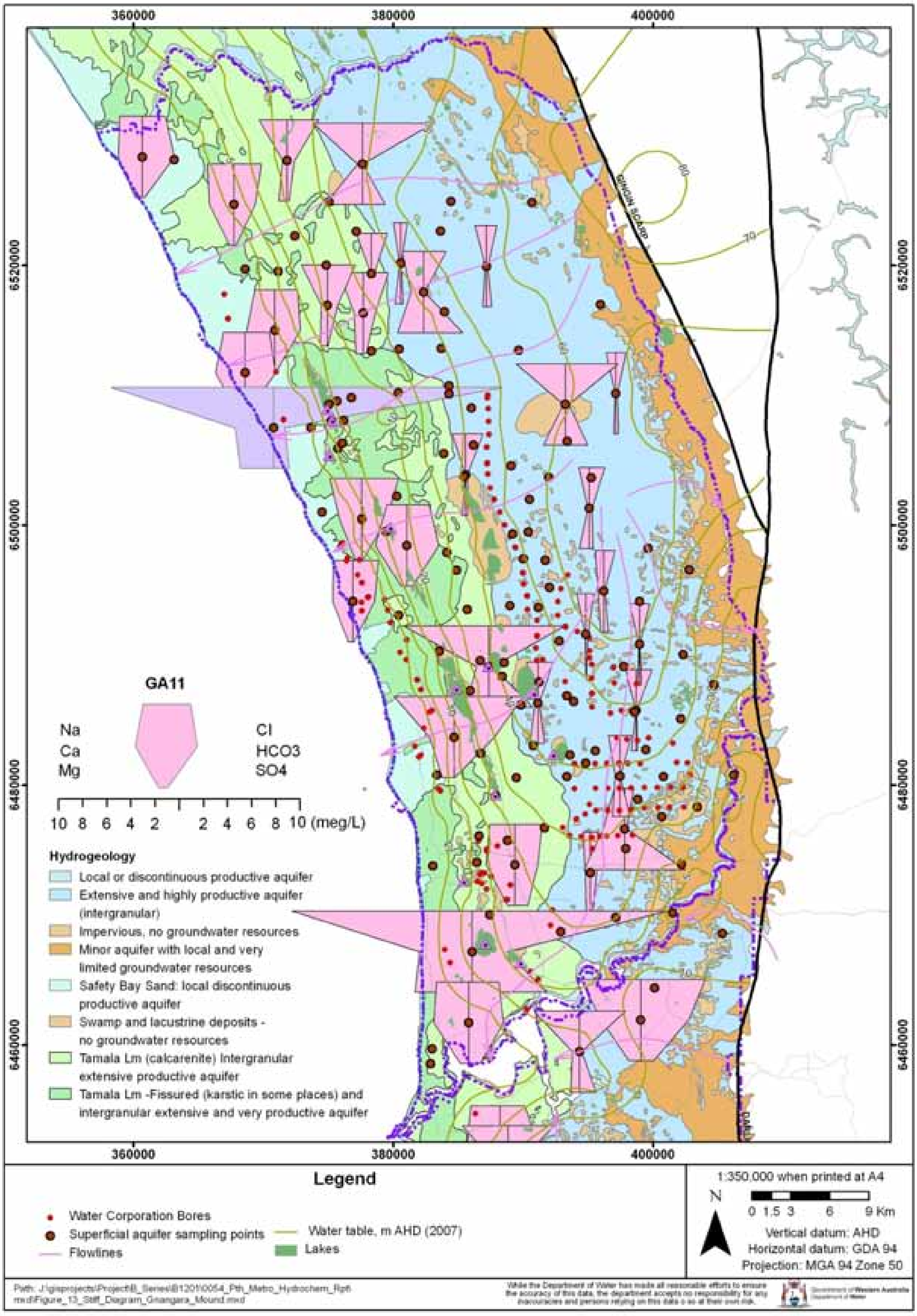


Figure 14 Superficial aquifer north – representative Stiff diagrams

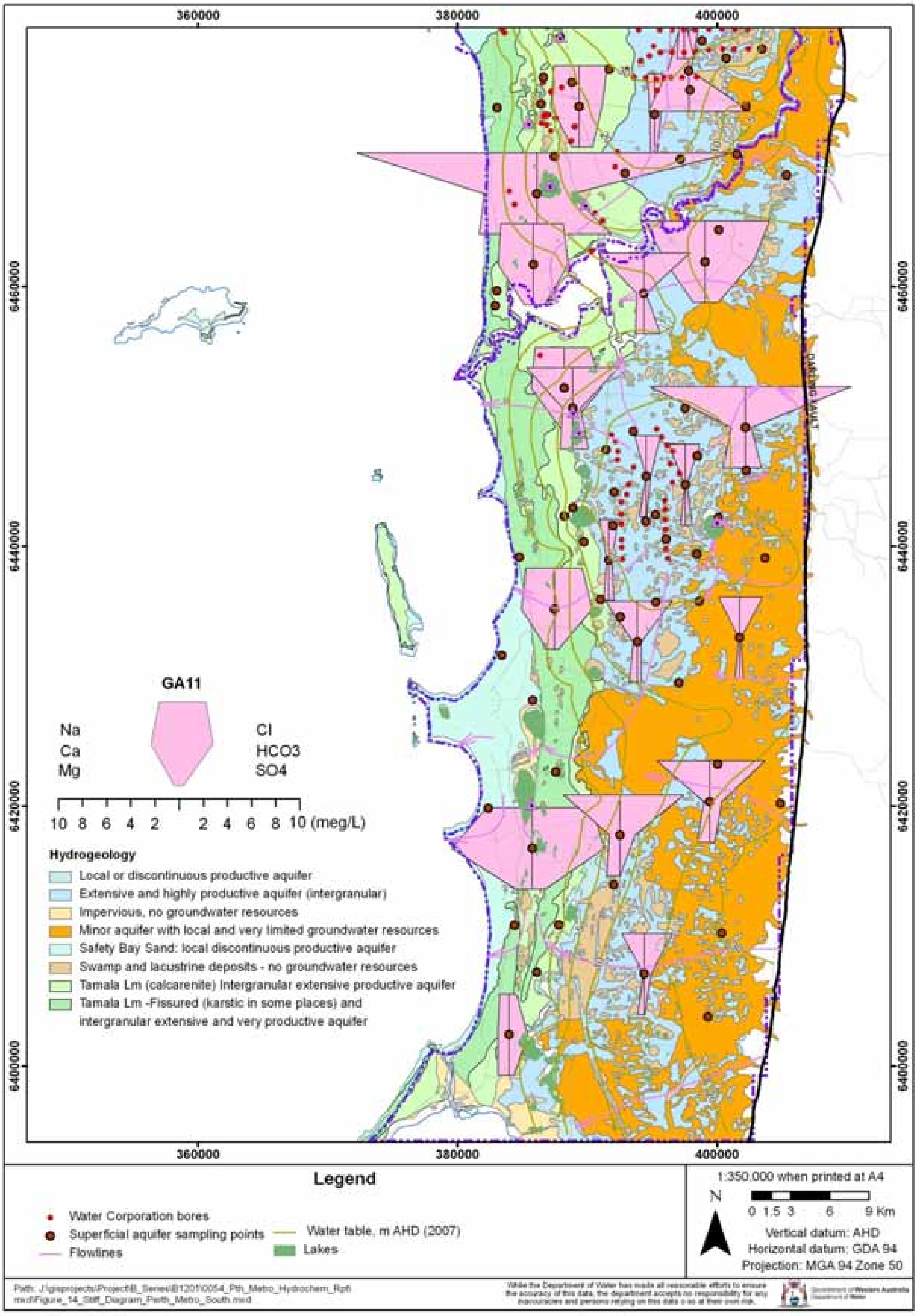


Figure 15 Superficial aquifer south – representative Stiff diagrams

Groundwater quality of the Superficial aquifer

Overall, the quality of groundwater in the Perth metropolitan area is acceptable for most uses. However, the quality in some parts of the Superficial aquifer, particularly where the groundwater is shallow, is changing as a result of human activities.

Water is usually not considered desirable for drinking if the quantity of total dissolved solids exceeds 1000 mg/L. Water with a few thousand mg/L of dissolved solids is classed as slightly saline and is not recommended for drinking for health reasons. Dissolved mineral constituents can be hazardous to animals or plants in large concentrations.

The *Perth groundwater atlas* (2004) has recommended categories for TDS of natural groundwater. These are shown below.

Fresh	0–500 mg/L
Marginal	501–1000 mg/L
Brackish	1001–5000 mg/L
Saline	> 5001 mg/L

The hardness of water is expressed in terms of the amount of calcium carbonate or equivalent minerals that would be formed if the water were evaporated. The hardness categories are shown below.

Soft	0 to 60 mg/L
Moderately hard	61 to 120 mg/L
Hard	121 to 180 mg/L
Very hard	> 180 mg/L

Very hard water is not desirable for many domestic uses. It will leave a scaly deposit on the inside of pipes, boilers and tanks. Hard water can be softened at a fairly reasonable cost, but it is not always desirable to remove all the minerals that make water hard. Extremely soft water is likely to corrode metals, although it is preferred for laundering, dishwashing, and bathing.

Groundwater, especially if it is acidic, in many places contains excessive amounts of iron. Iron causes reddish stains on plumbing fixtures and clothing. Like hardness, excessive iron content can be reduced by treatment. A test of the acidity of water is pH, which is a measure of the hydrogen ion concentration. The pH scale ranges from 0 to 14. A pH of 7 indicates neutral water. Greater than 7, the water is basic and less than 7, it is acidic. A one unit change in pH represents a 10-fold difference in hydrogen ion concentration. For example, water with a pH of 6 has 10 times more hydrogen ions than water with a pH of 7. Water that is basic can form scale, while acidic water can corrode. According to the *Australian drinking water guidelines 6* (NHMRC 2004), water for domestic use should have a pH between 6.5 and 8.5.

In recent years, the growth of industry, technology, population and water use has increased the stress upon both our land and water resources. Locally, the quality of groundwater has been degraded. Municipal and industrial wastes and chemical fertilisers, herbicides, and pesticides not properly contained have entered the soil, infiltrated some aquifers and degraded the groundwater quality. In some coastal areas, intensive pumping of fresh groundwater has caused salt water to intrude into freshwater aquifers.

The following sections discuss salinity, pH, and the distribution of some major ions and minor ions within the Perth metropolitan area.

Salinity

According to the data collected between 2003 and 2007, the salinity of the groundwater as total dissolved solid in the Superficial aquifer ranges from about 75 mg/L (GC17) to 3600 mg/L (YSI1) but rarely exceeds 1000 mg/L (Figures 16 and 17 and Map 4). The lowest salinity water is found in the direct rainfall recharge areas, where the groundwater flow system originates, and in particular, near the crests of the Gnangara and Jandakot groundwater mounds, where it is usually less than 250 mg/L. The salinity generally increases in the direction of groundwater flow and with depth (see Appendix C – MT1S and MT1D, NR3C, NR3B and NR3A). In the eastern clayey areas shown in Figure 7, particularly east of the Jandakot and Serpentine groundwater areas, the groundwater is relatively more saline higher than 1000 mg/L. Here, the clayey sediments reduce rainfall recharge, resulting in high evaporation rates, which increases the total dissolved solids in the groundwater.

The salinity maps showed that there are areas along the coast that have a high risk of seawater intrusion. Groundwater in Tamala Limestone under the YSI1 and GD5 monitoring sites close to the ocean has high salinity (3600 mg/L and 2820 mg/L, respectively) reflecting possible seawater intrusion probably caused by the nearby public and or private abstraction bores (Figure 16). The 2007 groundwater salinity maps show plumes down-hydraulic gradient from many of the lakes, where evaporation has concentrated dissolved salts. TDS values of wetlands, which were sampled at the same time are given for comparison in Figure 16 and Figure 17 together with areal distribution of salinity of the Superficial aquifer. The higher salinity groundwater that recharges down-hydraulic gradient from the lakes causes the plumes to extend to the base of the aquifer and gradually mix in the direction of groundwater flow resulting in an increase in salinity.

The fact that some wetlands (for example Lake Gwelup, Lake Herdsman and Lake Monger) have salinity fresher than groundwater, indicates they have had recent rainfall recharge, which has diluted the lake water salinity at the time of sampling. In contrast, Lake Walungup, which has a salinity of 26 000 mg/L, is a salt lake and is a groundwater sink.

Davidson (1995) also presented a salinity distribution (Map 3) for the Superficial aquifer in the Perth region using representative water analysis from Water Corporation production bores and some investigation bores. There is no information given by Davidson (1995) on sampling dates and locations of these investigation bores used to prepare the salinity distribution map. Therefore it may be subjective to compare Map 3 and Map 4 as they were not prepared using the same data points. The 2007 groundwater salinity study only covers the Department of Water Superficial aquifer bores sampled at the watertable.

Instead of comparing the salinity maps produced by this study and Davidson (1995), as they were not using the same data points, comparison has been made by using the historical measured salinity data from the WIN database and the current TDS values at the same data points. Historical data has been recorded in different units in the WIN database system, so these units have been converted to the common TDS units (total dissolved solids (grav) @ 180 °C) using the current TDS, EC (lab), and EC (field) correlation and regression parameters. Standard error in calculation also been calculated. Historical original salinity data and converted TDS in mg/L together with the recent TDS values are given in Appendix G.

The salinity increases by up to 225 mg/L in some areas near the crest of the Gnangara Groundwater Mound. Similarly, there is an increasing salinity trend in the Mirrabooka (up to 560 mg/L at MM16), Wanneroo (240 mg/L at JB4)and Gwelup (up to 210 mg/L), and Perth groundwater areas (up to 200 mg/L). This might be due to abstraction from the Superficial and confined aquifers and/or due to less permeable lake bed sediment associated with wetlands inhibiting the infiltration of rainfall and thereby causing the accumulation of salt through evaporation. A similar increase in salinity can also be seen in the southern Perth area, north of Jandakot groundwater area (up to 80 mg/L), and in the Cockburn and Stakehill groundwater areas (up to 390 mg/L).

There are some areas where the results conflict, such as Serpentine and Stakehill groundwater areas. The T-series bores especially indicate that groundwater in the Superficial aquifer in these areas has improved by up to 900 mg/L, compared with historical salinity data (see Attachment G). This major discrepancy indicates that historical data is not reliable for T-series bores. This needs to be confirmed by future sampling T-series bores and other bores which show large discrepancies between historical data and recent data.

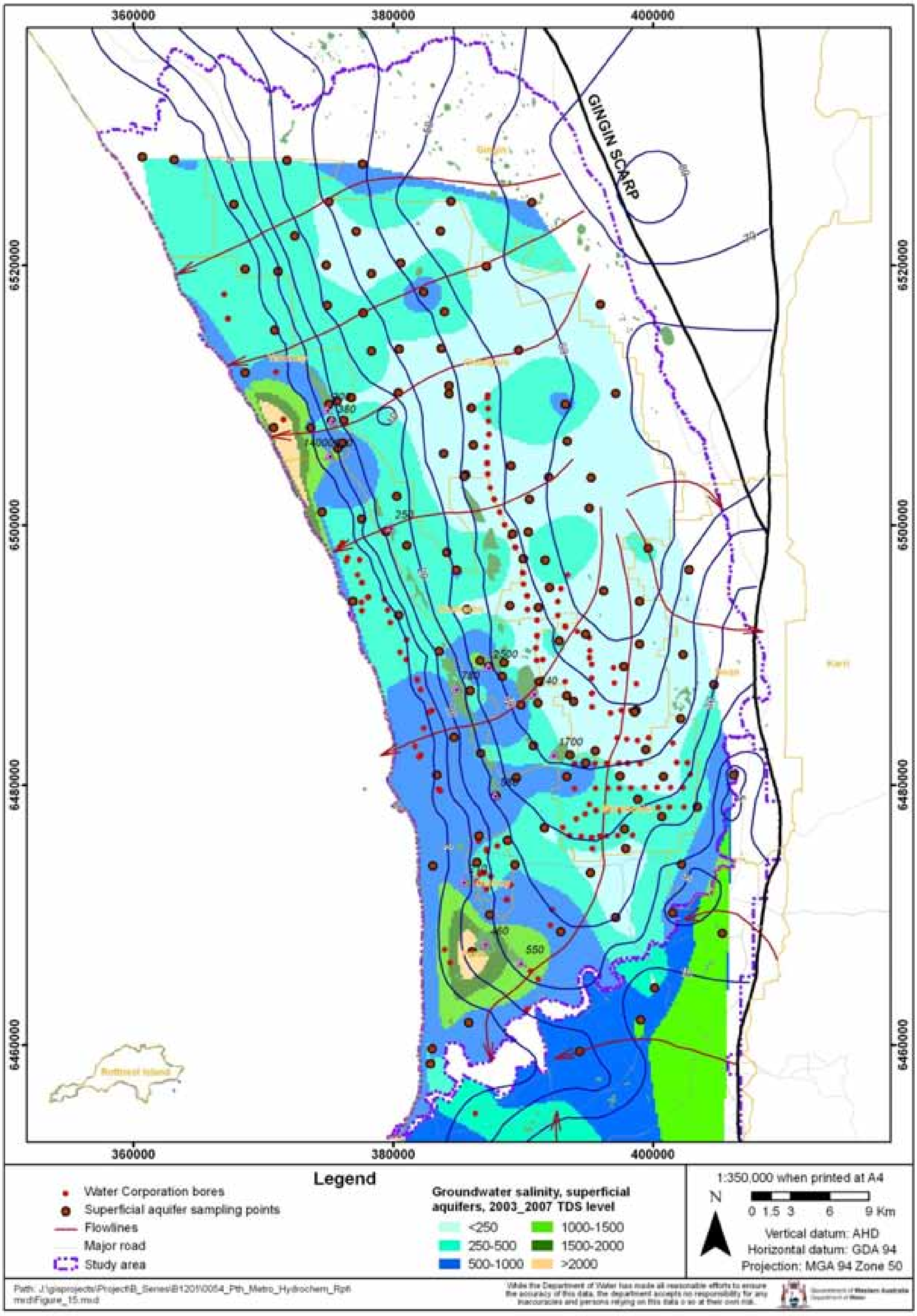


Figure 16 Superficial aquifer north – groundwater salinity

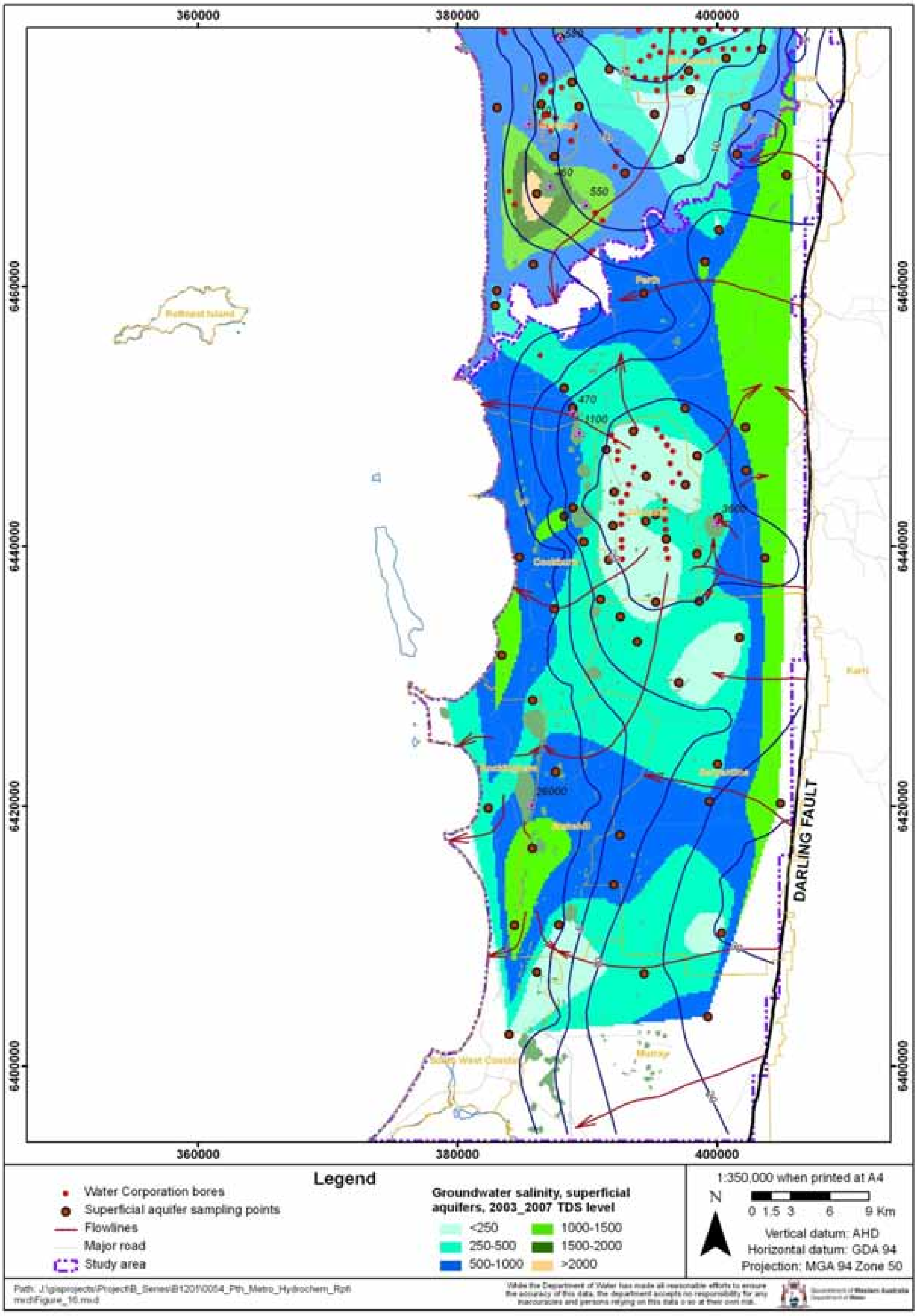


Figure 17 Superficial aquifer south – groundwater salinity

pH distribution

The in situ measurement of pH values of groundwater range from 3.6 (GA10) to 8 (bore 8283) (Appendix A).

Groundwater at the watertable within the Bassendean Sand is generally acidic with a pH range of 3.6 to 6.6. Groundwater within the calcareous sediments of Tamala Limestone is generally basic with a pH range of 6.5 to 8. Groundwater from the base of the Superficial aquifer has a pH range of 6.0 (NR3A) in Bassendean Sand up to 7.5 (JE 12A) in the calcareous sediments of the Ascot Formation.

Low pH values are sometimes due to organic acids resulting from decomposition of vegetation in swampy environments (Davidson 1995). This is natural acidification through CO_2 production and root respiration in the soil in such environments. Appelo and Postma (2005) pointed out that the lowest pH from CO_2 production in soil is around 4.6, so that groundwater which has a lower pH value must involve other processes of acidification. Maps 6 and 7 show the areal pH distribution of the groundwater in the Superficial aquifer within the Gnangara Groundwater Mound and southern metropolitan groundwater areas, respectively. Areas where the pH is less than 5 – indicating areas where other major acidification processes are occurring – are shown in yellow.

A second possible source of acidification is the excessive use of ammonia and manure fertilisers. Another major acidification process is the oxidation of pyrite (FeS_2). Pyrite is found, at least in small quantities, in most reduced sediments in the Bassendean Sand and swamp and lacustrine deposits at shallow depth. The lowering of the watertable by climate variability or from public and/or private abstraction may cause the oxidation of pyrite (see section on groundwater acidification on page 49).

Total hardness

Hardness is sum of the ions which can be precipitated from groundwater. It is the sum of Ca^{2+} and Mg^{2+}, and is expressed in mg $CaCO_3$/L. Hardness in water used for domestic purposes does not become particularly unacceptable until it reaches a level of 100 mg $CaCO_3$/L. The hardness of groundwater in the Superficial aquifer is less than 100 mg $CaCO_3$/L near the crest of the mounds within the Bassendean Sand and increases in the direction of the groundwater flow to 600 mg $CaCO_3$/L in the Tamala Limestone (Map 8).

Iron (Fe^{2+})

Ferrous iron is a common constituent of anoxic groundwater. Its origin may be the partial oxidation of pyrite, the dissolution of Fe^{2+} containing minerals, or reductive dissolution of iron oxides. Appelo and Postma (2005) suggest Fe^{2+} to be the dominant form of dissolved iron in the pH range of most groundwater (5 to 8), since under this condition Fe^{3+} is insoluble. During drinking water treatment, anoxic groundwater containing Fe^{2+} is aerated and Fe-oxyhydroxides precipitate. Fe-oxyhydroxides may clog distribution systems, so iron is removed during the water treatment.

The dissolved iron in the groundwater at the top of the Superficial aquifer within the Perth metropolitan areas ranges from 0.05 mg/L (GC19) to 19 mg/L (MS10). Bassendean Sand has layers of hard, cemented organic sands to loamy sand with high iron content, commonly called ‘coffee rock’, which occurs throughout most of the area near the watertable. The iron is probably from the chemical reaction between acidic groundwater and the limonite cemented sands, and/or ilmenite grains, which are contained mainly within the Bassendean Sand (Baxter 1977; Davidson 1995), or from solution of pyrite (iron sulfide) associated with palaeolake deposits (Davidson 1995).

The areal distribution of iron (Fe^{2+}) in the Superficial aquifer is been shown in Map 9. Fe^{2+} concentrations are higher than 1 mg/L around the Mirrabooka, Wanneroo and Lake Pinjar borefield areas, around the Lake Joondalup, Lake Mariginiup, Yeal Swamp areas in the Gnangara groundwater area, and also the Spectacles North and Sandy Lake area in the Perth south region. According to the *Australian drinking water guidelines 6* (NHMRC 2004), groundwater containing higher than 0.3 mg/L of Fe^{2+} has an unpleasant taste. High concentrations stain laundry and fittings. Iron bacteria cause blockages and corrosion and have a taste and odour.

Nitrate (NO_3^-)

Nitrate appears usually to be the only form of nitrogen of significance in groundwater (Hem 1970). The element is concentrated to a certain extent in soil or organic materials. Nitrogen in the form of dissolved nitrate is the major nutrient for vegetation, and the element is essential to all life. Nitrate in soil that is utilised by plants partly returns to the soil when the plants die. The nitrate in the soil however is artificially increased when nitrate fertilisers are used. Farm animals produce considerable amounts of nitrogenous organic waste that tend to concentrate in places where large numbers of animals are confined. High nitrate concentrations in groundwater under cultivated areas, intensive horticulture areas and on animal farms, results from direct leaching of nitrate from fertilisers and reduced nitrogen compounds.

Davidson (1983, 1995) showed that beneath native bushland, and in rural and forest areas nitrate concentrations were less than 1 mg/L in the Perth region. In rural grazing areas, low nitrate concentrations in groundwater reflect the low nitrate input from animal faeces. However in urban areas, including some market gardens, nitrate concentrations varied greatly and frequently exceeded 20 mg/L according to the 1983 figures (Davidson 1995).

The nitrate data collected between 2003 and 2007 indicate that nitrate concentrations in the Superficial aquifer in the Perth metropolitan areas are elevated, especially under the intensive irrigated horticultural areas, and have extended over a more widespread area (Map 10). Nitrate levels in the Perth metropolitan south region are below the acceptable limits, but in some areas in the Gnangara Groundwater Mound, nitrate levels already exceed the acceptable limit of 50 mg/L given in the *Australian drinking water guidelines 6* (NHMRC 2004). Maximum nitrate concentrations are 292 mg/L in Carabooda area, 280 mg/L in north east of Lake Wilgarup, 280 mg/L in Lake Neerabup area, 266 mg/L in the Coogee Swamp area, and 53 mg/L in the Lake Nowergup area. These areas are intensive horticulture areas. Nitrate concentration of groundwater under Landsdale, which is a newly established residential area, is 140 mg/L. This is because the area was previously used for irrigated horticulture and NO_3 levels continue to be higher than the drinking water limit. If the residence time is known, either from tracer measurements or from hydrogeological conditions, the change in concentration over time can be estimated using the following equation if there is no further application of fertiliser on the surface.

$$c = c_o\,(1-e^{-t/T}) + c_i\, e^{-t/T}$$

where:

- c is the required concentration of NO_3^- in mg/L in the future
- c_o is the initial concentration of NO_3^- in the groundwater
- c_i is the concentration NO_3^- at present
- t is time required to change from c_i to c in years
- T is residence time in years.

To estimate the time required to reduce the nitrate concentration from 140 mg/L to 25 mg/L (50 mg/L is the drinking water limit), the residence time of groundwater is needed, and it can be calculated from the following equation:

$$T = D \times n / P$$

where:

- D is aquifer saturated thickness (m)
- n is porosity (dimensionless)
- P is rainfall (m/yr)

According to the site information, average rainfall in dry period is 0.75 m/yr, porosity is about 0.3, and saturated thickness of the Superficial aquifer is about 50m, hence the residence time is calculated as 20 years. The time required for flushing of nitrate and reduce it to 25 mg/L is calculated as 34.5 years.

Table 6 shows the nitrate (mg/L) concentration of groundwater in the Superficial aquifer around the Carabooda area, which is due to the excessive use of fertilisers in the area. Distribution of nitrate concentrations in areas where the acceptable limit has been exceeded, including Carabooda, are given together with wetlands nitrate values for comparison in Figure 18.

Table 6 NO_3^- concentrations in Superficial monitoring bores in Carabooda area

Bore name	**Easting**	**Northing**	**Date**	**NO_3^- mg/L**
CG4-90	377478	6504388	09/2005	55.9
YN8	376244	6506452	07/2003	200.0
YN8	376244	6506452	09/2005	296.8
GNM10	376371	6506712	09/2005	279.9
GNM10	376371	6506712	10/2005	217.1
Wilgarup	375726	6505902	09/2005	57.6
Monte	377173	6506801	11/2005	8.8
Nanovich	379103	6502318	11/2005	292.4
Walding	377252	6505472	11/2005	0.9
Benara	379625	6503727	11/2005	0.4
Complete Turf	375994	6504953	11/2005	2.6
Avowest	379039	6502839	11/2005	36.8

Phosphates (PO_4^{3+})

Phosphorus concentrations are generally less than 0.3 mg/L but in some areas they exceed 0.6 mg/L and are even elevated to more than 1 mg/L in some locations (Map 11). Davidson (1995) showed that early phosphorus values were usually less than 0.1 mg/L and in a few locations exceeded 0.2 mg/L, which is equivalent to 0.3–0.60 mg/L PO_4. The source of phosphate is primarily fertilisers, and secondarily from sewage, as it is an essential in metabolism (Hem 1970). Elevated phosphate in the Perth region might be from fertilisers, animal metabolic wastes, and unsewered areas where the adsorption capacity of the sediments for phosphate has been exceeded.

Sulfate (SO_4^{2-})

Sulfate concentrations in the groundwater are generally less than 100 mg/L within the Perth metropolitan area. Higher concentrations can result from oxidation of sulfides associated with peaty wetland deposits, evaporative concentrations from shallow watertables, saltwater intrusion, or from the solution of pyrite (iron sulfide).

Areas with a very shallow watertable and sandy soils are also often very susceptible to higher sulfate caused by pyrite oxidation, as they are often underlain by organic-rich (often peaty) wetland sediments that create suitable conditions for the in situ growth of pyrite below the watertable. Hydrochemical indicators, which may indicate that groundwater at the watertable is being affected by the oxidation of sulfides include:

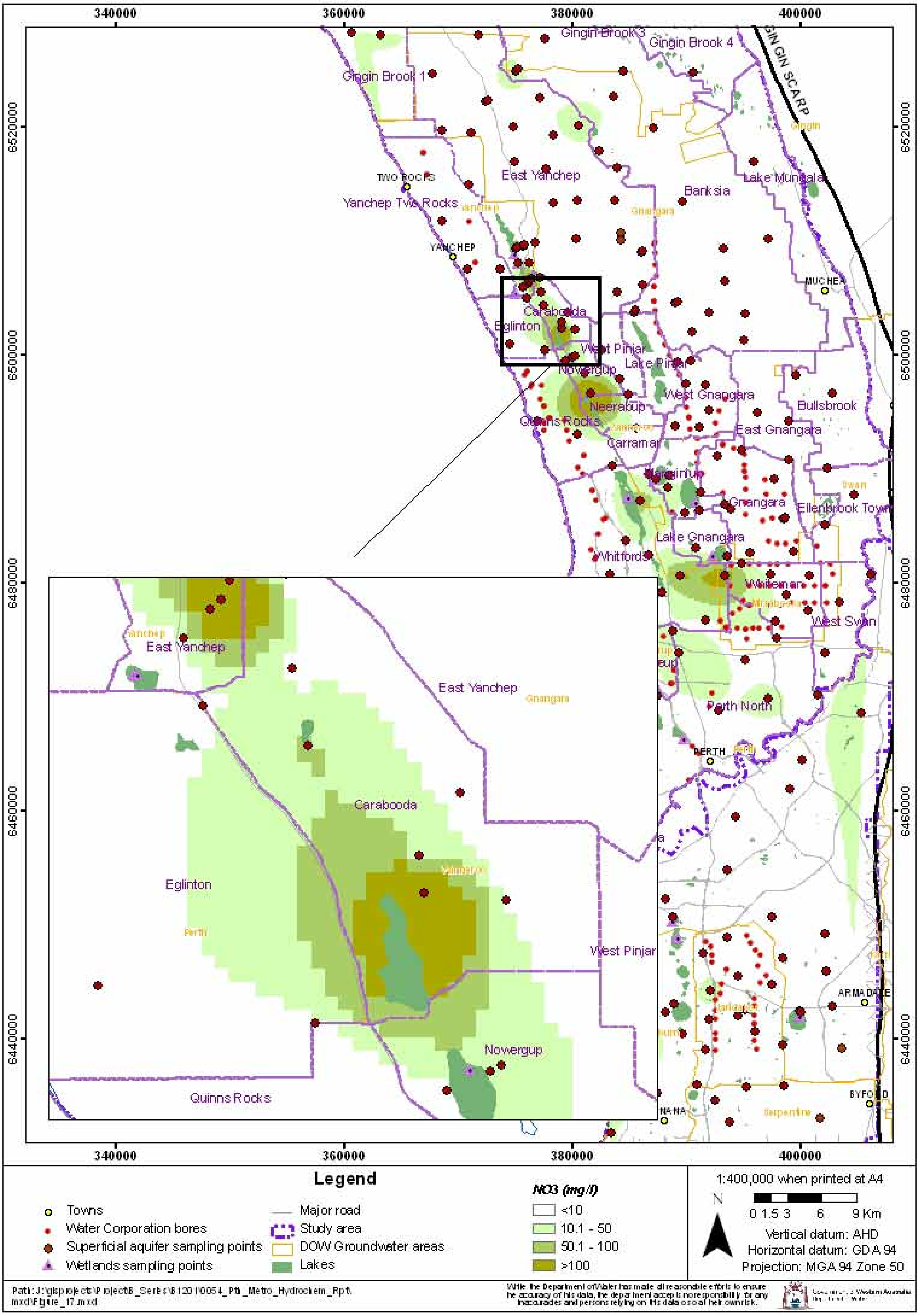


Figure 18 Distribution of nitrate in groundwater within the Carabooda area

- sulfate/chloride (in mg/L) ratio greater than 0.5 (Mulvey 1993)
- a pH of less than 5
- a soluble aluminium concentration greater than 1 mg/L.

The distribution of sulfate in the Superficial aquifer is given in Map 12. This shows that sulfate concentrations are higher than 100 mg/L around the Mirrabooka, Wanneroo and Lake Pinjar borefield areas, and around the Lake Joondalup, Lake Mariginiup, Lake Bindiar and Yeal Swamp areas in the northern Perth metropolitan region.

Groundwater in the Superficial aquifer along the coastline near Yanchep, west of Lake Monger, and north-east of Rockingham, also have high sulfate levels, indicating seawater intrusion in these areas.

Hydrochemical processes in the Superficial aquifer

The Superficial aquifer within the Perth metropolitan area provides an excellent example of hydrochemical variations within a groundwater system in that the processes of solution, oxidation-reduction, ion exchange, and mixing are seen to occur. To determine the relevant water–rock interactions and some other processes that may contribute to these changes, the AquaChem 5.1 software package has been used for numerical analysis and modelling of water quality data. Some hydrochemical indicators that have been suggested by Hounslow (1995) were calculated and are summarised in Appendix H. In addition, hydrochemical modelling was carried out using PHREEQC (Parkhurst & Appelo 1999), which is a built-in link to the AquaChem software package, and saturation indices were calculated for the major minerals present in the Superficial formation (Appendix I).

In the following sections, some of these hydrochemical processes are examined graphically to visualise their effects and to help understand the source of ions.

Figure 19 gives some major element concentrations plotted against the concentration of Cl^- in mmol/L. The black straight line represents the seawater line. The Na/Cl ratios of the groundwater are very close to that of seawater because these elements are geochemically conservative. However, the ratios of Cl to Ca, Mg and SO_4 have values mostly greater than or equal to, and rarely less than, the seawater line.

In Figure 19, the groundwater samples have been illustrated with different symbols and colours depending on the location or aquifer sampled. Table 7 describes the symbols used in Figures 19, 20, 22, 24 and 25.

The different symbols helped to classify the different groundwater samples from different locations and aquifer sediments. This approach suggested that the elements/Cl ratios greater than the equivalent seawater line result mostly from the dissolution of carbonates in Tamala Limestone, and the dissolution of gypsum and/or oxidation of pyrites, which occurs as thin layers in Bassendean Sand and in lake and swamp deposits beneath the wetlands.

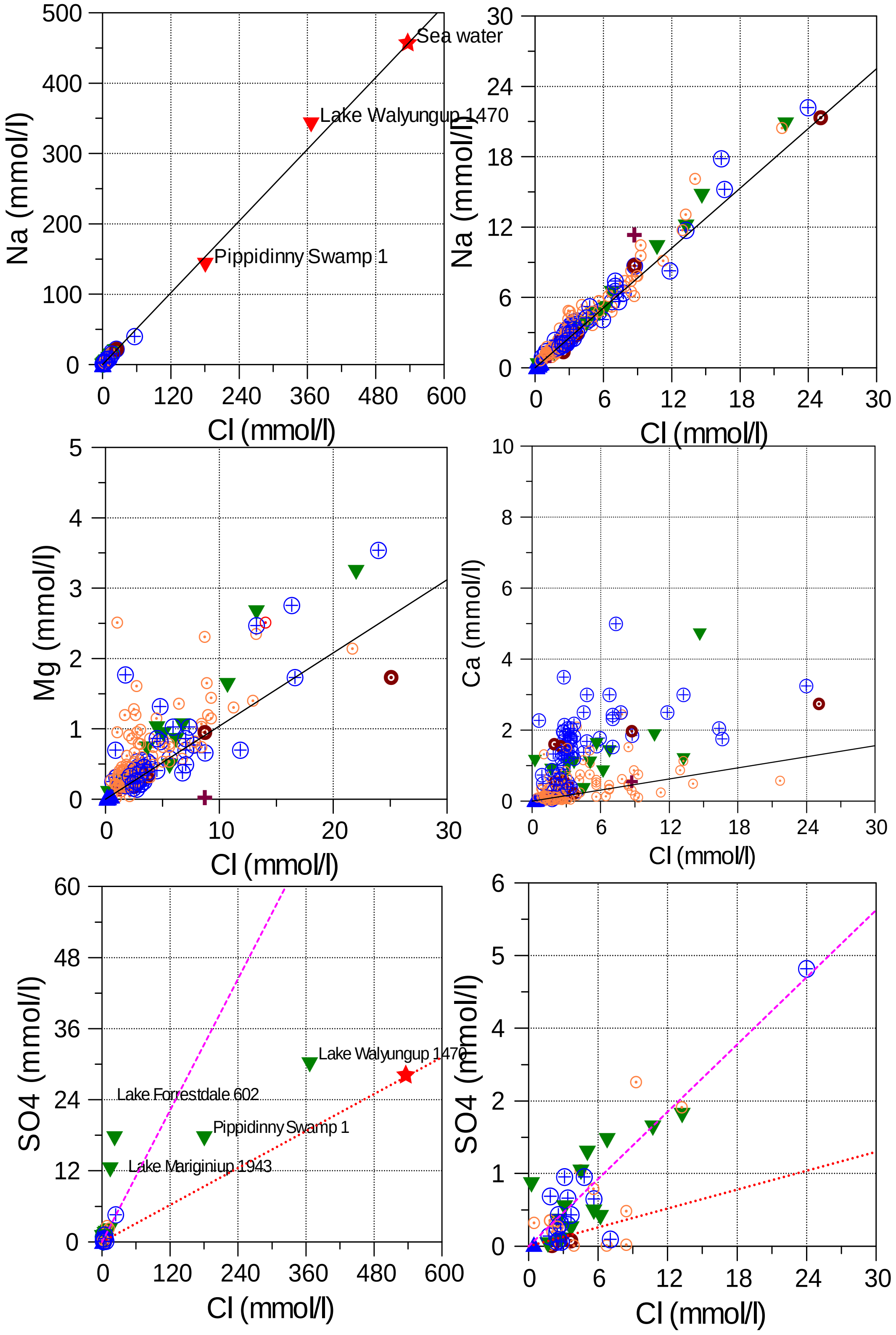


Figure 19 *Major ions concentrations plotted against the concentration of Cl.*

Table 7 Symbols used in Figures 19, 20, 22, 24 and 25

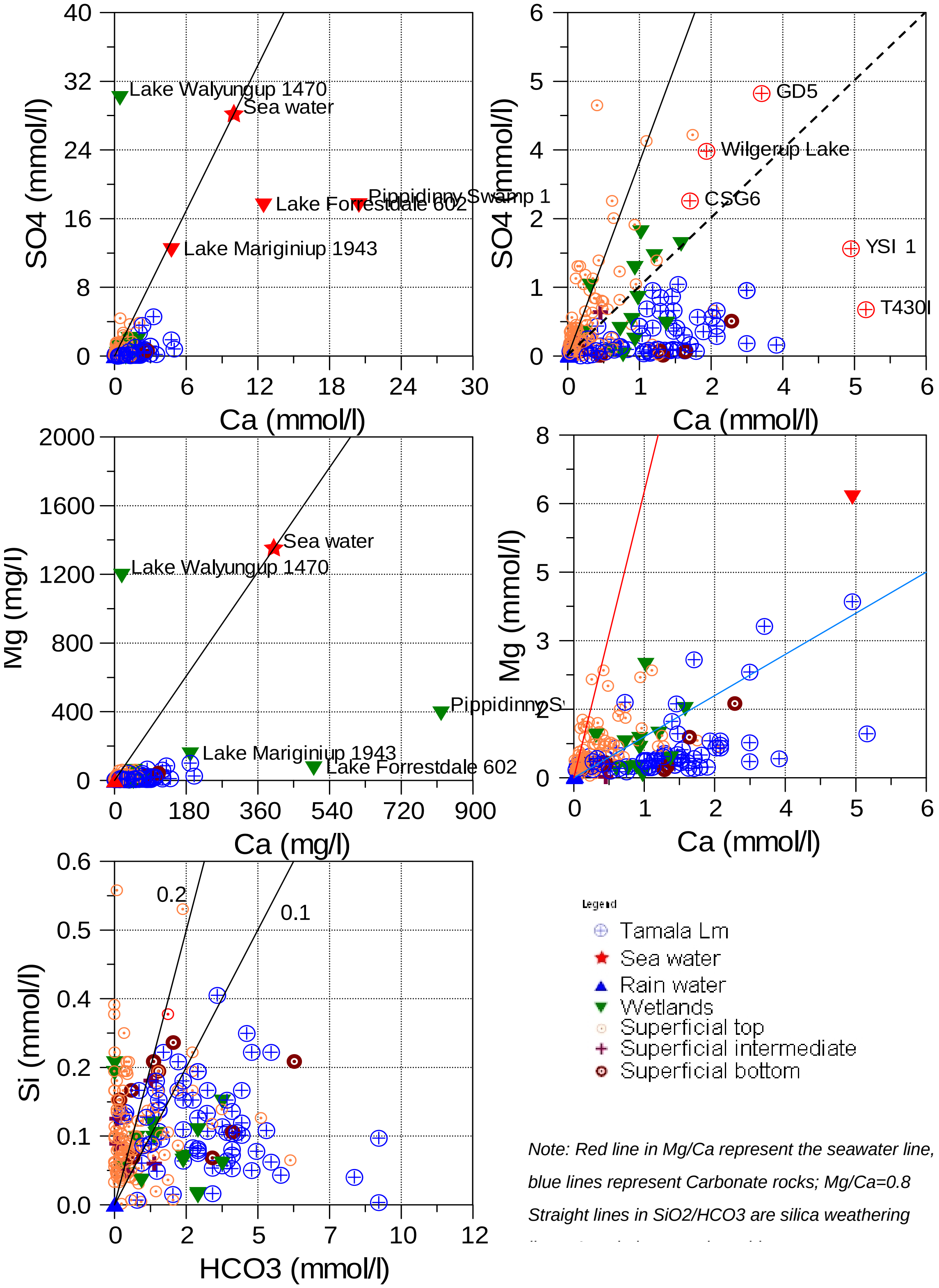
Symbol	Meaning
Small orange circles	Samples from Bassendean Sand
Bigger blue circles	Samples from Tamala Limestone
Plus sign red	Samples from the middle of the aquifer (intermediate)
Small red circles	Samples from the bottom of the aquifer
Upside down triangle red and green	Samples from Wetlands/Lakes
Triangle blue	Samples from rainfall
Star sign red	Ocean water

The ratios of Ca to SO_4 and Ca to Mg are mostly less than or equal to the seawater line. For several samples from the crest of the groundwater mounds, SO_4/Ca and Mg/Ca ratios closely approach or are on the seawater line suggesting they are in recharge areas. The dashed line in Figure 20 represents the gypsum line (Ca = SO_4). The ratios of Ca to SO_4 have values greater than or equal to the gypsum line indicating that excess SO_4 results from other sources in groundwater. Mg/Ca ratios of groundwater are mostly less than or equal to the seawater line. The light blue line is for carbonate rocks and includes the dolomite line (Mg/Ca = 0.8) by Appelo (2005). This line indicates that Mg/Ca ratio remains at about 0.8, when equilibrium with both calcite and dolomite is maintained. If the Mg/Ca ratio of groundwater is less than 0.8 it means that the water comes from carbonate aquifers, if greater than 0.8, then excess Mg may originate from sources other than carbonates.

The ratios of HCO_3 to SiO_2 are good indicators of silica and carbonate weathering processes in aquifer. The low (less than 0.1) SiO_2/HCO_3 ratios in groundwater indicate carbonate weathering and greater than 0.2 results from silica weathering. Groundwater from the Bassendean Sand shows silica weathering while groundwater from Tamala Limestone show carbonate weathering processes. Lake Mariginiup, Gnangara Lake, Lake Forrestdale and North Lake wetlands waters show silica weathering (Figure 20).

Figure 21 gives pH values of the groundwater plotted against the ratio of Ca/(Ca+SO_4) in mmol/L. The graph is prepared using the indicator values suggested by Hounslow (1995) and is commonly used as indicator to classify the groundwater based on which hydrochemical processes. Groundwater with pH lower than 6 and a Ca/(Ca+SO_4) ratio less than 0.5 shows gypsum dissolution and or pyrite oxidation. If pH is higher than 6, then the groundwater possibly has experienced some ion exchange and also precipitation of calcite.

The HCO_3/SiO_2 ratios and the Ca/SO_4 ratios of groundwater in the Superficial aquifer are shown in Map 13 and Map 14 together with a hydrogeological map of the study area to show the types of water–rock interactions, where they occur, and some other hydrochemical processes.



Note: Red line in Mg/Ca represent the seawater line,

blue lines represent Carbonate rocks; Mg/Ca=0.8

Straight lines in SiO2/HCO3 are silica weathering

Figure 20 Major element concentrations plotted against the concentration of Ca and HCO_3. Dashed line in SO_4/Ca represents the gypsum line (Ca=SO_4)

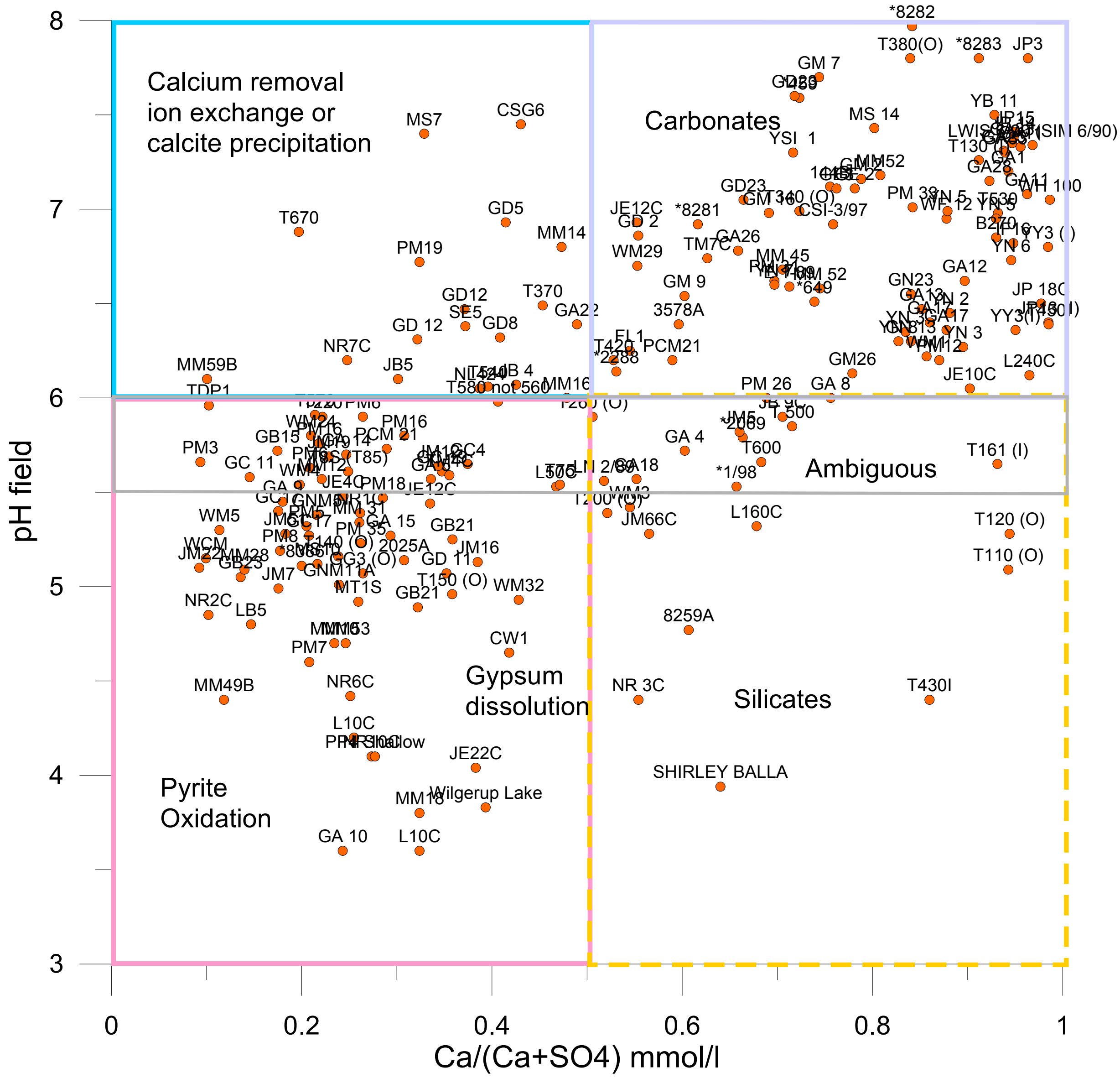


Figure 21 pH versus Ca/(Ca+SO_4) in the Superficial aquifer

The groundwater in the Superficial aquifer has also been examined for saturation indices (Appendix I) and Mg/Ca ratio versus saturation indices for calcite (Sic). The results are shown in Figure 22. The distribution of the saturation indices for calcite is shown in Maps 15 and 16.

Groundwater in sandy parts of the Superficial aquifer (Bassendean Sand) is undersaturated with respect to calcite. When it enters and interacts with the Tamala Limestone, aggressive waters start to dissolve the limestone and it gradually becomes saturated by calcite along the flowline towards the ocean (Map 15). Once the groundwater becomes supersaturated with calcite, then calcite is sometimes secondarily re-precipitated and the water may become undersaturated with respect to calcite.

Heterogeneity in the distribution of the saturation index indicates there is a conduit flow system. Conduit flows are common in highly karstic carbonate aquifers and occur in the cave system within the Yanchep National Park.

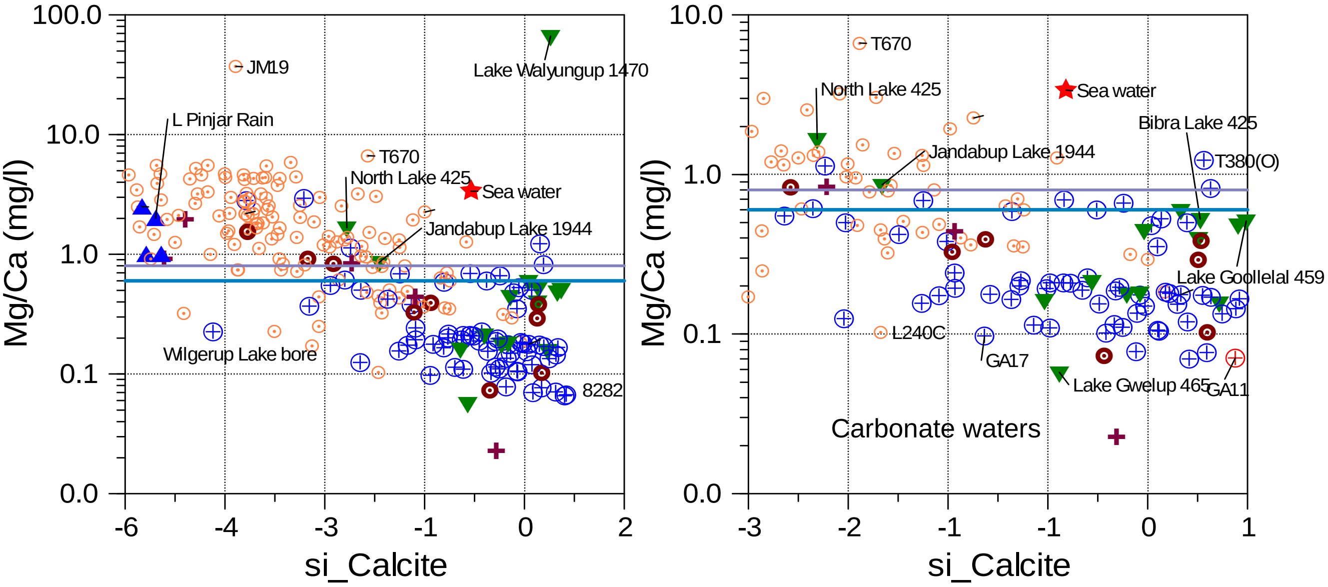


Figure 22 Mg/Ca ratio versus Sic in the Superficial aquifer. Grey and blue lines are Mg/Ca = 0.6 and 0.8 carbonate lines as referred by Burdon and Papkis (1963) and Appelo and Postma (2005), respectively.

Groundwater acidification

As discussed in the section on pH distribution (page 39), groundwater in the Bassendean Sand usually has pH values less than 6.0 and as low as 3.6 (Appendix B), while in carbonate aquifers the pH is usually higher (neutral to alkaline), except at the Lake Wilgarup bore site (pH < 4). Appelo and Postma (2005) suggests that natural acidification in groundwater caused by CO_2 production and root respiration does not produce a pH of less than 4.6 in very shallow aquifers. However, in some places in the Perth metropolitan area, for example Lexia, Mirrabooka, Wanneroo, Yeal Swamp and Jandakot (Maps 6 and 7), groundwater pH values are lower than 4.6, which indicates that there are other causes that might explain low pH groundwater.

Several processes may cause the acidification of groundwater. As indicated previously, there is a natural acidification through CO_2 production in soil. Another potential source of acidification is the excessive use of ammonia and manure as fertilisers. Research carried out by the Geological Survey of Western Australia, the Water Authority and the Department of Agriculture in the early 1990s indicated that market gardeners in the Perth metropolitan area typically used poultry manure at rates that greatly exceeded plant uptake rates, and that nitrate concentrations in excess of 50 mg/L commonly occurred in shallow groundwater beneath horticultural areas and manure stockpiles (see Map 10). Nitrate leaching through soils into groundwater is an oxidising agent in aquifer sediments. The nitrification of ammonia (NH_4) is a major acidifying process in the soil. The horticultural areas in Perth metropolitan areas are usually located on carbonaceous sediment and groundwater having a high HCO_3 concentration, which is a natural trigger for denitrification processes and H^+ produced by nitrification is balanced by the HCO_3.

This process commonly occurs in groundwater under horticultural areas that show high nitrate levels but low pH, which indicates that the nitrification process causes acidification in groundwater (see Maps 6 and 10). An exception is the area near Lake Wilgarup where groundwater has high NO_3^- and high pH.

A third major acidifying process is the oxidation of iron sulfides, predominantly in the form of pyrite (FeS_2) materials. The naturally occurring soils, sediments and peats that contain iron sulfides are commonly found in low lying land bordering the coast and estuarine and saline wetlands, and wetlands dependent on fresh groundwater throughout the state (DEC 2009b). These soils or sediments are also called acid sulfate soils. The Department of Environment and Conservation (2009b) also mapped possible acid sulfate soils risk areas for several regions of Western Australia. According to the report shallow acid sulfate soils are present in riverine, estuarine, coastal lowland, swamps, and wetland areas, particularly peaty wetlands in the Perth metropolitan area such as Stirling, Gwelup, Bayswater and Ashfield. Typically peaty and sandy sediments are associated with some wetlands on the Swan Coastal Plain. Pyrite in the sediments can acidify wetlands if the watertable falls well below the base of wetland due to dry weather or excessive groundwater pumping. Sulfidic sediments associated with wetlands may occur at elevations of up to 70 m above sea level near the crest of the Gnangara groundwater mound and other smaller groundwater systems on the Swan Coastal Plain. Laboratory analyses indicate that ‘coffee rock’ horizons contain stored potential acidity in a number of forms. They may contain inorganic sulfides including pyrites. Oxygen transported into such layers, by either convective transport or direct exposure to air by lowering of groundwater levels, can result in oxidation of such minerals and generates acid groundwater. When the iron sulfide and/or sulfidic minerals are oxidised, sulfuric acid is formed, resulting in the release of metals, nutrients and acidity into the soil and groundwater system. The release of contaminants such as acid, nutrients, iron, aluminium, arsenic and other heavy metals may adversely affect the natural and built environment and human health (DEC 2009a).

The SO_4 /Cl ratios are used as an indicator to illustrate potential pyrite oxidation and/or gypsum dissolution. Groundwater with increasing SO_4, SO_4/Cl and Fe^{+2} is typically associated with the oxidation of pyrite and or dissolution of gypsum. The SO_4 / Cl ratio of seawater is 0.15. A SO_4 / Cl ratio greater than 0.5 is commonly used to show additional sources of SO_4 in groundwater (see Fig 19).

The SO_4 / Cl ratios of groundwater in the Superficial aquifer are shown in Map 17 together with As concentrations, and in Map 18 with Al concentration. Most of the samples do not have Al data, therefore comparison of the Al concentrations with SO_4/Cl is only indicative.

Groundwater in the Perth metropolitan area with higher SO_4/Cl ratios also has high Fe and As concentrations, and low pH indicating that groundwater acidification mostly results from the oxidation of the iron sulfide and/or other sulfidic minerals. The high iron concentrations in groundwater may also result from the oxidation of ferrous iron (FeO_2) layers. This is evidenced by high dissolved oxygen values in the groundwater where iron concentrations are high (Map 19).

It is known that when sulfide soils remain under the watertable, significant oxidation does not occur and the soils are effectively harmless over the long term. Oxidation of iron sulfides will only occur if the sulfide soils are exposed to air.

Figure 23 compares the SO_4/Cl ratios of groundwater in the Superficial aquifer in the Mirrabooka area in 1972, 1992 and 2005. The SO_4/Cl ratios were as low as the ratio for seawater in Mirrabooka, Gwelup, and east of Lake Joondalup. This indicates that the background groundwater SO_4 content has originated from rainfall, and was low in the early stages of public abstraction in 1972. In 1992, in some of the Mirrabooka bores and Gwelup bores, the SO_4/Cl ratio increased to greater than 0.5, indicating additional SO_4. Through the years the ratios have gradually increased and the higher ratios had extended over larger areas by 2005. This occurred because of the lowering the groundwater levels from abstraction, exposing the sulfide minerals in the soils to oxidation, which was then leached to the watertable thereby increasing groundwater acidity. Areas affected by sulfide oxidation are the Mirrabooka, Wanneroo and Gwelup groundwater areas, east of Lake Goollelal, east of Lake Joondalup, Jandabup Lake, Lake Mariginiup and Lake Wilgarup areas.

The lowering of groundwater levels in the Perth metropolitan area is not due only to extensive abstraction from the Superficial and/or confined aquifers. Yesertener (2002) separated the effects of declining water levels in the Superficial aquifer in the Perth metropolitan area and showed that reduced rainfall is the major cause of the lowering of groundwater levels on the Gnangara Groundwater Mound since 1969. The drier climate has caused a decline of up to 4 m near the crest of the groundwater mound. High SO_4/Cl ratios in the Yeal area (PM3 and PM4) near wetlands could be the result of the oxidation of sulfidic sediments that have been exposed by water level decline resulting from the reduced rainfall since 1969 (Map 17).

The overall areal distribution of acid sulfate soils does correlate well with the SO_4/Cl ratio distribution of groundwater in the Superficial aquifer in Perth metropolitan area. The SO4/Cl distribution could therefore act as an indicator for an acid groundwater risk .

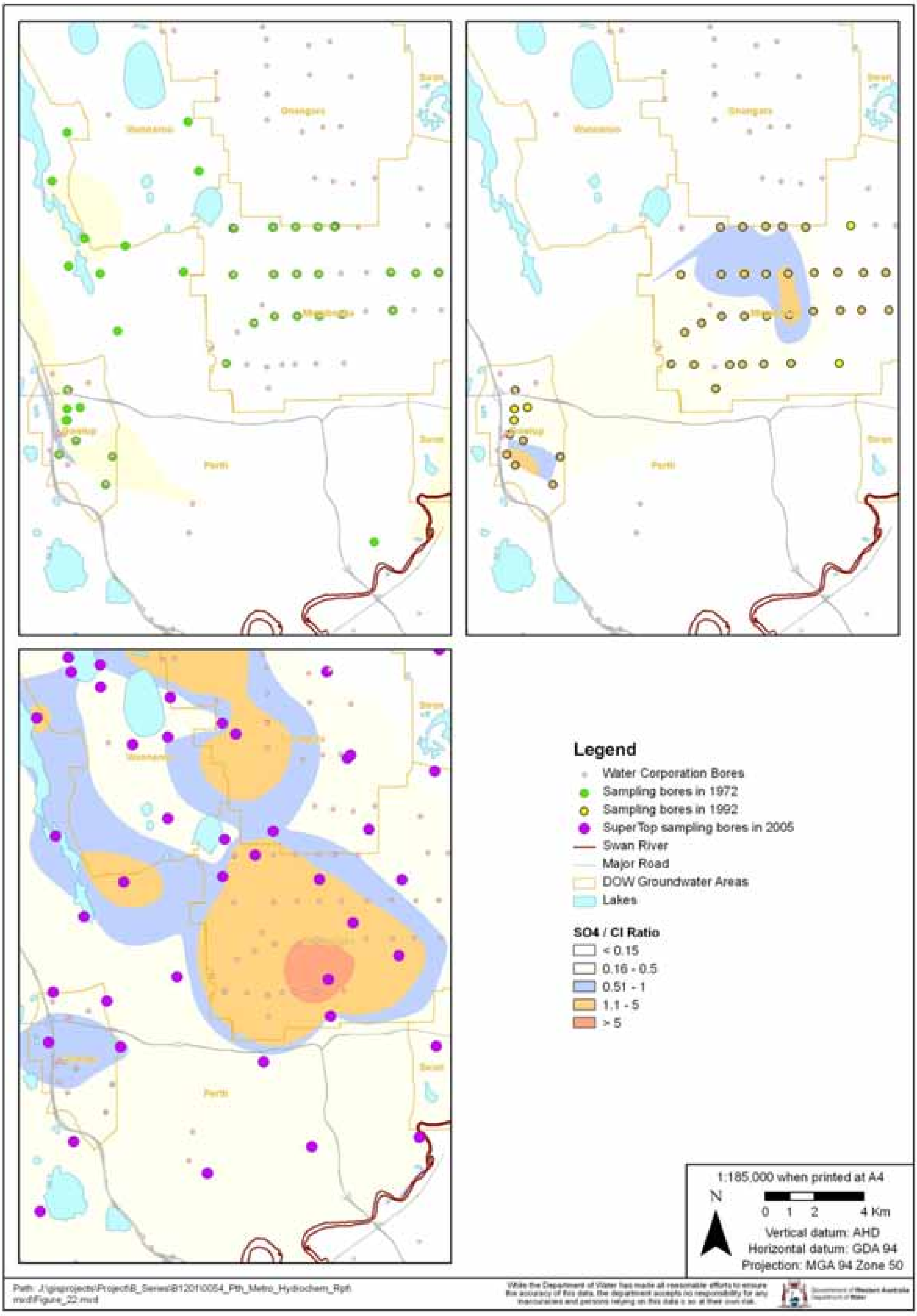


Figure 23 SO_4/Cl ratio changes of groundwater in the Superficial aquifer from 1972 to 2005

Superficial aquifer and wetland interactions

There is a relationship between the hydrochemistry of groundwater in the Superficial aquifer and wetland hydrochemistry. As water stored in wetlands commonly is not uniformly mixed, thermal stratification and associated changes in water composition are among the most frequently observed effects. Therefore, single samples from wetlands can be assumed to represent only a spot within the water body at a particular time.

The effect of stratification on water composition is noticeable in the concentrations of ions whose behaviour is influenced by oxidation and reduction, the reduced species commonly increasing in concentration with depth below the surface and assuming particulate form in oxidising shallower water. The components that are used by life forms in the water also are often considerably affected. In the study, only one spot sample was taken from the wetlands, but it can give some overall information on salinity, pH and major anions and cations to compare to the underlying groundwater.

Wetlands, of which only 17 have permanent water, have been sampled close to the gauging stations (Figures 9 and 10).

Figure 24 gives concentrations of some major elements plotted against the concentration of Cl. It is useful for showing the relationship between wetlands and groundwater. The dashed red line is the seawater line and the pink line represents $SO_4/Cl = 0.5$. The Na/Cl ratios of the wetlands and groundwater beneath are very close to the seawater line indicating that waters are of marine aerosol origin. However, the ratios of Cl to Ca, Mg, SO_4 have values mostly greater than or equal to, but rarely less than, the seawater line. Symbols used in Figure 24 are explained in Table 7. The element/Cl ratios greater than the seawater line mostly result from the dissolution of carbonates in the Tamala Limestone, and the dissolution of gypsum and probably pyrites, which occurs as thin layers in Bassendean Sand and lake and swamp deposits under the wetlands. Lake Mariginiup, Lake Forestdale, Gnangara Lake, Lake Joondalup, North Lake, Lake Goollelal, Lake Monger and Lake Herdsman have Mg/Cl ratios that is higher than the seawater ratio, indicating ion-exchange reactions are occurring from carbonate dissolution in limestone areas. In wetlands, a SO_4/Cl ratio higher than 0.5 indicates pyrite oxidation, gypsum dissolution, or both combined. Lake Forrestdale, Lake Mariginiup, Gnangara Lake, Lake Joondalup, and Lake Goollelal are wetlands that have higher SO_4/Cl ratios. Lake Loch McNess, Lake Yonderup, Lake Nowergup and Lake Herdsman SO_4/Cl ratios are similar to the seawater line.

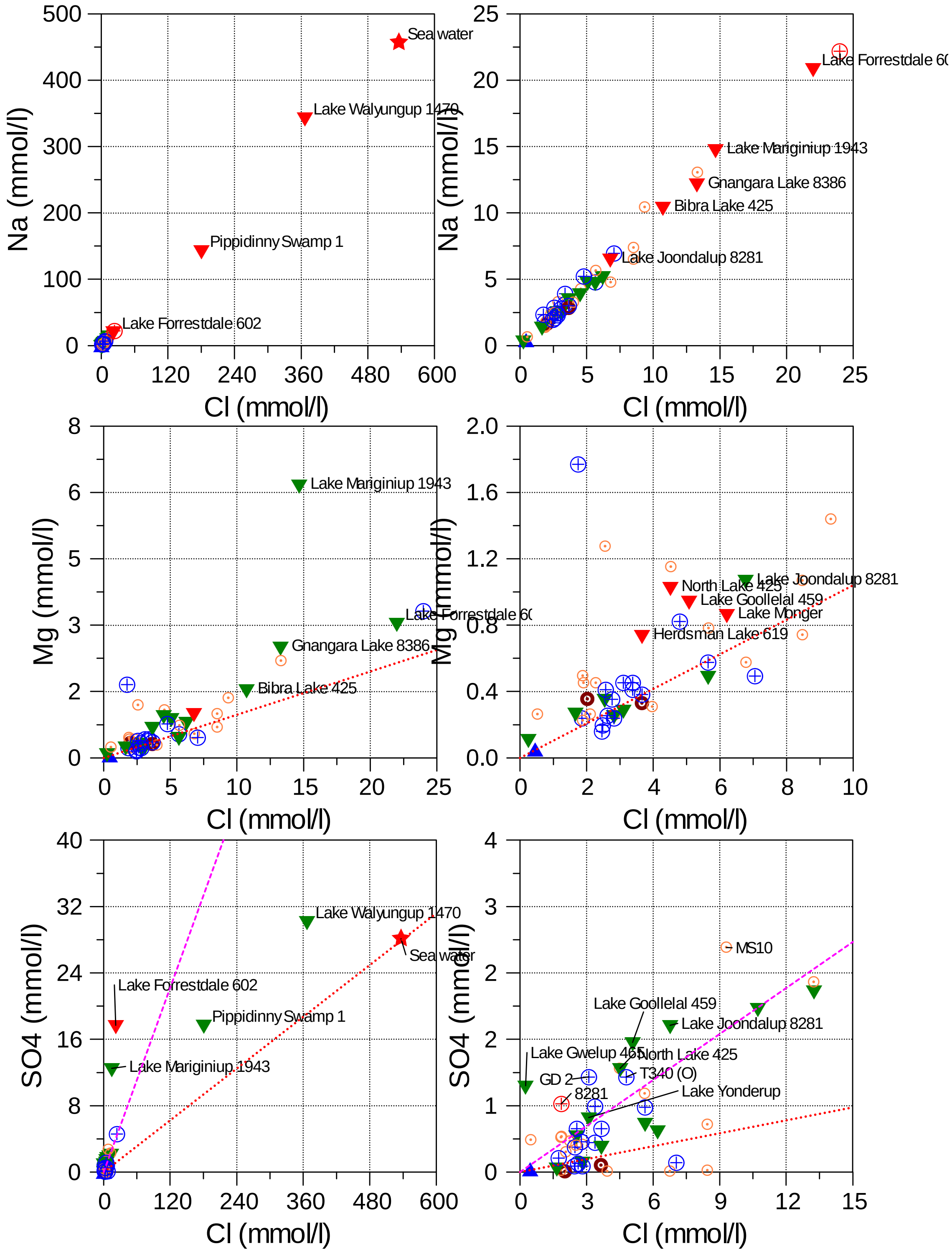


Figure 24 Wetlands and groundwater relationships – major element concentrations plotted against the concentration of Cl.

Figure 25 gives concentrations of some major elements plotted against the concentration of Ca and HCO_3. These plots are also useful for showing the relationship between wetlands and groundwater. The dashed pink lines in the SO_4/Ca plots represent the gypsum line (Ca=SO_4) and in the SiO_2/HCO_3 plot it represents the silica weathering line. The area in between is ambiguous.

The ratios of Ca to SO_4 and Mg in wetlands and surrounding groundwater have values less than or equal to the seawater line. This indicates that excess SO_4 results from gypsum dissolution and/or pyrite oxidation in wetlands. Mg/Ca ratios of wetlands are also less than the seawater line. Wetlands located in Spearwood Tamala Limestone depressions have Mg/Ca ratio lower than 0.8 as expected, but some of these wetlands in carbonate sediments, for example Lake Goollelal, Lake Joondalup and Bibra Lake, have a higher SO_4/Ca ratio. The ratio of HCO_3 to SiO_2 is a good indicator of silica and carbonate weathering processes in wetlands and the Superficial aquifer. Bassendean Sand groundwater provides evidence for silica weathering while Tamala Limestone groundwater indicates carbonate weathering processes. Water in Lake Mariginiup, Gnangara Lake, Lake Forrestdale and North Lake wetlands show silica weathering.

Wetland water samples have been examined using the AquaChem software package to compare wetland water chemistry with groundwater hydrochemistry in both up-gradient and down-gradient samples. The sample comparison reports (Appendix J) produced by the AquaChem software used a linear regression algorithm to generate a correlation and Euclidean distance between the selected sample and all the other samples. Samples having a chemical composition similar to the selected sample will have a correlation coefficient close to one. The difference in absolute concentrations is expressed by the Euclidean distance.

According to the results (Appendix J), Lake Walungup is a groundwater discharge lake with very limited outflow from the lake. As there is little flushing from the lake system, evaporative concentration of salts make the lake water highly saline. The relation between the lake water chemistry and up-gradient groundwater hydrochemistry is fairly good but poor correlation with down-gradient groundwater indicates that there is limited or no groundwater outflow from the lake. Pipidinny Swamp No. 1 has a good correlation with the up-gradient hydrochemistry but poor correlation with down-gradient groundwater hydrochemistry indicating that the swamp acts as a groundwater discharge lake with limited groundwater outflow, therefore salt accumulates and water in the wetland has become saline. It is considered as a semi-perched wetland. Other wetlands, which are part of the Spearwood Lake system, are very well connected with the groundwater beneath and interact with the groundwater system. These include Lake Loch McNess, Lake Yonderup, Lake Nowergup, Lake Joondalup and Lake Goollelal. They are considered as groundwater windows of the Superficial aquifer. Jandabup Lake, Gnangara Lake, Lake Monger and Lake Herdsman are also groundwater throughflow lakes and show high correlation between up-gradient and down-gradient groundwater chemistry.

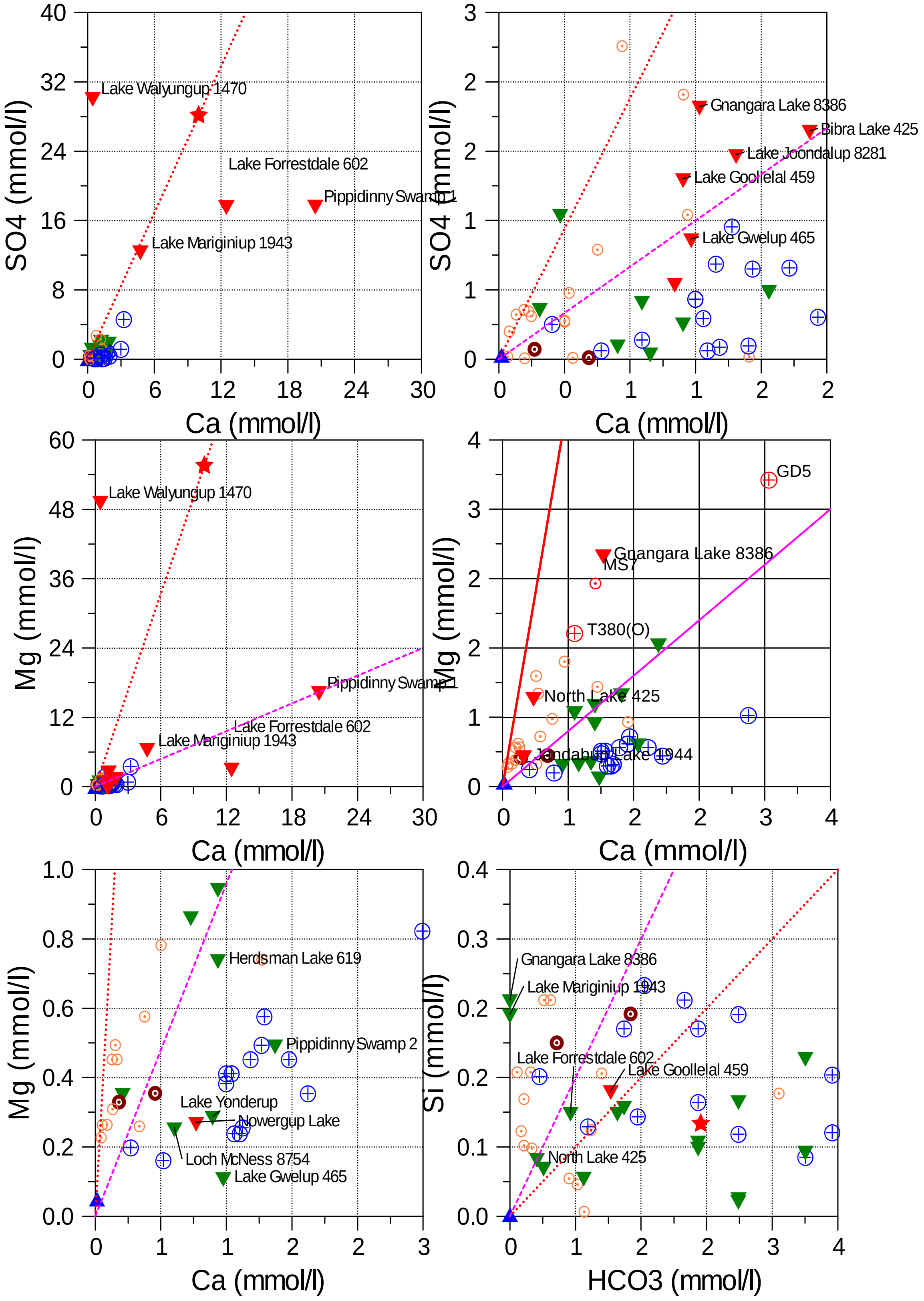


Figure 25 Wetlands and groundwater relationships – major element concentrations plotted against the concentration of Ca and HCO_3

Lake Mariginiup, Pipidinny Swamp No. 2, Gwelup Lake, North Lake, Bibra Lake and Forestdale Lake are considered as semi-perched wetlands. These wetlands have similar chemistry to the surrounding groundwater. Some of these have a high correlation with up-gradient groundwater chemistry, while others have a better correlation with down-gradient groundwater chemistry (Appendix J).

Groundwater recharge estimates using the chloride ratio method

Various techniques are available to quantify recharge. These include those based on surface water and unsaturated zone data, and others based on groundwater data. The reliability of recharge estimates using different techniques is variable. Techniques based on surface water and unsaturated zone data provide estimates of potential recharge, whereas those based on groundwater data generally provide estimates of actual recharge. Uncertainties in each approach to estimating recharge underscore the need for application of multiple techniques to increase reliability of recharge estimates (Scanlon et al. 2002).

The techniques based on groundwater data include the watertable fluctuation method, hydrograph analysis (CDFM technique), Darcy's law, tracer techniques, environmental tracers -chloride, and numerical modelling. In this study the chloride ratio method has been selected to quantify groundwater recharge into the Superficial aquifer in the Perth metropolitan area. Results of the analysis are considered for Cl concentration of rainfall at 19 locations and Cl concentrations from 226 groundwater monitoring bores from the top of the Superficial aquifer. Previous studies on estimating recharge rates in or around the study area have been summarised in Table 1.

The chloride ratio method (CRM) can be used in the unsaturated and saturated zones to estimate groundwater recharge. This approach was originally applied in the saturated zone by Eriksson and Khunakasem (1969) and Scanlon et al. (2002), providing estimates of recharge of 30 to 326 mm/yr on the coastal plain of Israel. Recharge rates estimated from groundwater Cl concentrations range from 13 to 100 mm/year in south-western Australia (Johnston 1987) and 9 to 31% of rainfall at the Melaleuca Park on the Gnangara Groundwater Mound (Sharma & Craig 1988). The CRM approach spatially integrates recharge over areas up-gradient from the measurement point. Spatial scales range from ~ 200 m to several kilometres (Wood & Sanford 1995). The time scales range from years to thousands of years (Scanlon et al. 2002).

The results of the chloride ratio analysis show that average recharge from rainfall into the Superficial aquifer in the Perth metropolitan north region is 11% of rainfall, and has a range of over 30% in Whiteman Park, Ballajura, and Bindiar lake, to 2% in the Mariginiup and Jandabup areas (Map 20). The average rainfall recharge to the Superficial aquifer in the Perth metropolitan south region is 5.5% of rainfall and ranges from 2% at the eastern and western margin to between 15 and 28% in the Jandakot and Success areas (Map 21). In the Yanchep area in the north-west, and west of Lake Herdsman and Lake Monger area, groundwater shows seawater intrusion, therefore Cl concentrations are not representative of the real groundwater concentrations. Results using the CRM are similar to net recharge rates estimated using the CDFM technique at the crest of mounds (Yesertener 2009; in review). The CDFM method estimated the net recharge rate as percentage of rainfall in 2006 and 2007 as 16% and 20% in the Wanneroo rainfall zone, 19% and 28% in Yanchep rainfall zone, and as 21% and 28% of the rainfall across the Gnangara Groundwater Mound.

5 Conclusions

The results indicated an overall salinity increase of up to 225 mg/L in some areas near the crest of the Gnangara Groundwater Mound when recent salinity data is compared with historical data. Similarly, there is a trend of increasing salinity in the Mirrabooka, Wanneroo, Gwelup, and Perth groundwater areas. This might be due to abstraction from the Superficial and deeper aquifers, less permeable sediment associated with old wetlands inhibiting the infiltration of rainfall and accumulation of salt through evaporation. A similar increase in salinity can be seen also in the southern Perth area including Jandakot, Cockburn and Stakehill groundwater areas.

The groundwater chemistry correlates with the geology. For example, the groundwater HCO_3 concentration increases as a result of carbonate dissolution within the Tamala Limestone. Mapping of HCO_3 concentrations of groundwater in the Superficial aquifer shows that HCO_3 concentration is low in Bassendean Sand and high in Tamala Limestone and the Ascot Formation.

The nitrate data indicates that the application of fertilisers in agriculture have increased concentrations of nitrates in the Superficial aquifer in the Perth metropolitan area, especially in the intensively irrigated horticultural areas. The effects of this have become more widespread since 1992. Maximum nitrate concentrations are 292 mg/L in the Carabooda area, 280 mg/L north-east of Lake Wilgarup, 280 mg/L in the Lake Neerabup area, 266 mg/L in the Coogee Swamp area and 53 mg/L in the Lake Nowergup area. All these areas have intensive horticulture. Groundwater nitrate concentrations of 140 mg/L associated with a former agricultural area occur under the newly established Landsdale residential area. An example of the nitrification process causing acidification in groundwater occurs near Lake Wilgarup where the groundwater has a high nitrate concentration and low pH.

Acidification of the Superficial aquifer groundwater is evident from sulfate concentrations. The areal distribution of sulfate in the Superficial aquifer is shown in Map 12. It shows that sulfate concentrations are higher than 100 mg/L in the Mirrabooka, Wanneroo and Lake Pinjar borefield areas. Sulfate is also high in the Lake Joondalup, Lake Mariginiup, Lake Bindiar and Yeal Swamp areas in the northern Perth metropolitan region.

Groundwater in sandy parts of the Superficial aquifer (Bassendean Sand) is undersaturated with respect to calcite. When groundwater flows from the Bassendean Sand into the Tamala Limestone it interacts with carbonate rocks and aggressively starts to dissolve the calcite. The Tamala Limestone sandy facies is composed of a yellow or brown calcareous aeolian sand remnant from leaching of the underlying limestone of the Tamala Limestone that gradually becomes saturated by calcite along the groundwater flowline towards the ocean (Map 16). Once groundwater becomes supersaturated by calcite, then calcite is sometimes secondarily re-precipitated and the water may become undersaturated with respect to calcite. Heterogeneity in the distribution of the saturation index for calcite indicates there is a conduit flow system. Conduit flows are common in highly karstic carbonate aquifers and occur in the cave system within the Yanchep National Park

Groundwater with higher SO_4/Cl ratios also has high Fe and As concentrations, and low pH, indicating that groundwater acidification in the Perth metropolitan area mostly results from the oxidation of iron sulfide and other sulfidic minerals. The high iron concentrations in groundwater may also result from the oxidation of ferrous iron (FeO_2) layers resulting in low dissolved oxygen values in groundwater where iron concentrations are high (Map 19).

The SO_4/Cl ratios are as low as the seawater ratio in Mirrabooka, Gwelup and east of Lake Joondalup. This indicates that the background SO_4 values of groundwater have a seawater origin. The ratio in the groundwater was similar to seawater in the early stages of public abstraction in 1972. In 1992, in some of the Mirrabooka and Gwelup bores, the SO_4/Cl ratios had increased to greater than 0.5, indicating additional SO_4. Since then, there has been a gradual increase extending over a larger area at least until 2005. This is probably due to falling groundwater levels resulting from abstraction that has exposed the sulfide minerals in the soils to oxidation, which has then been leached causing the groundwater to acidify. Areas affected by sulfide oxidation are Mirrabooka, Wanneroo and Gwelup groundwater areas, east of Lake Goollelal, east of Lake Joondalup, Jandabup Lake, Lake Mariginiup and Lake Wilgarup areas.

Increased SO_4/Cl ratios in the Yeal area and bores PM3 and PM4 close to wetlands are the result of oxidation of exposed sulfidic sediments due to water level decline resulting from reduced rainfall since 1969. The areal distribution of acid sulfate soils does correlate well with the SO_4/Cl ratio in groundwater in the Superficial aquifer in the Perth metropolitan area.

Groundwater flowthrough wetlands which have good hydraulic connection with the underlying groundwater, show similar hydrochemical characteristics with groundwater surrounding the wetlands. Wetlands which are part of the Spearwood Lake system, are very well connected with the groundwater beneath and interact strongly. These wetlands include Lake Loch McNess, Lake Yonderup, Lake Nowergup, Lake Joondalup, and Lake Goollelal. They are considered as groundwater windows of the Superficial aquifer. Jandabup Lake, Gnangara Lake, Lake Monger and Lake Herdsman are also groundwater throughflow lakes showing a high correlation between up-gradient and down-gradient groundwater chemistry. The hydrochemical processes are very similar with the difference being only in magnitude. When wetland major anions and cations are compared to the Superficial aquifer, indications are that Lake Walungup is a groundwater discharge lake with limited outflow from the lake and consequently evaporative losses cause the lake water to be highly saline. Pipidinny Swamp No. 1 has good correlation with the up-gradient but poor correlation with down-gradient groundwater chemistry. It is also an example of a groundwater discharge lake with limited groundwater outflow from the lake causing salt to accumulate and the wetland to become saline. It is considered as semi-perched wetland. Lake Mariginiup, Pipidinny Swamp No. 2, Gwelup Lake, North

Lake, Bibra Lake, and Forestdale Lake are considered to be semi-perched wetlands. These wetlands have similar chemistry to the surrounding groundwater. Some of these have high correlation with up-gradient groundwater chemistry, while others have better correlation with down-gradient groundwater chemistry (Appendix J).

The chloride ratio method was used to estimate the areal distribution of recharge into the Superficial aquifer in the Perth metropolitan area. The approach spatially integrated recharge over areas up-gradient from the measurement point. Spatial scales range from about 200 m to several kilometres and time scales range from years to thousands of years, according to the literature. Results could be improved in future studies by closer spacing sampling of groundwater at the watertable.

The results from the chloride ratio analysis show that the average recharge from rainfall into Gnangara Groundwater Mound is about 11% of rainfall, and ranges from over 30% in Whiteman Park, Ballajura and Bindiar lake, to about 2% in the Lake Mariginiup and Jandabup Lake area (Map 20). The average rainfall recharge to the Superficial aquifer in the southern area is about 5.5% of rainfall and ranges from 2% at the eastern and western margins to between 15 and 28% in the Jandakot and Success areas (Map 21).

6 Recommendations

The hydrogeochemical sampling and laboratory analyses program was carried out by different contractors over four years, which has probably increased the risk of sampling and analysis error. Although a number of chemical analyses were rejected and re-sampled, the author has also corrected some chemical analyses using the AquaChem software, including calculating missing chemical parameters and correcting other parameters such as HCO_3. This has resulted in an improved and more reliable chemical analysis dataset.

It is recommended that in future:

- all sampling be done by experienced technicians or hydrogeologists
- the same personnel should work on each sampling program, to minimise sampling and field measurement errors
- the project scientist be the primary contact with the laboratory, to minimise possible analytical errors
- field instruments be checked and all necessary adjustments and calibration be undertaken before fieldwork, to minimise field measurement error
- sample delivery and turnover times for analyses should conform to the relevant guidelines.

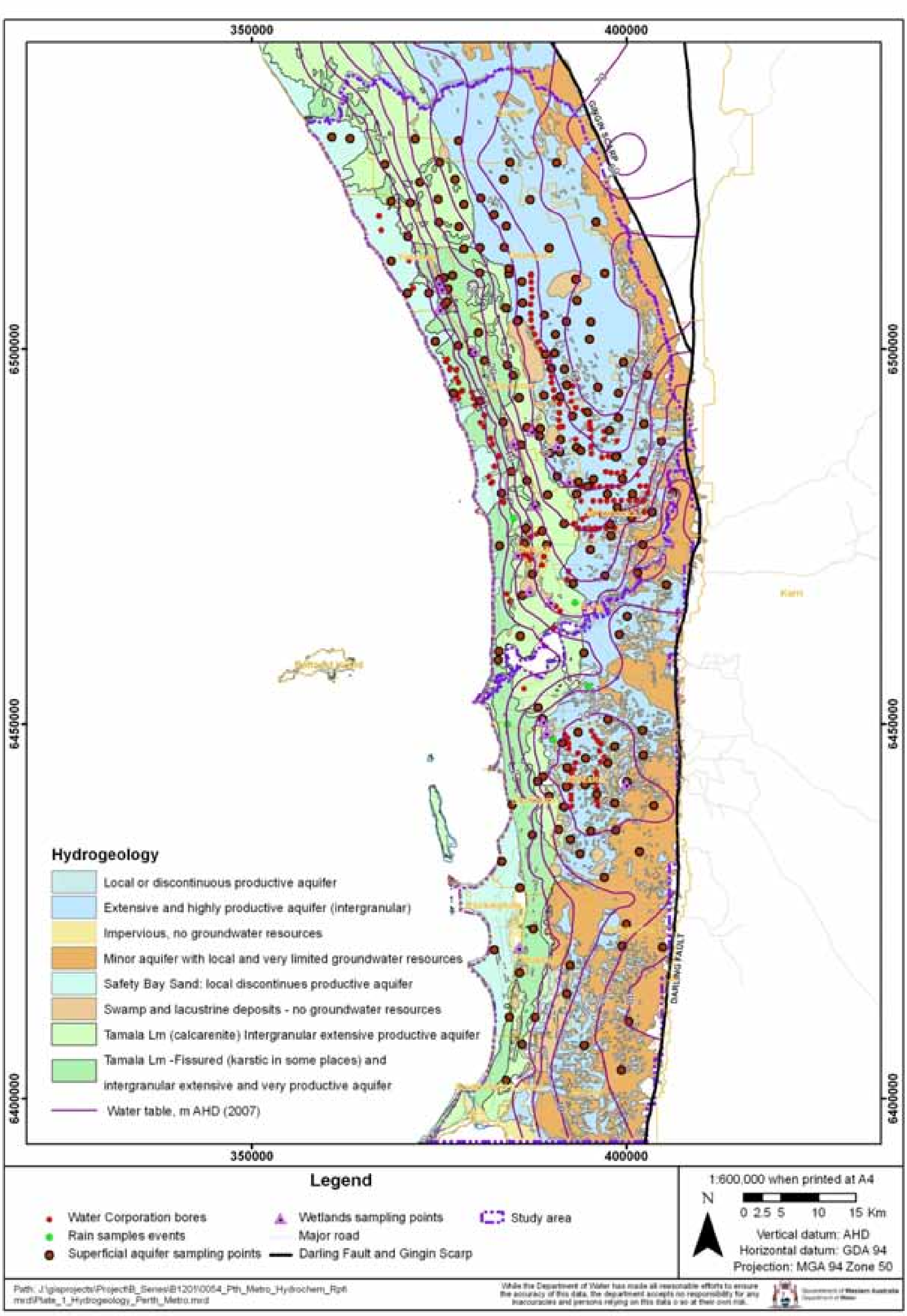
There are some bores where there is a major discrepancy between recent observations and historical salinity data. In particular, it is recommended that data that shows improvement in salinity should be re-sampled to confirm this result. This will also provide greater confidence in the reliability of historical data of these particular bores.

For the study area, only one spot sample was taken from each wetland, and this provided only limited data on salinity, pH and major anions and cations to compare to the underlying groundwater. To better understand the interaction between wetlands and underlying groundwater, it is recommended that monthly or at least seasonal data for both groundwater and wetlands chemistry are obtained.

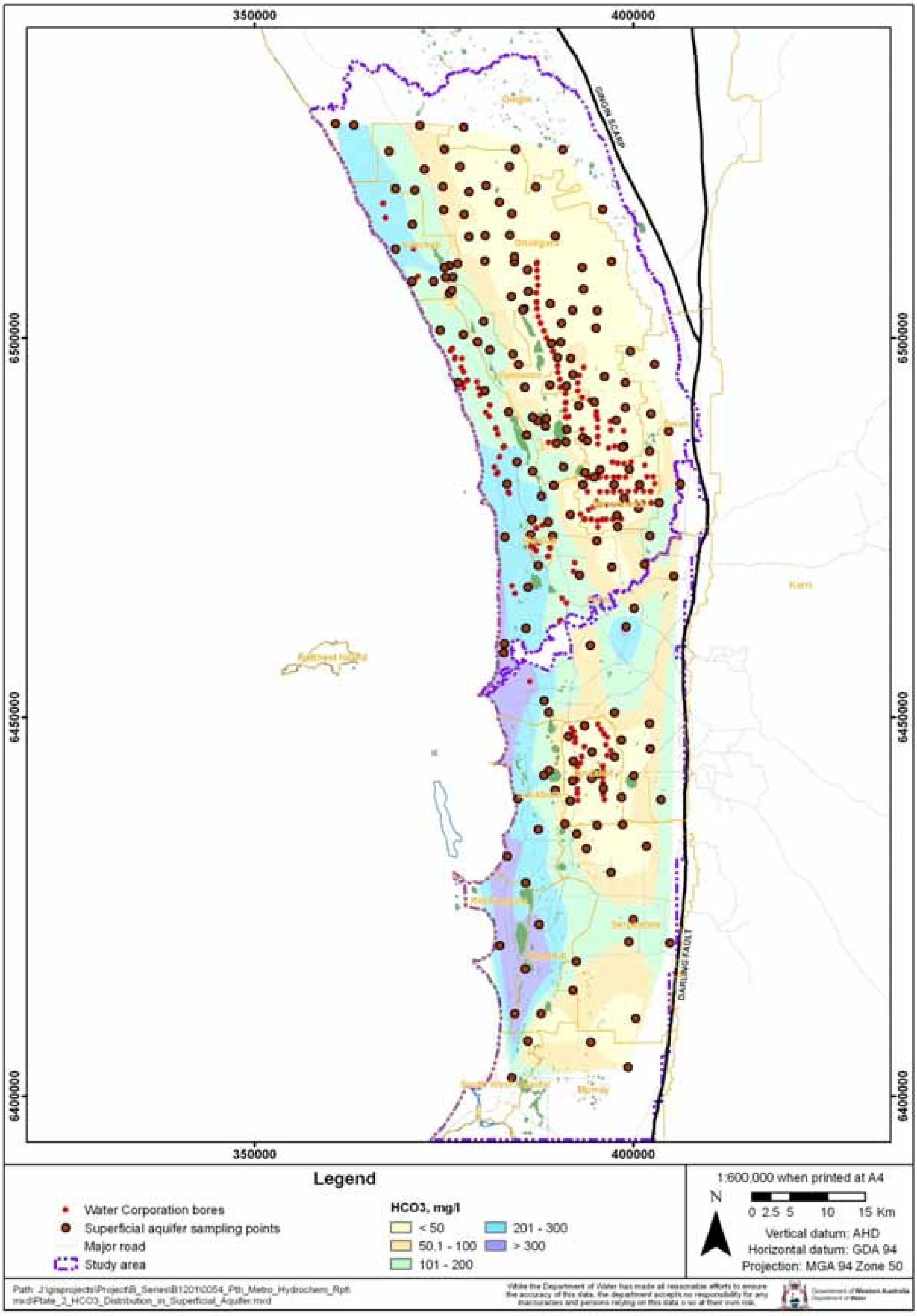
It is recommended that the number of bores that monitor the Superficial aquifer at the watertable be increased so that the chloride ratio method can provide a better estimate of the areal distribution of recharge.

Maps

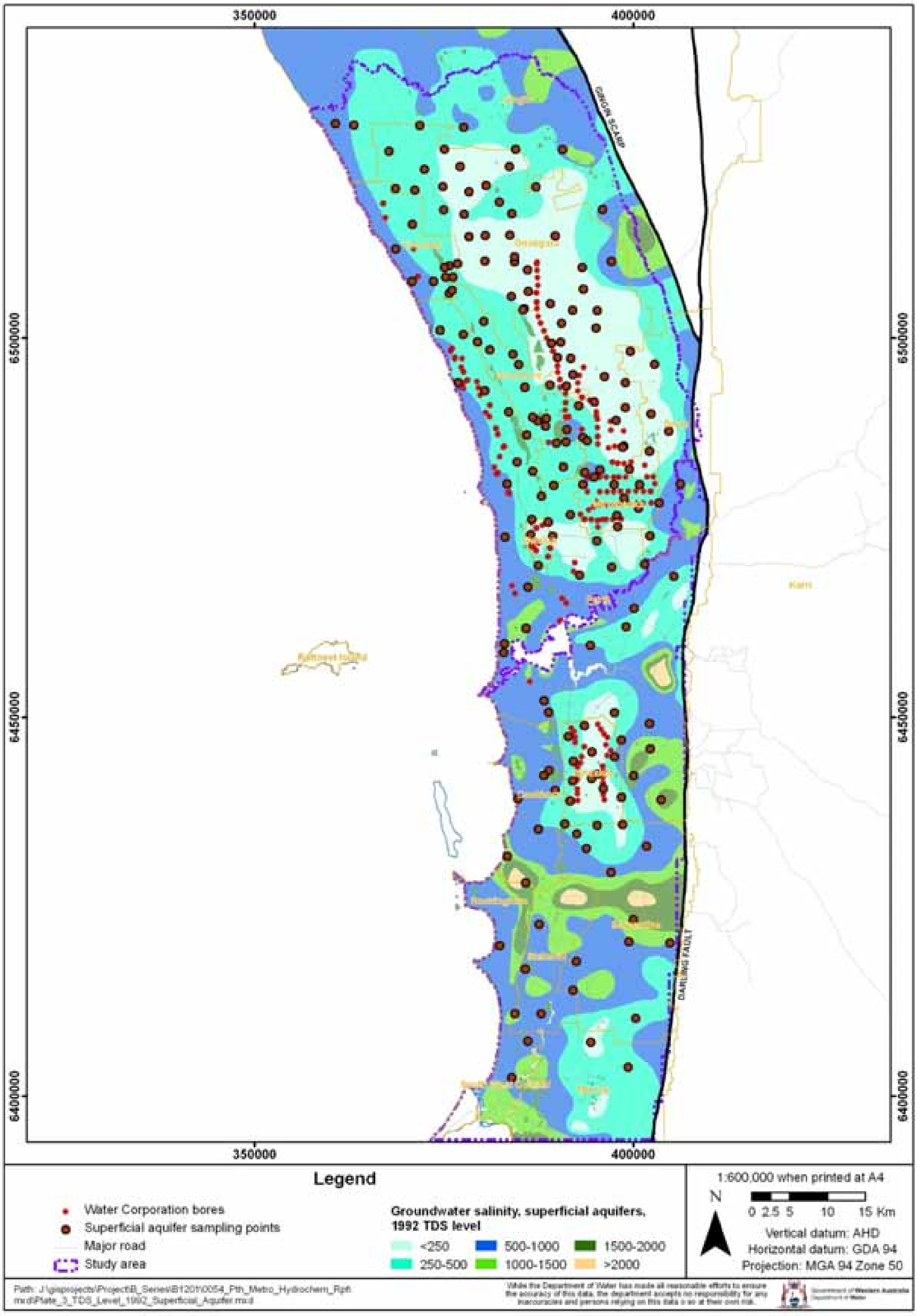
Note: Some of the maps have been simplified and also placed in the body of the text.



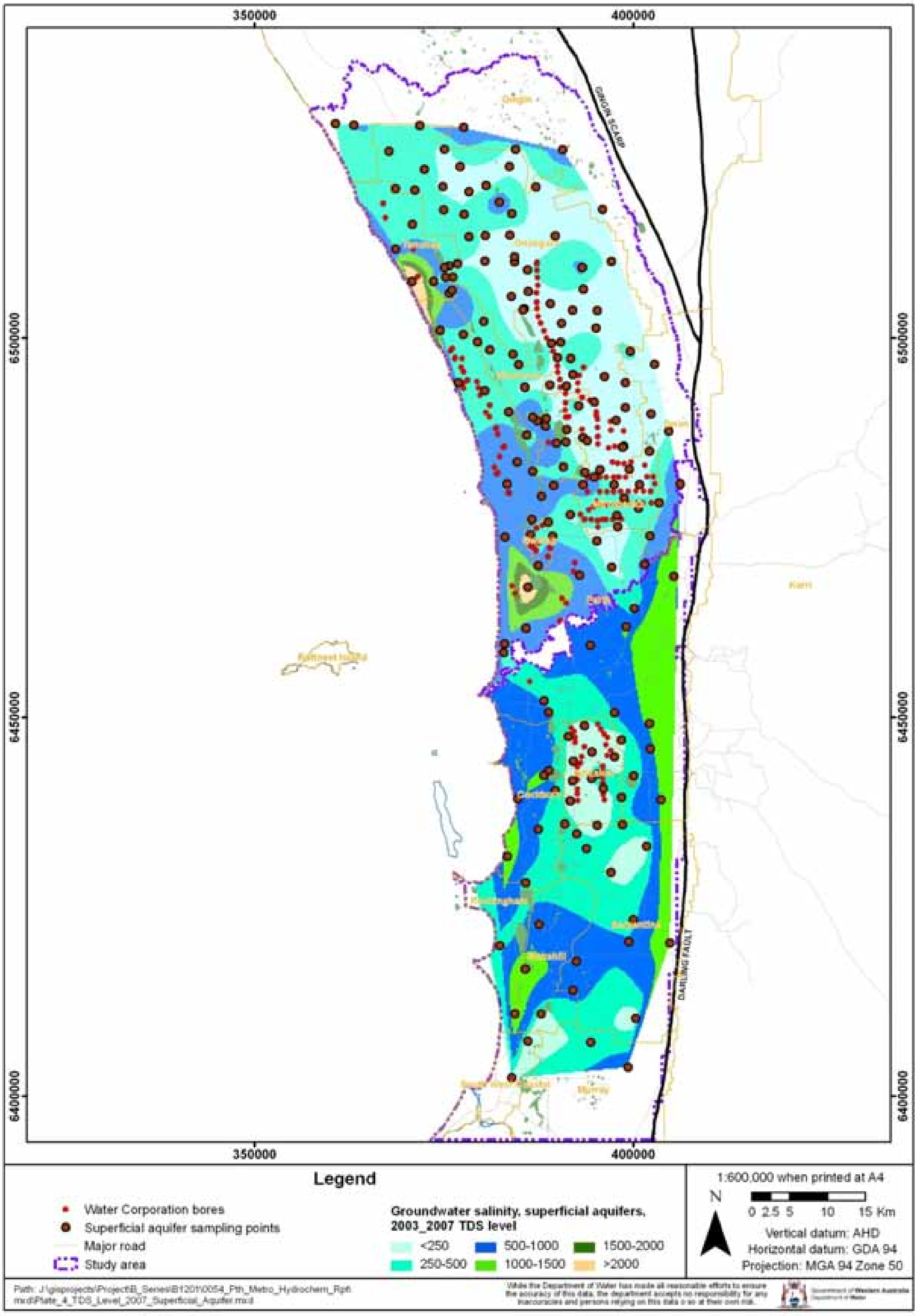
Map 1 Hydrogeology of the Superficial aquifer – Perth metropolitan area



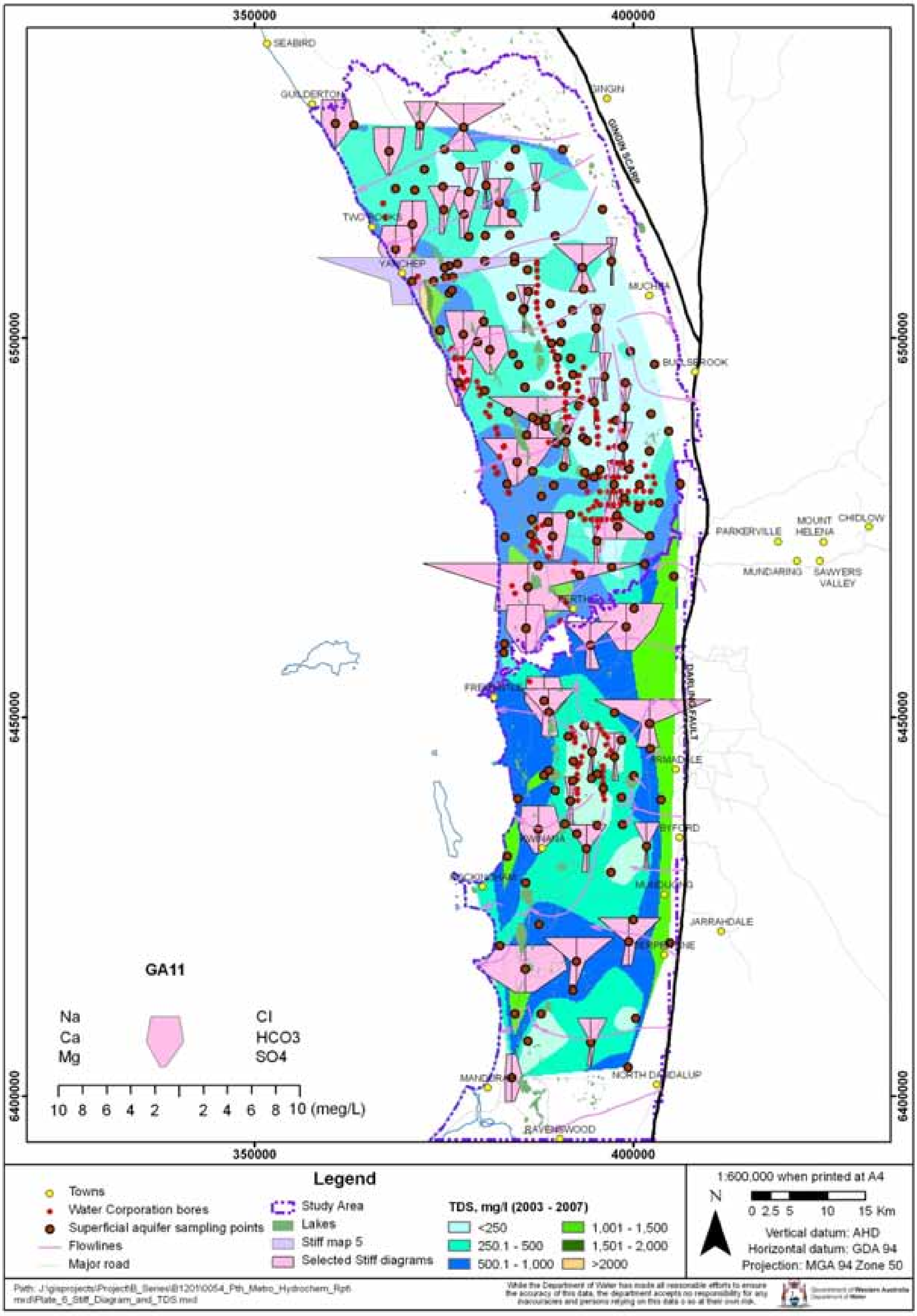
Map 2 HCO_3 distribution in the Superficial aquifer



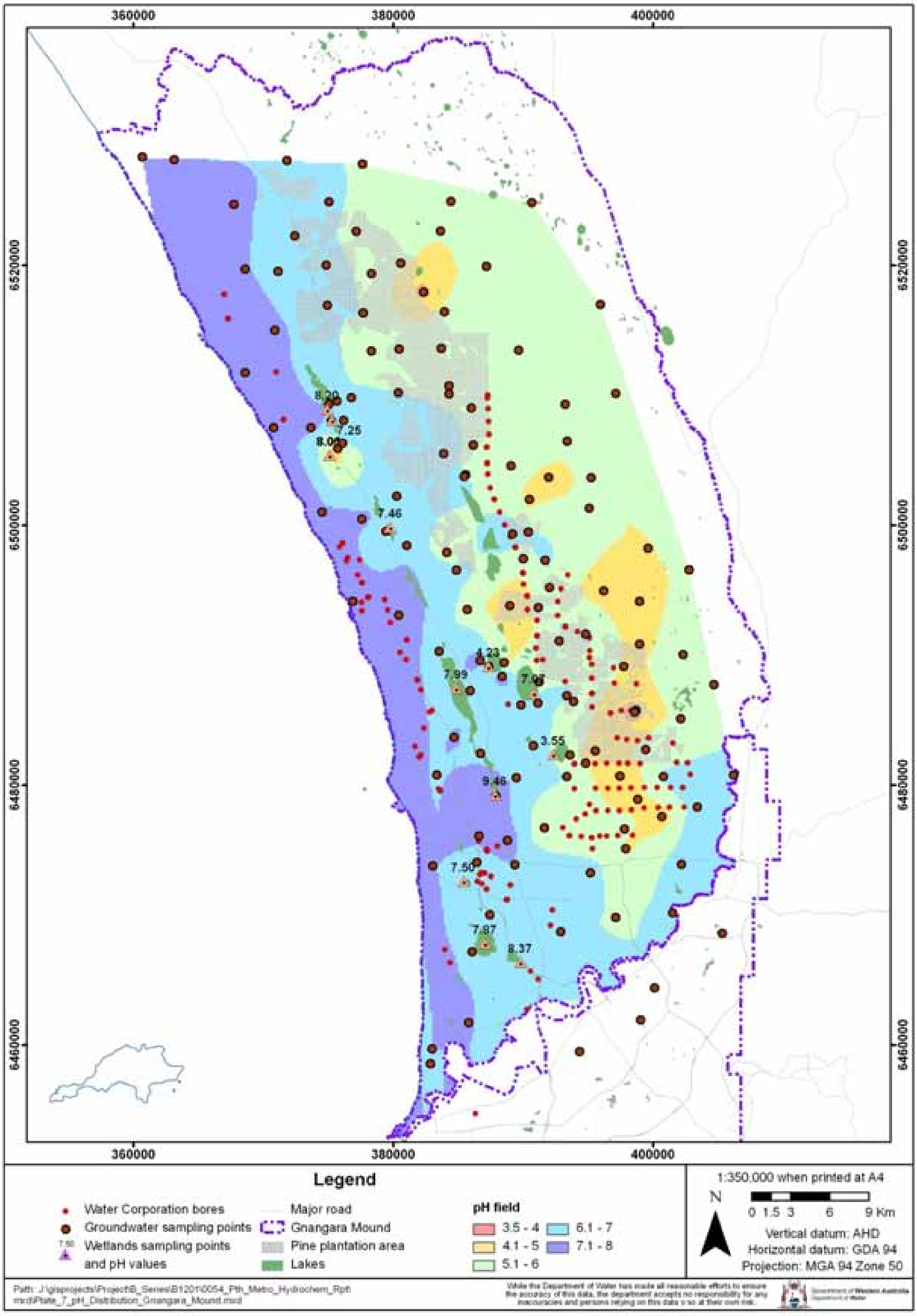
Map 3 Salinity in the Superficial aquifer in 1992 (revised from Davidson 1995)



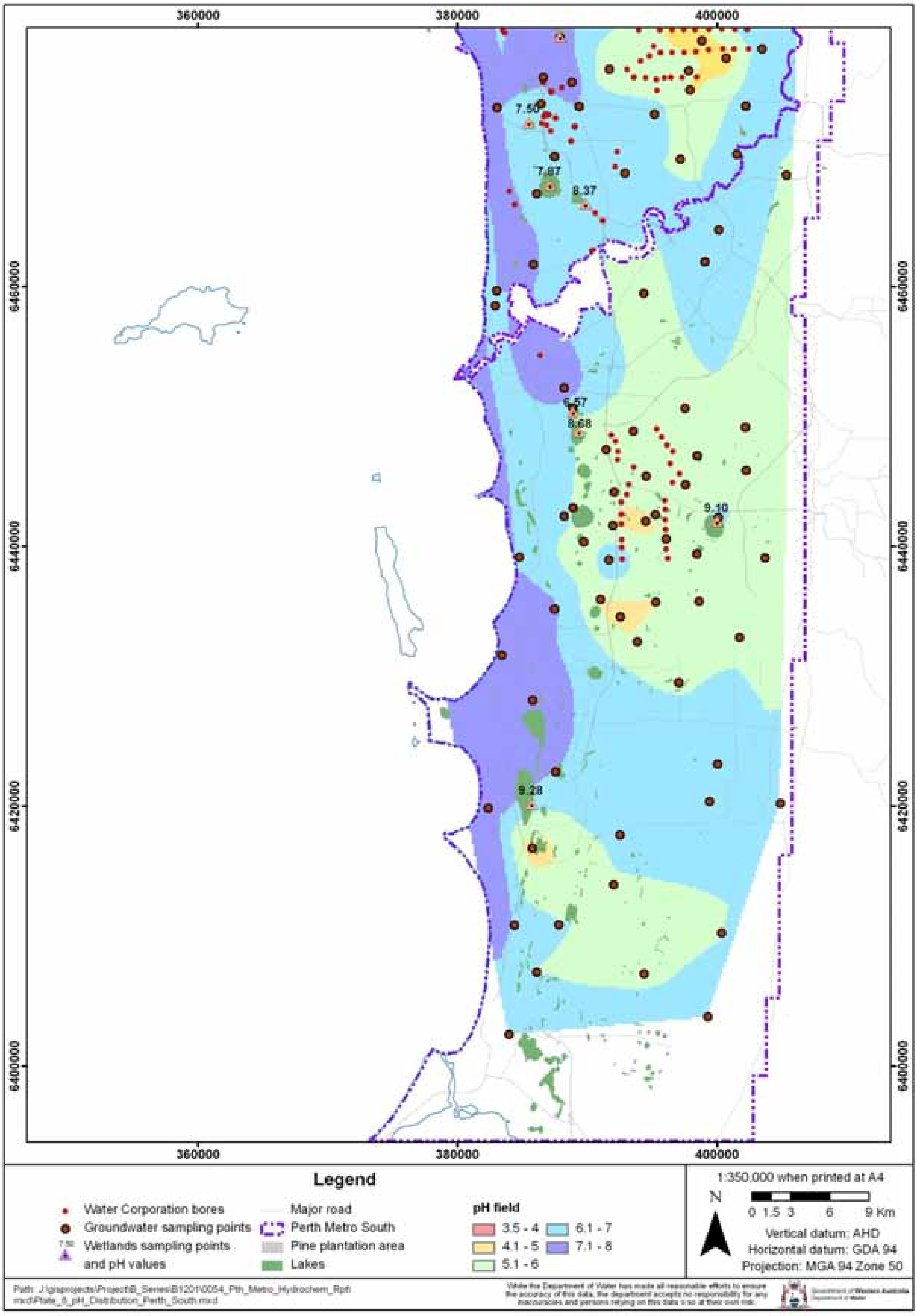
Map 4 Salinity in the Superficial aquifer in 2007



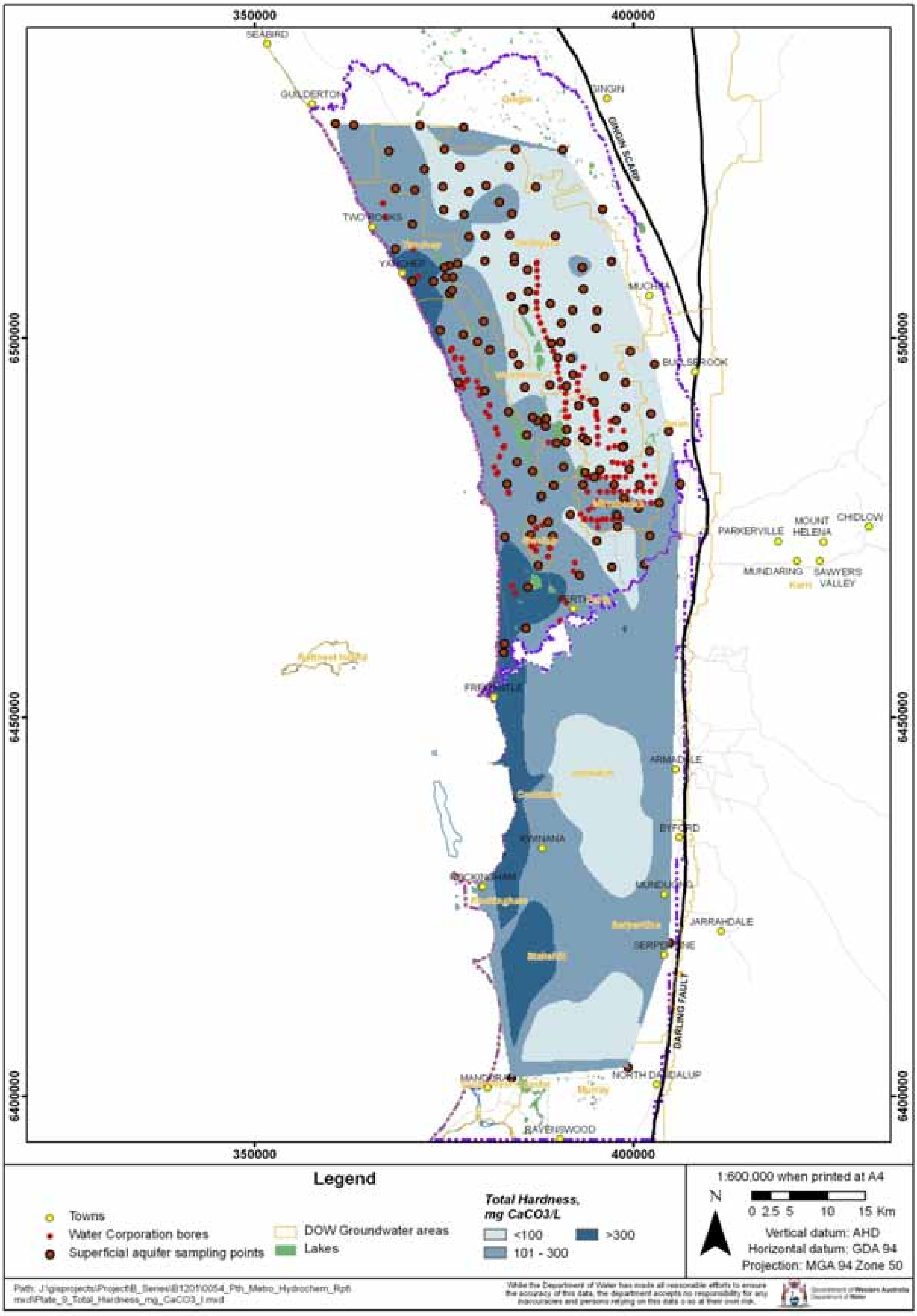
Map 5 Stiff diagrams and TDS distribution for the Superficial aquifer



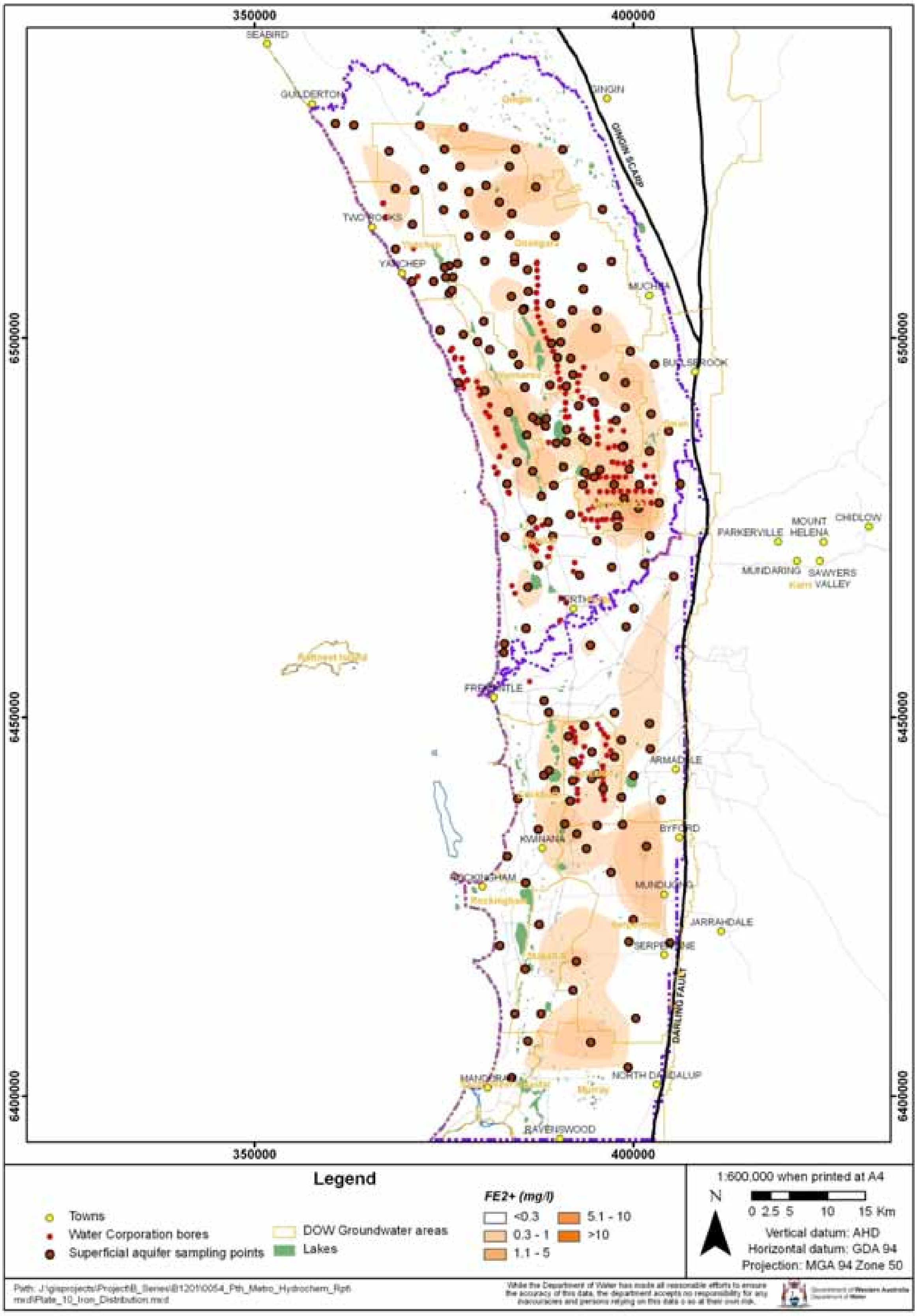
Map 6 pH distribution in the northern Superficial aquifer



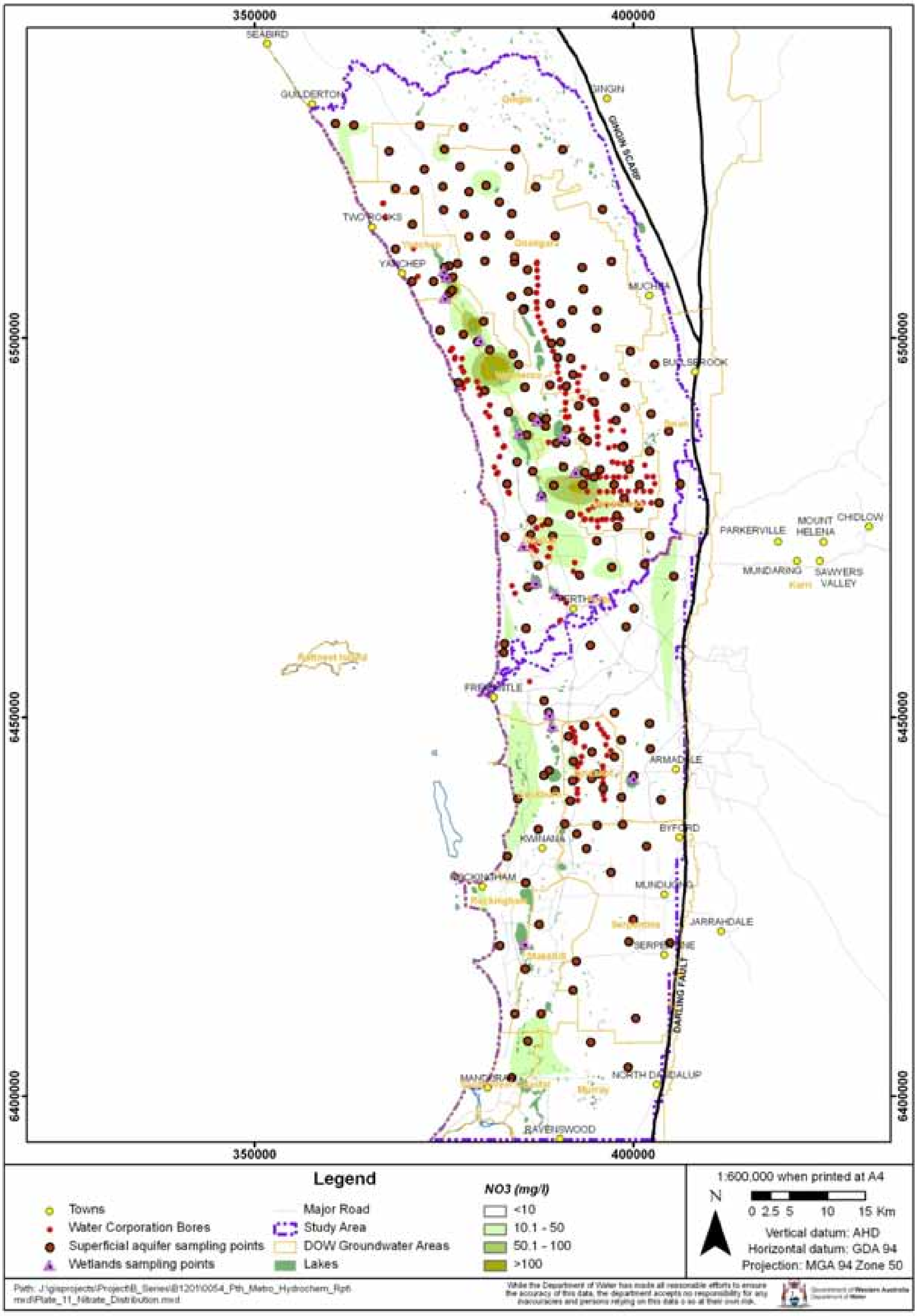
Map 7 pH distribution in the southern Superficial aquifer



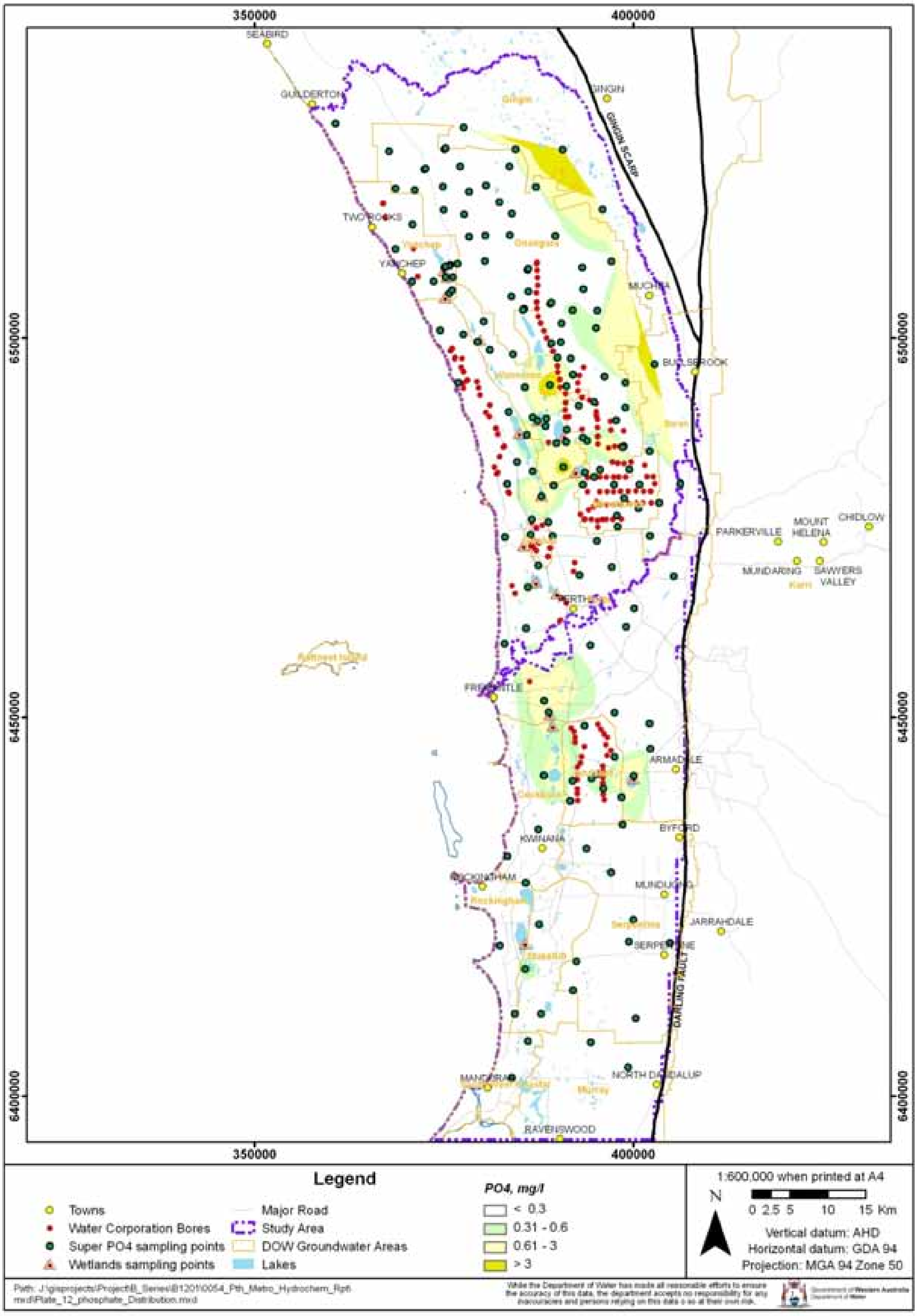
Map 8 Total hardness in the Superficial aquifer



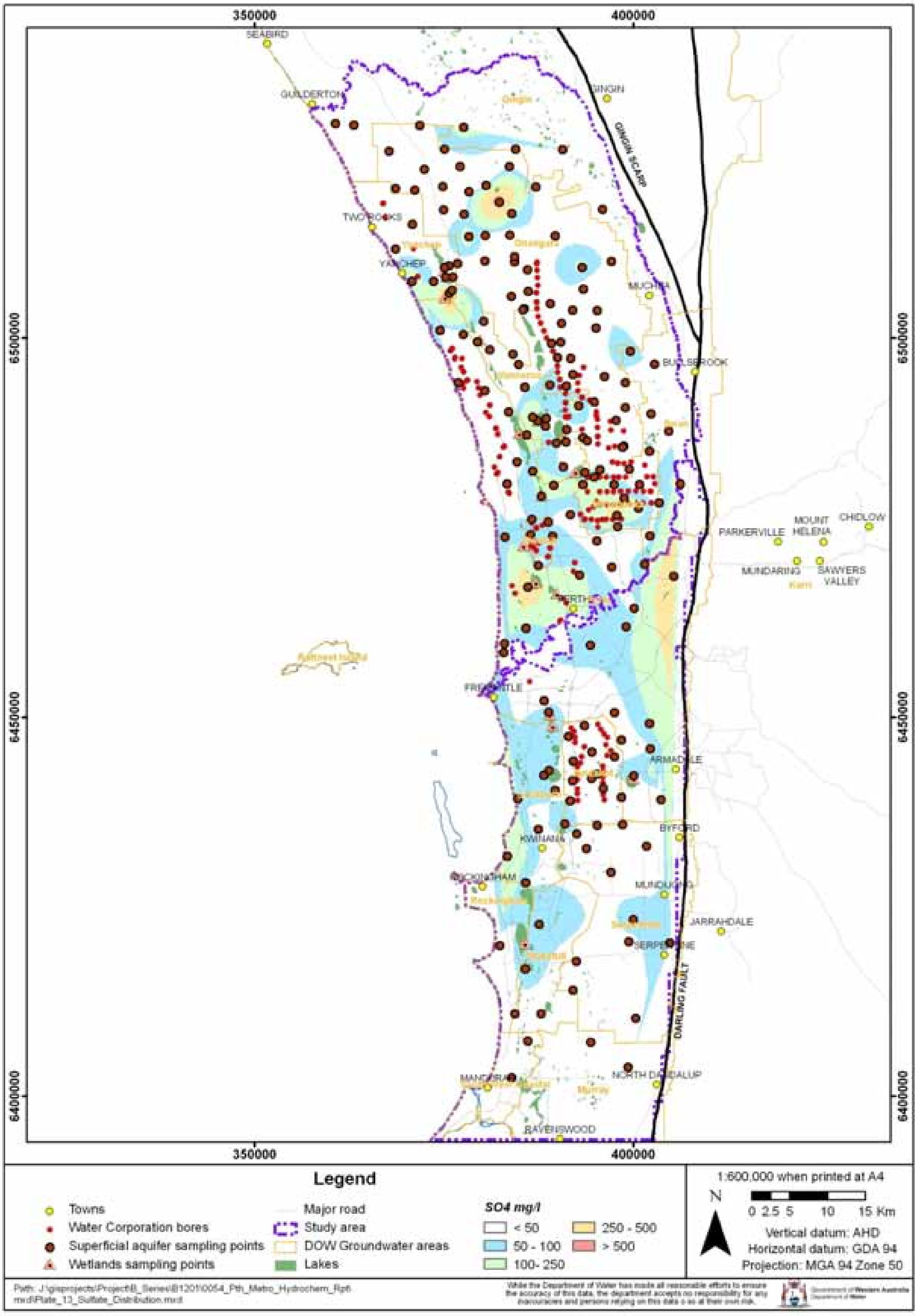
Map 9 Iron (Fe^{2+}) distribution in the Superficial aquifer



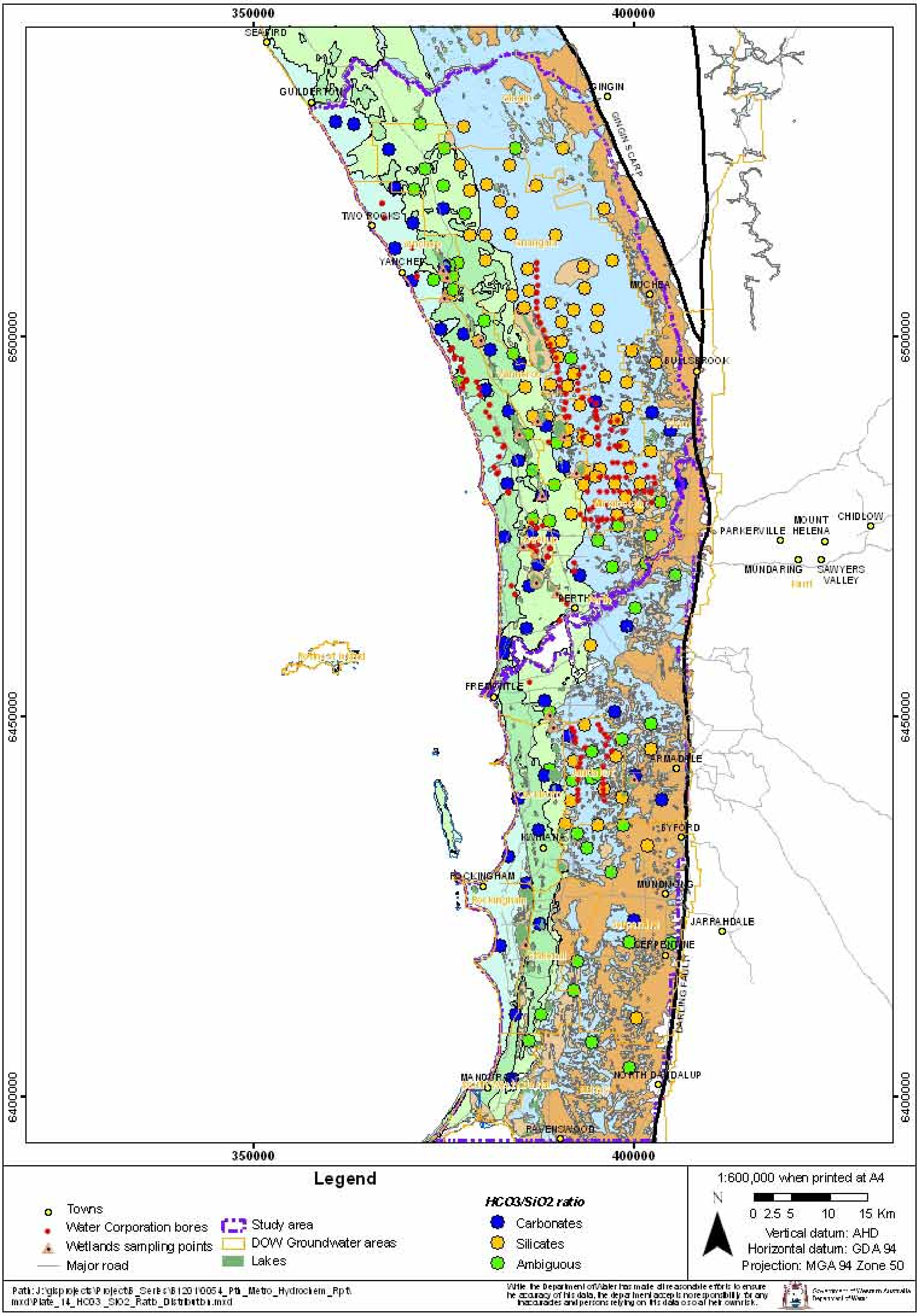
Map 10 Nitrate (NO_3^-) distribution in the Superficial aquifer



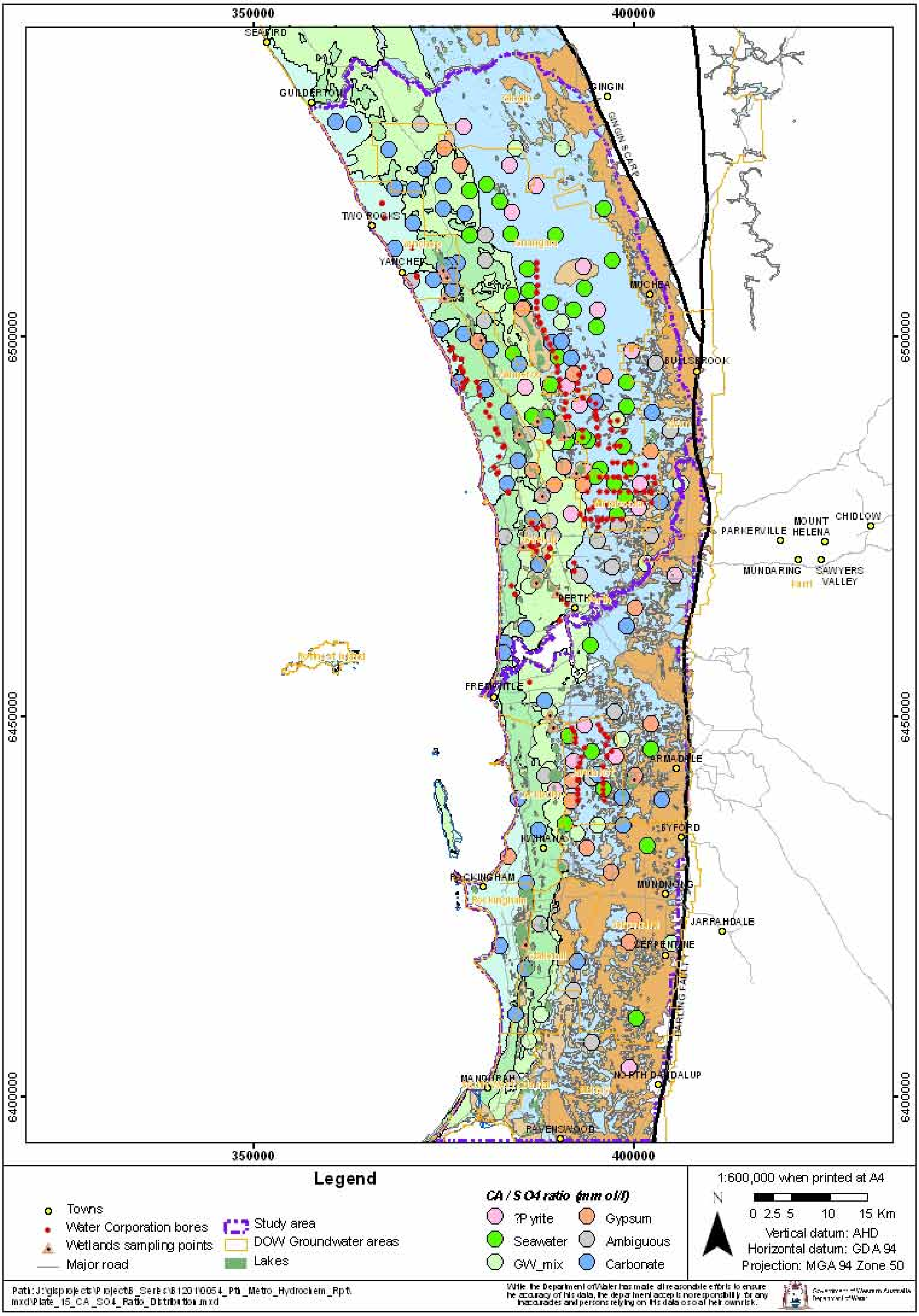
Map 11 Phosphate (PO_4^{3-}) distribution in the Superficial aquifer



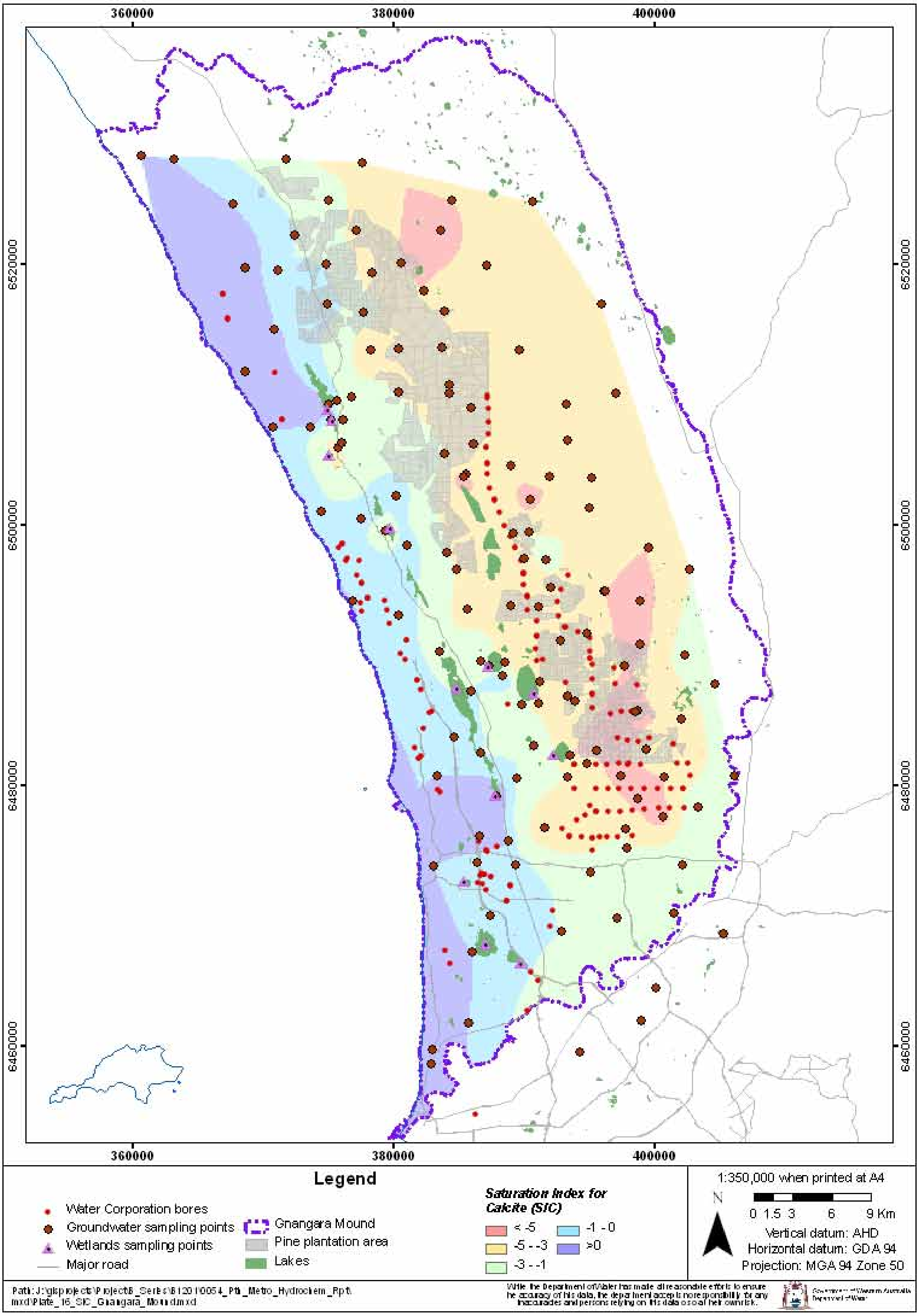
Map 12 Sulfate (SO_4^{2-}) distribution in the Superficial aquifer



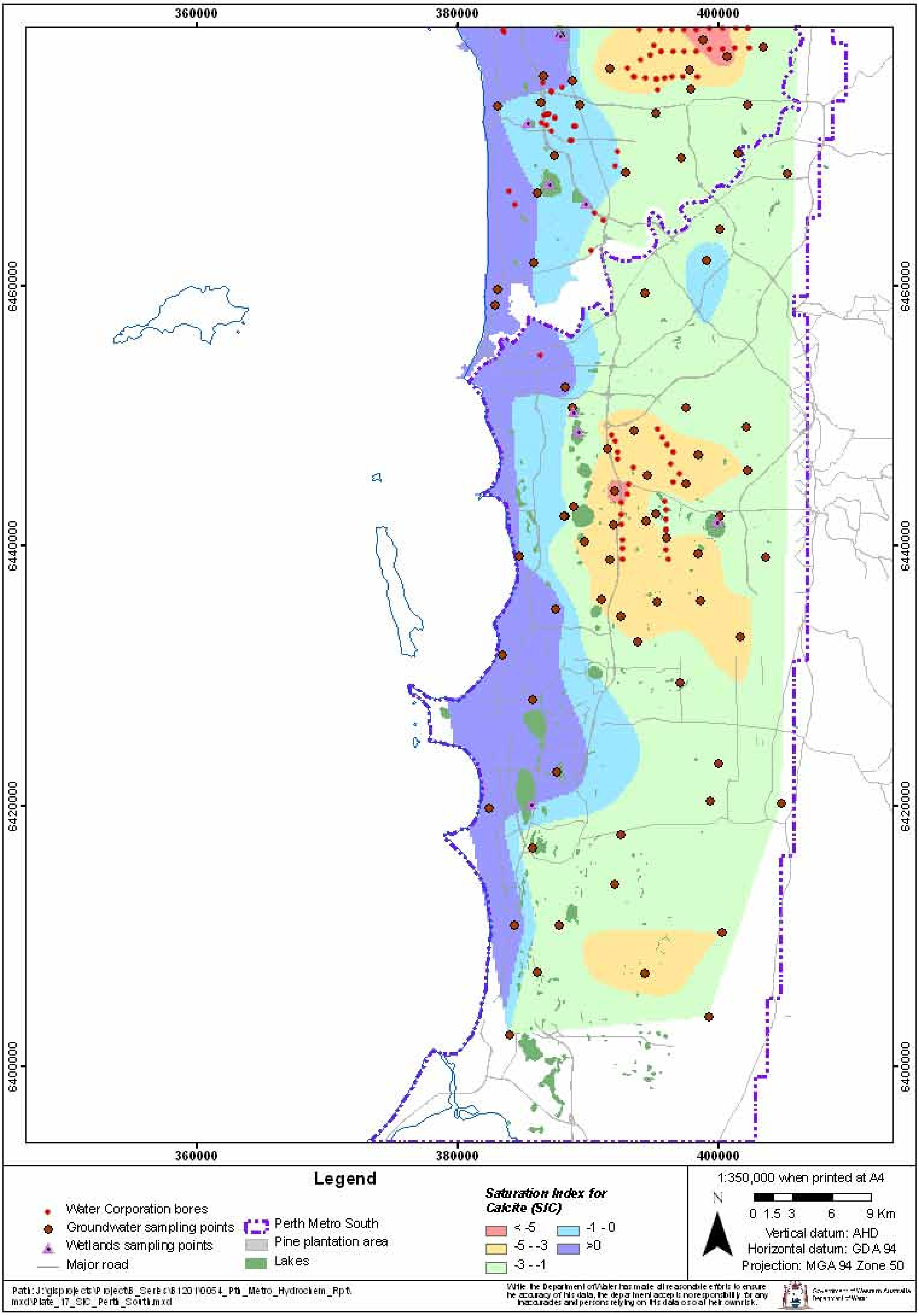
Map 13 HCO_3 / SiO_2 ratios in the Superficial aquifer



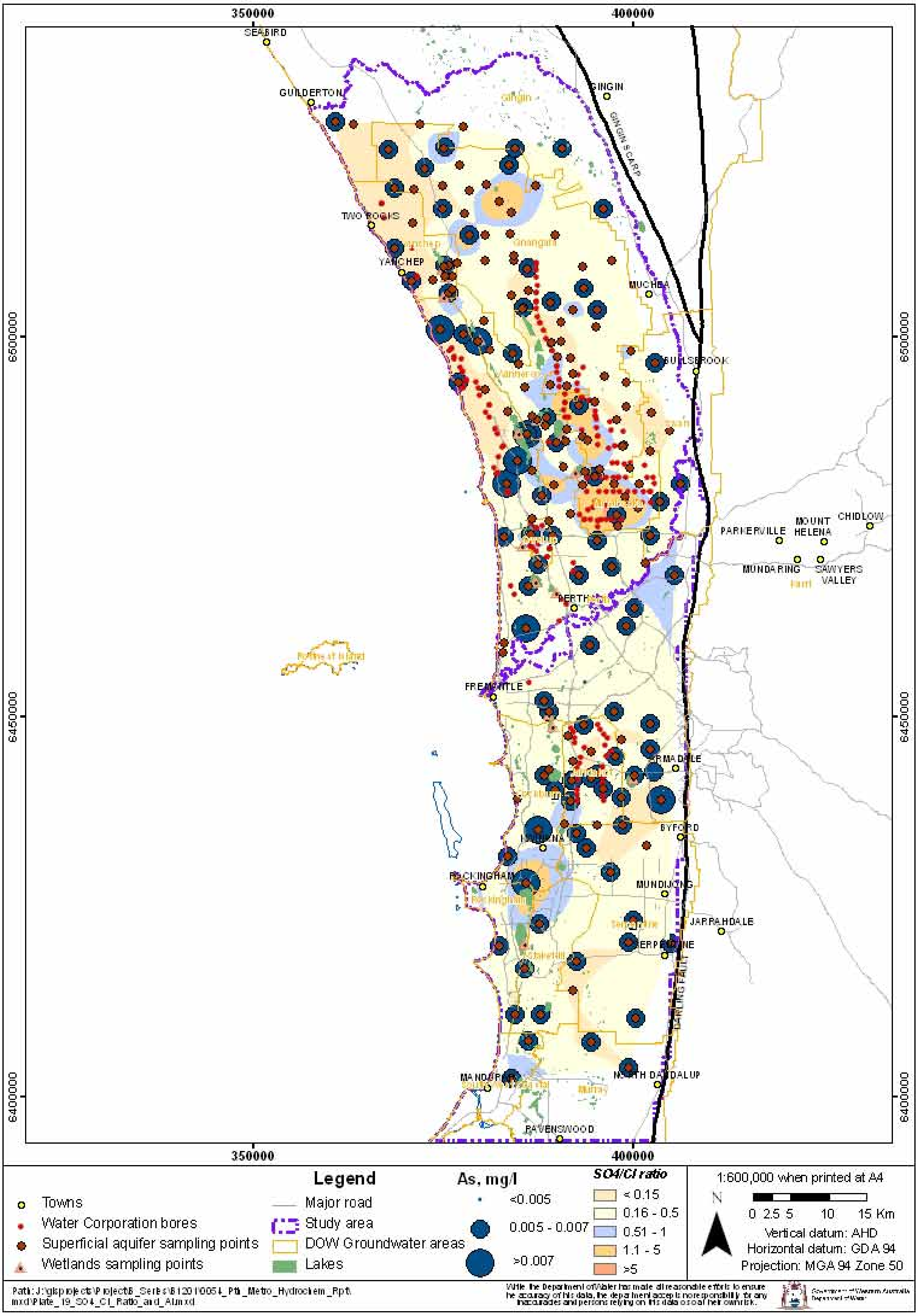
Map 14 Ca/SO_4 ratios in the Superficial aquifer



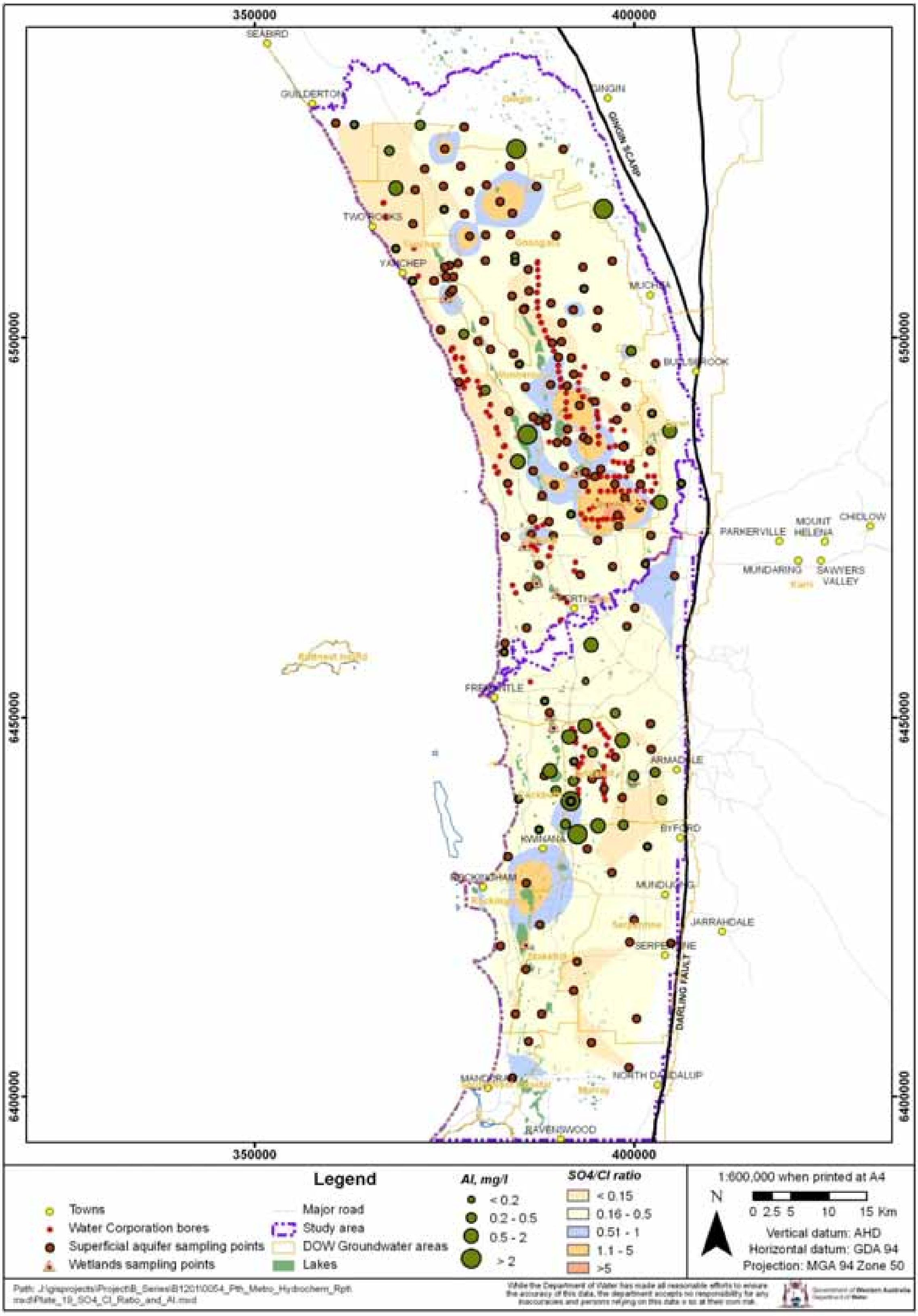
Map 15 Saturation indices for calcite in the northern Superficial aquifer



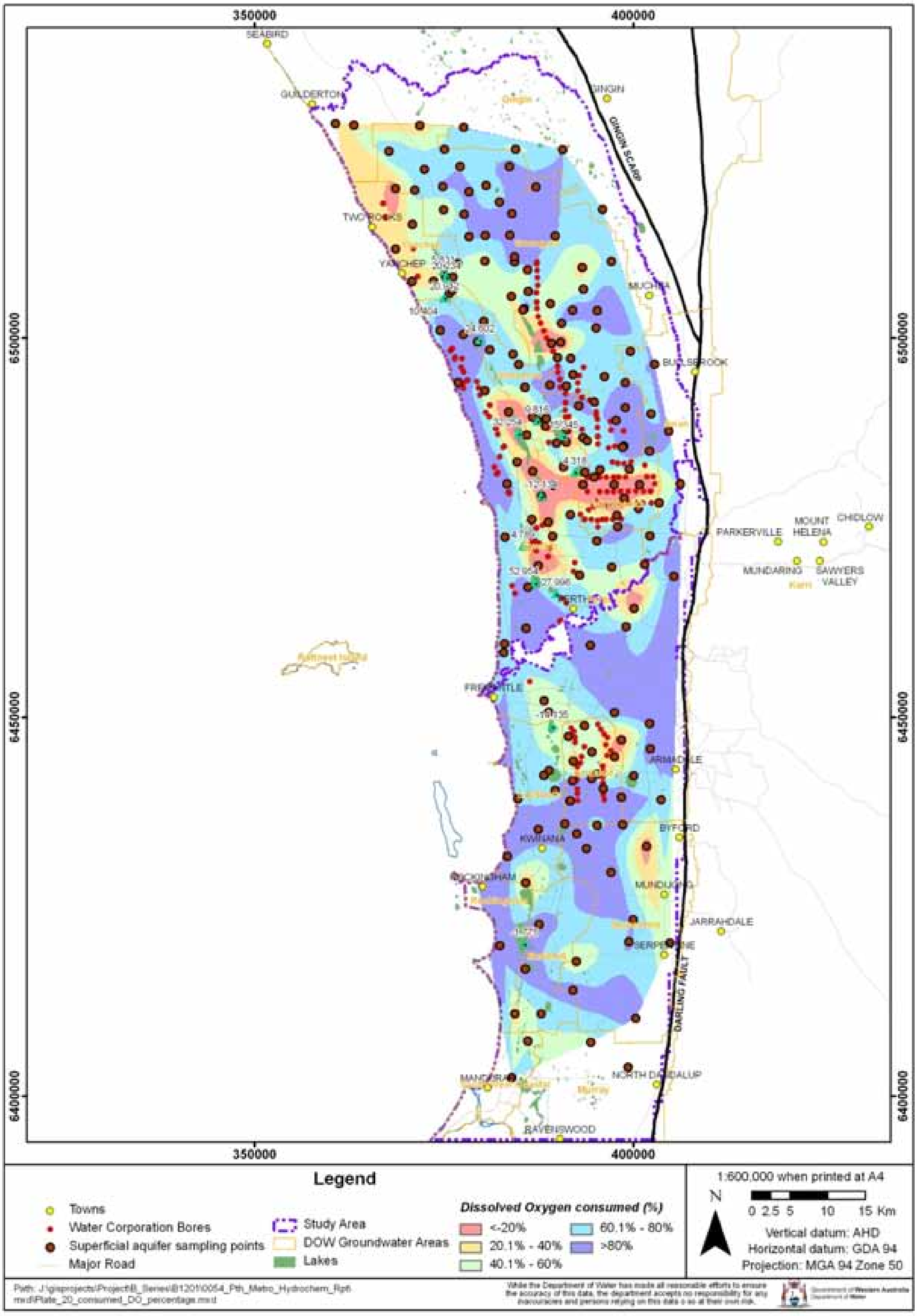
Map 16 Saturation indices for calcite in the southern Superficial aquifer



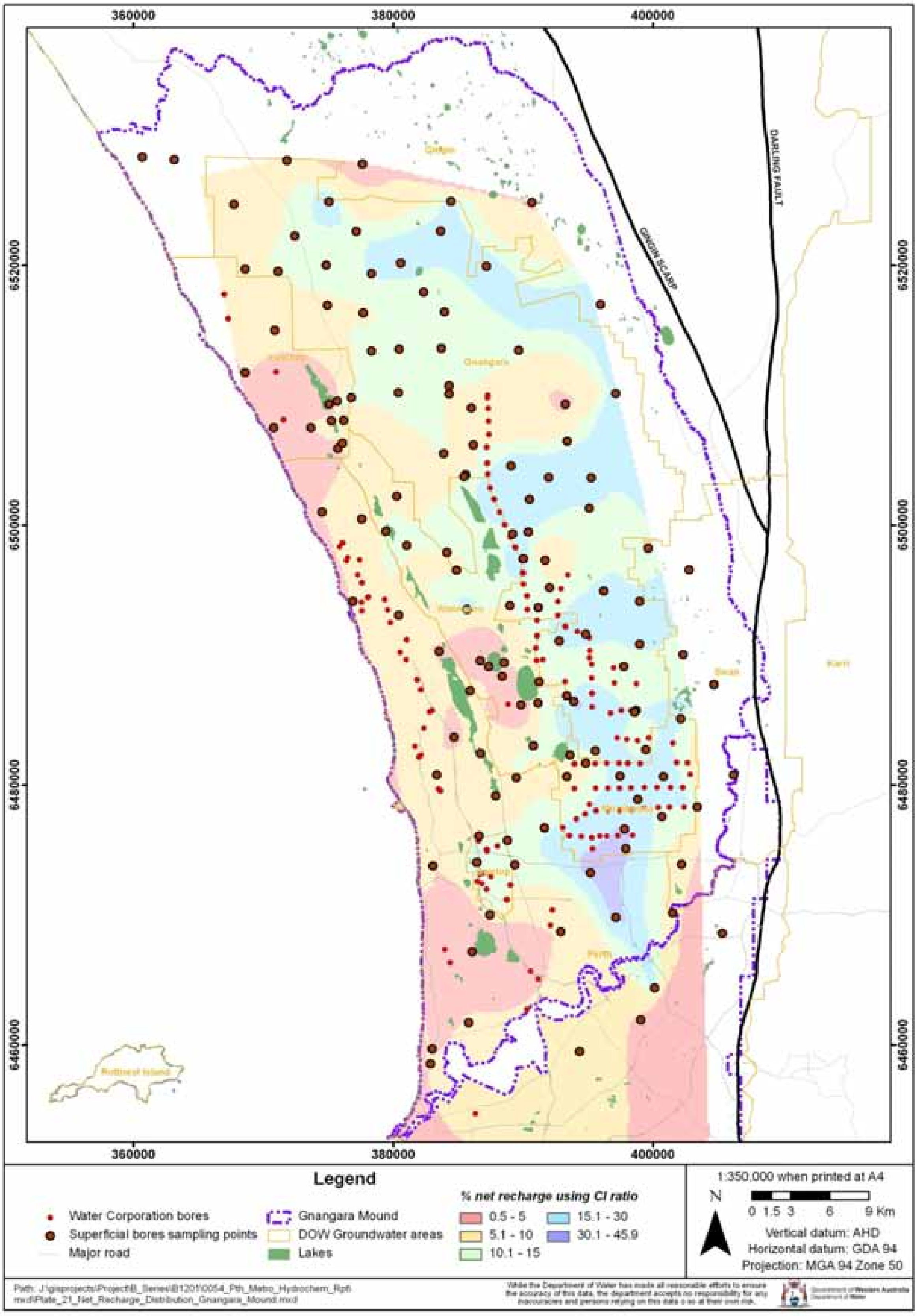
Map 17 SO_4/Cl ratio and As concentrations of groundwater in the northern Superficial aquifer



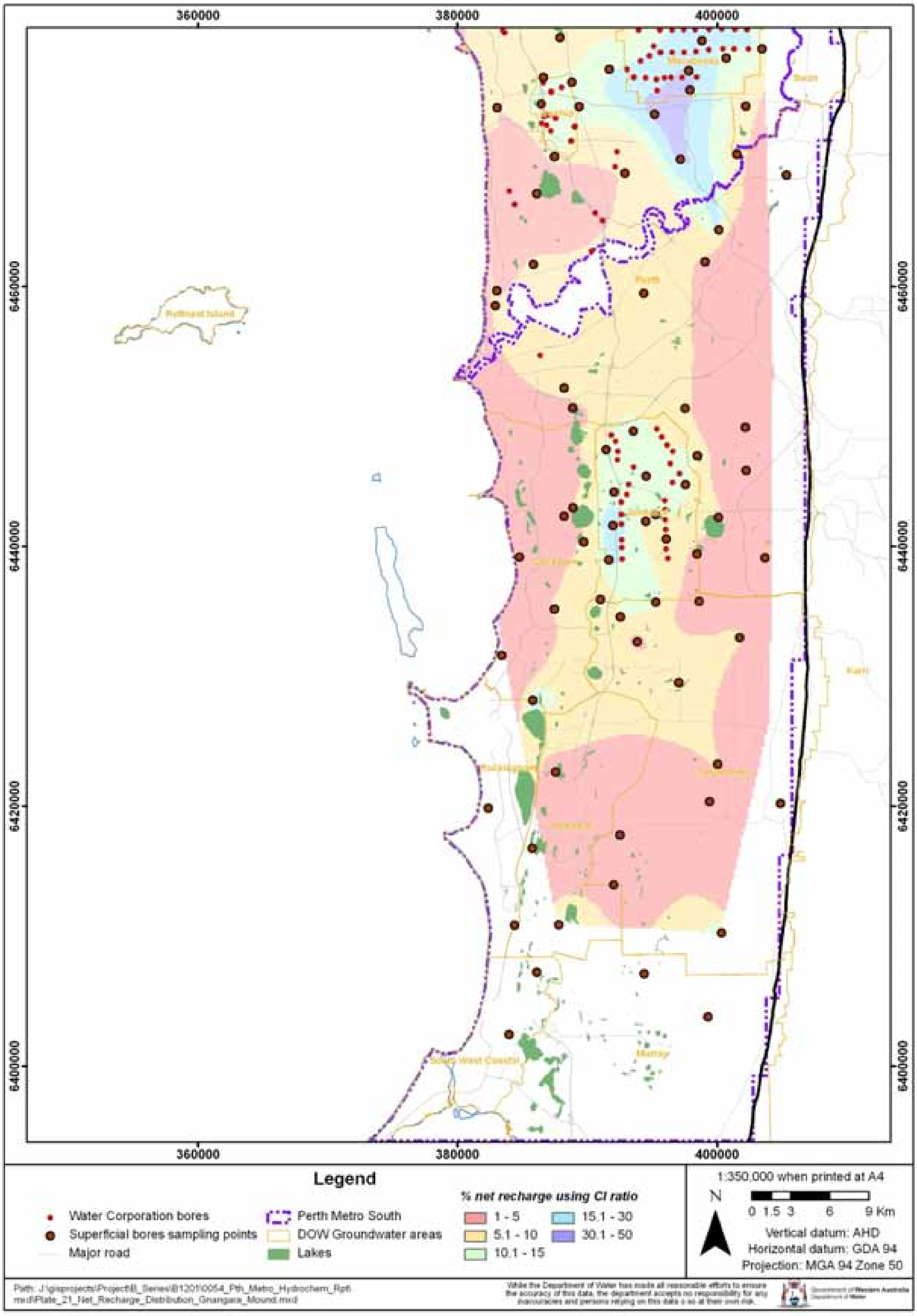
Map 18 SO_4/Cl ratio and Al concentrations in the Superficial aquifer



Map 19 Consumed dissolved oxygen in the Superficial aquifer



Map 20 Net recharge distribution for the northern Superficial aquifer



Map 21 Net recharge distribution for the southern Superficial aquifer

Appendices

In the tables in this section the following abbreviations are used.

NR – not recorded

nd – not detectable

? – in doubt

n/a – not applicable

ppm – part per million

ppb – part per billion

TDS calc@180-HCO_3 – total dissolved solids - + calculation to adjust for loss of HCO_3 – calculated at 180 °C

uncomp EC (lab) – conductivity uncompensated (laboratory)

uncomp EC (in situ) – conductivity uncompensated (in situ)

Cond calc 25 °C – electrical conductivity – calculated to 25 °C

EC comp 25 °C lab – conductivity compensated to 25 °C – laboratory

TDS calc@180-0.5HCO_3 – total dissolved solids - + calculation to adjust for loss of 0.5 HCO_3 – calculated at 180 °C

Appendix A – Bore site information and physico-chemical characteristics

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
459	387870	6479158	3.30	29.58	Shallow		20/06/2005	7.59	-220.0	18.2	1371		8.6	90.3	NR		Superficial top
602	399919	6442341	6.36	25.00	1.40	6.40	15/04/2004	6.27	128.0	18.2	1745	1404	2.5				Superficial top
649	395174	6473247	2.83	30.55	Shallow		22/06/2005	6.51	165.0	19.4	321.0		1.8	18.9	0.8		Superficial top
1081	393618	6454734	3.23	10.00	Shallow		26/03/2004	7.55	-166.3	27.1	2300	2240	1.3				Superficial top
2069	397139	6469799	4.50	24.95	Shallow		21/07/2005	5.79	86.0	20.5	189.0	210	3.3	36.6	16.4	140.0	Superficial top
2288	400116	6464360	5.90	18.00	2.90	5.90	28/06/2005	6.14	178.0	22.0	318.0		9.8	111.0	45.0		Superficial top
8281	385935	6487238	4.60	21.00	0.00	4.60	20/06/2005	6.92	223.0	20.0	511.0		9.0	99.1	NR		Superficial top
8281	385935	6487238	4.60	21.00	0.00	4.60	9/03/2004	7.66	-48.8	23.7	1072.	1111.0	4.6				Superficial top
8282	385779	6428149	3.03	4.36	Shallow		19/07/2005	7.97	125.0	18.1	582.0	630.0	7.3	76.1	236.4	350.0	Superficial top
8283	388209	6452184	2.60	8.00	Shallow		21/07/2005	7.80	301.0	17.9	868.0	870.0	5.6	43.0	301.0	490.0	Superficial top
8283	388209	6452184	2.60	8.00	Shallow		26/03/2004	7.33	-204.9	24.8	608.0	611.0	2.0				Superficial top
8386	393595	6482300	6.31	46.16	2.80	5.70	12/09/2005	5.11	-130.0	18.4	345.0	330.0	0.6	6.6	9.6	220.0	Superficial top
1/98	402787	6496568	6.30	50.00	0.30	6.30	9/06/2005	5.53	-238.0	22.0	218.0		1.7	19.6	1.2		Superficial top
144B	399057	6461912	3.50	14.00	Shallow		28/06/2005	7.12	-253.0	21.9	1613		1.7	19.5	348.0		Superficial top
2025A	394341	6459473	7.60	8.74	5.60	7.60	28/06/2005	5.14	-143.0	20.7	848.0		5.3	58.5	26.0		Superficial top
2025A	394341	6459473	7.60	8.74	5.60	7.60	25/03/2004	5.03	125.7	21.1	933.0	913.0	1.4				Superficial top
3578A	392886	6468709	5.50	22.99	3.00	5.50	27/06/2005	6.39	157.0	21.3	1333		4.0	44.7	119.0		Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
8259A	397899	6475109	5.00	30.77	2.00	5.00	30/04/2007	4.77		20.7	106.3	120.0	0.5			64.0	Superficial top
B270	367727	6524667	45.30	19.13	18.30	45.30	26/07/2005	6.85	114.0	20.3	675.0	720.0	1.6	17.8	152.0	390.0	Superficial top
B270	367727	6524667	45.30	19.13	18.30	45.30	5/03/2004	7.26	15.3	19.9	689.0	689.0					Superficial top
CSG6	383407	6431631	27.00	4.57	0.00	27.00	15/07/2005	7.45	-153.0	21.0	2830	2900.0	0.6	6.4	310.4	1400.0	Superficial top
CSI-3/97	384757	6439185	27.30	20.00	25.30	27.30	7/04/2004	6.92	507.0	20.9	1392	1291.0	2.0				Superficial top
CW1	390497	6501968	8.72	61.90	5.72	8.72	23/06/2003	4.65	-180.0	17.9	225.0	200.0	0.8			113.0	Superficial top
E 1-89	383963	6402412	11.90	6.00			5/07/2005	6.59	128.0	21.1	361.0	420.0	3.4	37.8	170.8	210.0	Superficial top
FL1	400077	6442232	7.00	24.00			30/06/2005	6.25	115.0	17.0	468.0		4.1	42.4	41.2		Superficial top
GA 10	382335	6517936	22.90	57.42	9.50	22.00	15/07/2003	3.60	46.0	17.8	889.0	1000.0	2.1	22.9		760.0	Superficial top
GA 14	378325	6519339	44.00	70.98	32.00	44.00	15/07/2003	5.70	80.0	18.6	256.0	280.0	1.1	11.9		190.0	Superficial top
GA 15	380550	6520142	21.81	54.15	8.50	21.00	15/07/2003	5.27	314.0	17.9	168.0	190.0	3.8	42.0		130.0	Superficial top
GA 4	380433	6513524	28.21	45.36	16.00	28.00	15/07/2003	5.72	182.0	18.8	247.0	280.0	1.3	13.8		170.0	Superficial top
GA 5	383703	6513588	31.00	60.15	19.00	31.00	15/07/2003	5.57	335.9	18.2	240.0	270.0	1.7	19.0		150.0	Superficial top
GA 8	377675	6516311	35.00	54.65	22.00	35.00	15/07/2003	6.00	143.9	18.7	458.0	520.0	1.6	18.0		290.0	Superficial top
GA 9	383945	6516420	23.13	61.42	10.50	23.00	15/07/2003	5.45	148.1	18.1	535.0	630.0	0.9	10.2		380.0	Superficial top
GA1	370868	6514980	40.00	30.49	28.00	40.00	17/07/2003	7.20	259.1	20.1	625.0	690.0	4.4	48.8		370.0	Superficial top
GA11	368595	6519709	41.00	31.00			27/07/2005	7.08	135.0	20.5	678.0	730.0	3.6	39.4	183.0	410.0	Superficial top
GA11	368595	6519709	41.00	31.00			8/03/2004	7.33	29.4	20.1	658.0	650.0	8.1				Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
GA12	371138	6519531	21.40	15.17	9.00	21.00	17/07/2003	6.62	271.0	19.6	490.0	540.0	2.7	29.7		290.0	Superficial top
GA13	374840	6519990	41.00	58.65	29.00	41.00	17/07/2003	6.47	119.0	19.6	384.0	420.0	1.6	18.2		230.0	Superficial top
GA17	372559	6522392	38.60	47.70	24.50	37.00	27/07/2005	6.36	139.0	21.5	485.0	510.0	2.6	29.6	65.0	310.0	Superficial top
GA17	372420	6522243	38.60	47.70	24.50	37.00	17/07/2003	6.40	155.8	19.8	444.0	480.0	1.4	16.0		260.0	Superficial top
GA18	377150	6522612	31.60	57.06	18.50	31.00	17/07/2003	5.57	-124.1	18.5	295.0	330.0	1.8	20.2		190.0	Superficial top
GA22	375208	6525069	33.70	55.00	20.50	33.00	27/07/2005	6.39	106.0	22.1	349.0	370.0	3.5	40.6	80.0	190.0	Superficial top
GA22	375055	6524900	33.70	55.37	20.50	33.00	17/07/2003	6.57	-3.0	18.5	447.0	460.0	2.3	25.0		270.0	Superficial top
GA25	363139	6528109	37.82	26.00	24.00	37.60	5/03/2004	7.31	28.6	20.0	861.0	793.0					Superficial top
GA26	371807	6528074	35.00	49.00	23.00	35.00	5/03/2004	6.78	12.2	20.0	696.0	629.0	7.0	77.0			Superficial top
GA28	360682	6528336	43.90	32.17	32.00	43.90	26/07/2005	7.15	-22.0	22.2	784.0	820.0	6.3	72.1	164.0	400.0	Superficial top
GA33	368586	6511729	27.50	16.00	15.50	27.50	27/07/2005	7.30	136.0	20.8	747.0	770.0	7.1	78.2	182.0	390.0	Superficial top
GA33	368586	6511729	27.50	16.00	15.50	27.50	8/03/2004	7.35	29.2	21.5	489.0	756.0	3.7				Superficial top
GB15	377618	6527807	18.00	46.89	3.50	18.00	17/07/2003	5.72	-104.8	18.7	11870	1400.0	1.6	17.9		840.0	Superficial top
GB21	384439	6524929	18.18	67.00	3.00	17.50	7/06/2005	5.25	-235.0	18.6	251.0		6.6	71.5	27.6		Superficial top
GB21	384439	6524929	18.18	67.00	3.00	17.50	16/03/2004	4.89	45.6	19.6	283.0	293.0	4.5				Superficial top
GB23	383649	6522639	21.00	68.20	7.00	21.00	27/07/2005	5.05	-51.0	19.7	273.0	290.0	0.2	2.3	9.6	170.0	Superficial top
GC 11	387159	6519921	21.00	69.33	9.00	21.00	21/07/2003	5.58	137.9	18.7	202.0	250.0	1.3	14.0		130.0	Superficial top
GC 19	389668	6513454	26.05	73.55	14.00	26.00	15/07/2003	5.61	352.9	17.6	244.0	280.0	1.7	18.9		160.0	Superficial top
GC17	395948	6516980	13.70	67.85	1.70	13.70	8/06/2005	5.27	-238.0	22.2	146.0		2.7	31.2	0.8		Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
GC17	395948	6516980	13.70	67.85	1.70	13.70	16/03/2004	5.40	90.3	22.1	174.4	169.0	2.9				Superficial top
GC4	390667	6524840	10.00	65.50	1.00	10.00	7/06/2005	5.65	-209.0	19.6	996.0		1.8	19.5	4.0		Superficial top
GD 11	394831	6481668	17.03	45.63	4.00	16.00	20/06/2005	5.07	185.0	22.0	1069.		10.8	123.2	0.4		Superficial top
GD 12	406189	6480749	17.47	6.00	5.00	17.00	21/06/2005	6.31	8.0	20.8	1210.		3.4	37.7	NR		Superficial top
GD 2	386714	6482424	13.50	21.12	1.50	13.50	6/06/2003	6.86	-25.0	20.5	805.0	690.0	10.9			450.0	Superficial top
GD12	406189	6480749	17.47	6.00	5.00	17.00	24/03/2004	6.47	69.9	21.3	1951	1908.0					Superficial top
GD23	383048	6473766	13.00	11.56	10.00	13.00	27/06/2005	7.05	35.0	20.6	1177		2.8	30.5	NR		Superficial top
GD23	383048	6473766	13.00	11.56	10.00	13.00	9/06/2003	7.60	100.0	18.0	996.0	1000.0				600.0	Superficial top
GD5	386081	6467163	17.00	10.98	5.00	17.00	27/06/2005	6.93	-275.0	21.0	3740.0		0.1	1.4	243.0		Superficial top
GD8	401501	6470165	17.93	9.00	5.54	17.54	25/03/2004	6.32	190.4	21.8	903.0	893.0	3.9				Superficial top
GE 2	383006	6459695	23.20	10.53			13/09/2005	7.11	107.0	21.2	1414.0	1400.0	2.3	25.9	288.8	760.0	Superficial top
GE3	385821	6461699	30.80	20.00	18.50	30.00	27/06/2005	7.11	-92.0	21.6	902.0		0.5	6.1	223.0		Superficial top
GG3 (O)	397132	6510134	69.00	78.14	18?	78.00	21/07/2003	5.07	307.3	18.6	163.0	190.0	2.2	23.8		100.0	Superficial top
GM 16	389361	6473848	24.47	32.00	12.47	24.47	22/06/2005	6.98	148.0	20.8	778.0		4.7	52.6	103.0		Superficial top
GM 2	386606	6476084	24.65	21.72	12.65	24.65	6/06/2003	7.16	151.0	20.5	1073.0	950.0	4.8			560.0	Superficial top
GM 7	388797	6475726	24.30	36.14	12.30	24.30	6/06/2003	7.70	158.0	20.1	779.0	680.0	9.8			410.0	Superficial top
GM 9	386423	6474049	17.09	12.41	5.09	17.09	22/06/2005	6.54	117.0	21.2	676.0		1.3	15.1	9.2		Superficial top
GM26	387447	6470000	21.80	18.65	9.80	21.80	27/06/2005	6.13	-185.0	22.7	805.0		12.6	145.9	NR		Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
GN 13	394830	6491603	70.10	66.99	46.00	46.60	5/06/2003	6.30	20.0	18.8	205.6	190.0	2.6			100.0	Superficial top
GN23	389200	6499320	76.81	57.25	37.50	38.10	16/06/2003	6.55	44.0	18.6	384.0	350.0	12.3			230.0	Superficial top
GNM11A	378299	6513400	11.60	34.40	5.60	11.60	7/06/2005	5.01	-202.0	19.3	620.0		1.6	18.1	0.4		Superficial top
GNM5	390013	6497415	12.04	57.38	5.50	11.50	16/06/2003	5.38	-103.0	19.3	304.0	280.0	2.1			180.0	Superficial top
IF16	382886	6458534		15.00			20/04/2004	6.82	407.0	21.9	1010.0	641.0	1.9				Superficial top
JB 4	389845	6486158	30.00	63.28	18.00	30.00	2/08/2005	6.07	-199.0	21.8	1132.0	1200.0	1.1	13.0	67.0	830.0	Superficial top
JB 9A	391229	6487933	54.00	53.38	50.00	52.00	4/06/2003	7.10	123.0	18.6	410.0	350.0	10.1			220.0	Superficial bottom
JB 9C	391229	6487930	22.00	53.45	18.00	20.00	4/06/2003	5.90	-44.0	18.5	264.0	230.0	12.6			140.0	Superficial top
JB5	391132	6486310	10.75	49.94	6.00	10.70	9/06/2003	6.10	-96.0	20.2	372.0	330.0	10.0			210.0	Superficial top
JE10C	395209	6442439	10.00	28.24	0.75	10.00	19/07/2005	6.05	-130.0	19.8	335.0	380.0	5.3	57.7	74.8	340.0	Superficial top
JE12A	391645	6438966	58.00	37.00	48.00	51.00	20/07/2005	7.48	-88.0	20.4	539.0	580.0	0.2	2.2	173.6	320.0	Superficial bottom
JE12A	391645	6438966	58.00	37.00	48.00	51.00	7/04/2004	7.24	-431.0	21.5	541.0	126.3	0.6				Superficial bottom
JE12B	391647	6438966	38.00	37.00	35?	38?	20/07/2005		nr	20.2	2420.0	1400.0			81.6	750.0	Superficial intermediate
JE12B	391647	6438966	38.00	37.00	35?	38?	7/04/2004	7.36	48.0	21.2	1956.0	1078.0	1.2				Superficial intermediate
JE12C	391650	6438966	22.00	37.00	14.00	22.00	25/07/2005	5.44	90.0	21.2	219.0	260.0	0.3	3.6	18.8	180.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
JE12C	391650	6438966	22.00	37.00	14.00	22.00	7/04/2004	6.93	694.0	21.3	230.0	283.0	0.7				Superficial top
JE22C	392520	6434584	6.00	20.33	3.00	6.00	14/04/2004	4.04	56.0	23.7	483.0	503.0					Superficial top
JE4A	396059	6440574	45.00	28.37	33.00	42.00	30/06/2005	7.29	-202.0	20.0	1339.0		0.4	4.7	241.6		Superficial bottom
JE4C	396059	6440580	9.00	28.42	3.00	8.00	30/06/2005	5.48	-176.0	18.7	402.0		2.2	23.4	34.8		Superficial top
JM12	391437	6447453	24.40	35.00	12.40	24.40	5/04/2004	5.64	23.0	19.3	389.0	386.0	4.2				Superficial top
JM16	398446	6446981	15.30	28.00	3.30	15.30	5/04/2004	5.13	7.5	21.0	276.0	284.0	8.8				Superficial top
JM19	394501	6445398	17.70	32.00	5.70	17.70	5/04/2004	5.69	73.0	19.1	234.0	243.0	4.1				Superficial top
JM22	397523	6444745	17.10	33.92	5.10	17.10	30/06/2005	5.10	-150.0	19.8	281.0		7.6	83.3	32.8		Superficial top
JM5	397495	6450610	12.80	24.00	0.80	12.80	29/06/2005	5.82	-69.0	20.8	790.0		1.3	14.0	75.5		Superficial top
JM5	397495	6450610	12.80	24.00	0.80	12.80	16/04/2004	5.78	108.0	21.0	729.0	230.0	2.4				Superficial top
JM51	392062	6444181	17.27	37.00	11.27	17.27	20/04/2004	5.28	-239.0	20.1	258.0	307.0	7.1				Superficial top
JM66A	391960	6441600	41.50	24.88	38.00	41.00	16/04/2004	7.18	94.0	22.1	1067.0	1275.0	2.6				Superficial bottom
JM66C	391959	6441599	7.00	24.79	4.00	7.00	21/07/2005	5.28	-5.0	20.8	122.0	140.0	0.5	5.1	29.6	100.0	Superficial top
JM66C	391959	6441599	7.00	24.79	4.00	7.00	16/04/2004	5.58	-344.0	22.1	106.0	529.0	2.4				Superficial top
JM7	393538	6448869	16.10	29.00	4.79	16.10	29/06/2005	4.99	-208.0	19.2	271.0		4.8	51.4	6.8		Superficial top
JM7	393538	6448869	16.10	29.00	4.79	16.10	6/04/2004	5.58	-190.0	22.0	300.0	317.0	2.6				Superficial top
JP 14	374514	6501009	58.50	16.72	11.00	47.00	12/09/2005	7.38	151.0	21.0	768.0	750.0	0.4	4.5	152.0	420.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
JP 18C	383530	6490265		18.24			6/06/2003	6.50	168.0	20.1	825.0	830.0	12.0			440.0	Superficial top
JP13 (I)	384852	6496529	91.00	71.00	49.50	79.50	9/03/2004	6.40	23.4	20.2	855.0	852.0	2.9				Superficial top
JP15	377572	6500470	63.00	30.00	38.00	56.00	28/07/2005	7.41	-163.0	20.5	908.0	910.0	0.4	0.4	189.0	490.0	Superficial top
JP15	377572	6500470	63.00	30.00	38.00	56.00	9/03/2004	7.71	43.8	18.9	880.0	861.0	1.7				Superficial top
JP3	380402	6493063	61.00	20.00	50.00	59.00	9/03/2004	7.80	-49.8	20.6	679.0	283.0	3.3				Superficial top
L10A	398712	6485740	64.00	54.98	54.00	58.00	1/05/2007	6.95		19.5	439.0	500.0	0.1			280.0	Superficial bottom
L10C	398712	6485744	10.00	55.04	1.00	10.00	1/05/2007	3.6		20.1	238.0	290.0	0.1			190.0	Superficial top
L10C	398570	6485591	10.00	55.04	1.00	10.00	11/06/2003	4.20	-76.0	18.3	309.0	300.0	1.5			210.0	Superficial top
L160C	404682	6487726	6.00	34.00	0.00	6.00	18/03/2004	5.32	-149.1	22.5	438.0	439.0	1.4				Superficial top
L240C	402329	6490024	10.00	50.00	2.00	10.00	18/03/2004	6.12	20.7	23.1	267.0	274.0	2.2				Superficial top
L50C	402141	6485086	14.00	52.52			21/07/2003	5.53	155.7	18.7	218.0	240.0	1.2	13.0		150.0	Superficial top
LB5	389703	6440329	6.34	17.00	0.00	6.34	16/04/2004	4.80	-432.0	22.3	592.0	672.0	2.5				Superficial top
LN 2/89	379427	6499519	8.20	18.66	5.20	7.20	9/08/2005	5.56	-123.0	17.6	430.0	460.0	0.4	4.0	68.0	250.0	Superficial top
LWIS 6/90	376900	6494133	56.50	24.87			10/08/2005	7.34	-122.0	21.7	623.0	660.0	0.1	0.8	150.0	360.0	Superficial top
MM 31	397809	6476605	12.80	13.45	1.30	12.80	22/06/2005	5.34	-221.0	20.3	766.0		7.0	74.1	4.4		Superficial top
MM 45	402194	6473890	16.80	13.00	4.80	16.80	22/06/2005	6.68	-92.0	21.0	763.0		3.1	35.2	142.0		Superficial top
MM 52	403423	6478295	14.20	24.27	2.00	14.00	21/06/2005	6.58	62.0	21.0	502.0		4.2	46.7	5.6		Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
MM10	395565	6482635	15.84	47.78	2.84	15.84	11/06/2003	4.70	-60.0	19.2	333.0	320.0	1.8			180.0	Superficial top
MM12	399449	6482712	15.84	47.66	2.86	15.84	11/06/2003	5.57	-123.0	18.7	435.0	410.0	2.7			210.0	Superficial top
MM14	389482	6480567	31.69	54.28	18.78	31.69	6/06/2003	6.80	106.0	18.9	1083.0	960.0	11.7			570.0	Superficial top
MM16	393375	6480637	16.45	44.46	5.46	16.45	12/06/2003	6.00	67.0	17.1	1207.0	1800.0	12.2			650.0	Superficial top
MM18	397441	6480676	13.41	43.51	2.00	13.40	11/06/2003	3.80	139.0	18.8	422.0	390.0	11.9			210.0	Superficial top
MM28	391653	6476712	54.56	74.00	41.11	54.56	20/04/2004	5.09	-566.0	20.3	357.0	393.0	2.7			216.0	Superficial top
MM49B	400673	6477569	15.00	28.53	3.00	15.00	21/07/2003	4.40	-28.2	19.2	616.0	700.0	1.2	13.6		430.0	Superficial top
MM52	403423	6478295	14.20	24.27	2.00	14.00	24/03/2004	7.18	83.5	22.0	761.0	732.0	3.3				Superficial top
MM53	398804	6478901	18.00	37.06	6.00	18.00	12/06/2003	4.70	64.0	18.2	556.0	700.0	11.1			340.0	Superficial top
MM59B	400807	6480655		41.50			11/06/2003	6.10	72.0	17.4	167.9	170.0	11.6			110.0	Superficial top
MS 14	388398	6488361	16.00	51.12	8.00	16.00	4/06/2003	7.43	140.0	19.0	1156.0	1100.0	10.2			610.0	Superficial top
MS10	387344	6489116	9.00	43.49	2.00	9.00	7/05/2007	5.12		20.9	1660.0	1700.0	0.1			960.0	Superficial top
MS7	386708	6489554	9.00	43.84	2?	9?	9/06/2003	7.40	-194.0	17.3	2323.0	2000.0	7.6			1300.0	Superficial top
MT1D	388528	6489410	52.00	45.37	45.00	47.00	7/05/2007	5.2		19.6	459.0	470.0	0.2			300.0	Superficial bottom
MT1S	388528	6489410	9.00	45.25	2.00	9.00	9/06/2005	4.92	-185.0	20.4	345.0		1.4	15.7	1.6		Superficial top
NL424	388839	6450629	3.30	14.78			29/06/2005	6.05	-141.0	17.3	877.0		5.3	55.2			Superficial top
NR 3A	396205	6494917	60.00	74.35	56.00	59.00	5/06/2003	5.90	160.0	19.0	333.0	290.0				190.0	Superficial bottom

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
NR 3B	396201	6494917	32.50	74.30	29.00	32.00	5/06/2003	4.50	-17.0	18.8	323.0	364.0				193.0	Superficial intermediate
NR 3C	396211	6494917	11.00	73.64	5.00	11.00	5/06/2003	4.40	5.0	18.4	269.0	240.0	2.3			140.0	Superficial top
NR10C	398960	6494130	11.00	73.92	5.00	11.00	21/07/2003	4.10	257.2	18.2	203.0	230.0	1.9	20.9		190.0	Superficial top
NR1B	395072	6501312	30.67	82.87	26.70	29.70	23/06/2003	5.40	150.0	18.8	219.0	190.0	3.2			140.0	Superficial intermediate
NR1C	395073	6501314	14.95	82.76	11.90	13.50	23/06/2003	5.39	-150.0	18.9	319.0	410.0	1.6			300.0	Superficial top
NR2C	399619	6498229	16.04	71.00	11.00	15.00	18/03/2004	4.85	92.4	20.4	464.0	485.0	2.2				Superficial top
NR6C	398956	6490825	8.30	63.08	2.30	8.30	1/05/2007	4.42		19.1	183.3	210.0	0.2			100.0	Superficial top
NR7A	393357	6486872	53.50	53.67	49.50	52.50	9/06/2003	6.90	-149.0	17.9	518.0	460.0				290.0	Superficial bottom
NR7B	393359	6486872	26.00	53.67	22.00	25.00	9/06/2003	7.00	-177.0	17.6	568.0	510.0				320.0	Superficial intermediate
NR7C	393360	6486872	9.50	53.69	5.50	8.50	9/06/2003	6.20	-180.0	18.0	388.0	340.0	1.2			230.0	Superficial top
PCM 21	385583	6503879	25.90	49.13	5.00	25.90	9/08/2005	5.73	-163.0	19.6	307.0	340.0	0.1	0.7	46.0	200.0	Superficial top
PCM21	385441	6503736	25.90	49.13	5.00	25.90	24/06/2003	6.20	-65.0	16.9	355.0	220.0	6.5			140.0	Superficial top
PE2A	384301	6510092	69.00	73.00	66.00	69.00	17/03/2004	5.96	148.0	19.8	330.0	338.0	0.4	4.4			Superficial bottom
PE2B	384304	6510720	48.00	73.00	45.00	48.00	17/03/2004	5.90	56.8	19.6	309.0	307.0	0.6	6.2			Superficial intermediate

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
PM 26	380374	6510185	28.00	44.50	14.00	27.90	15/07/2003	6.00	356.0	18.1	275.0	310.0	5.0	54.8		180.0	Superficial top
PM 31	380260	6502208	45.70	53.61	32.00	45.70	26/07/2003	6.62	263.6	19.4	545.0	610.0	2.3	25.0		350.0	Superficial top
PM 33	381032	6498436	43.40	51.74	29.00	43.40	15/07/2003	7.01	204.0	18.8	610.0	720.0	2.2	24.6		410.0	Superficial top
PM 35	384107	6497877	36.40	51.22	19.00	36.40	10/08/2005	5.23	192.0	19.8	384.0	500.0	2.4	25.8	2.0	280.0	Superficial top
PM12	390406	6499451	13.40	58.80	1.00	13.40	16/06/2003	6.20	-97.0	18.5	298.0	270.0	10.8			230.0	Superficial top
PM16	386149	6509166	36.10	69.99	22.00	36.10	28/07/2005	5.80	-155.0	20.4	452.0	410.0	0.1	1.4	53.6	250.0	Superficial top
PM16	386010	6509017	36.10	69.99	22.00	36.10	24/06/2003	5.76	184.0	19.7	512.0	430.0	7.2			300.0	Superficial top
PM18	386150	6506157	30.80	65.19	17.00	30.80	24/06/2003	5.47	170.0	18.0	337.0	280.0	2.9			160.0	Superficial top
PM19	383894	6505497	31.50	57.99	18.00	31.50	24/06/2003	6.72	83.0	17.8	294.0	250.0	6.0			150.0	Superficial top
PM3	393260	6509295	17.80	70.72	6.00	17.80	24/06/2003	5.66	17.8	-49.0	1222.0	1000.0	6.5			630.0	Superficial top
PM5	393390	6506467	20.20	74.13	8.00	20.20	8/06/2005	5.32	-207.0	18.7	270.0		0.3	3.1	0.4		Superficial top
PM5	393390	6506467	20.20	74.13	8.00	20.20	17/03/2004	5.19	149.1	20.9	523.0	530.0	4.2				Superficial top
PM6	389194	6504700	20.80	64.49	7.00	20.80	8/06/2005	5.63	-248.0	18.6	250.0		0.5	5.1	196.0		Superficial top
PM6	389056	6504556	20.80	64.49	7.00	20.80	23/06/2003	5.90	-223.0	17.7	287.0	320.0	6.7			160.0	Superficial top
PM7	391980	6503669	19.10	70.21	5.00	19.10	4/05/2007	4.6		18.7	329.0	320.0	0.2			200.0	Superficial top
PM8	395224	6503644	21.20	80.71	10.00	21.20	8/06/2005	5.19	-237.0	18.8	193.0		0.3	2.7	1.6		Superficial top
PP4 Shallow	388982	6493797		49.70	shallow		4/05/2007	4.1		21.8	226.0	230.0	0.1			190.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
SE5	404857	6420200	37.00	39.45			7/07/2005	6.38	-9.0	21.4	2660.0	2700.0	5.2	57.8	166.0	1500.0	Superficial top
Shirley Balla	394492	6441918	4.50	26.00	shallow		21/07/2005	3.94	-41.0	16.9	413.0	460.0	0.6	6.1	0.9	350.0	Superficial top
T 500	392021	6413959	24.00	8.63			13/09/2005	5.85	-168.0	17.4	858.0	870.0	0.6	5.3	80.4	610.0	Superficial top
T110 (O)	398410	6439417	32.20	28.40			19/07/2005	5.09	-108.0	21.1	470.0	510.0	0.5	5.6	3.2	270.0	Superficial top
T115	402761	6442759	34.50	24.91	5.00	33.00	15/04/2004	6.96	-491.0	19.1	2630.0	166.4	2.5				Superficial top
T120 (O)	403669	6439124	36.20	28.00	23.20	33.20	14/04/2004	5.28	327.0	18.4	1570.0		1.9				Superficial top
T130 (I)	387464	6435175	35.00	14.69	26.00	32.00	15/07/2005	7.26	-146.0	21.0	856.0	900.0	0.1	1.7	244.8	460.0	Superficial top
T130 (O)	387464	6435208	32.00	14.00	0.00	32.00	7/04/2004	7.70	680.0	20.4	594.0	277.0	0.9				Superficial top
T140 (O)	390984	6435919	45.00	16.00	3.00	45?	7/04/2004	5.16	178.0	22.4	683.0	607.0	1.0				Superficial top
T150 (O)	395255	6435695	51.00	30.00	3.00	51?	14/04/2004	4.96	64.0	18.4	153.0		2.4				Superficial top
T161 (I)	398598	6435780	29.00	25.00	23.00	29.00	19/07/2005	5.65	-168.0	20.7	724.0	780.0	0.5	5.4	45.6	420.0	Superficial top
T161 (I)	398598	6435780	29.00	25.00	23.00	29.00	14/04/2004	6.08	629.0	19.1	498.0		4.6				Superficial top
T200 (O)	393823	6432664	39.50	21.90	3.00	36.00	20/07/2005	5.39	-160.0	20.4	562.0	610.0	0.4	3.9	47.2	410.0	Superficial top
T220	401711	6432975	21.50	21.44	3.00	13.00	14/04/2004	5.90	148.0	19.8	343.0	211.0	8.7				Superficial top
T260 (O)	397035	6429527	29.00	21.89	8.00	26.00	19/07/2005	5.90	-121.0	20.3	321.0	350.0	0.2	2.2	22.8	210.0	Superficial top
T340 (O)	387543	6422648	30.00	5.15	14.00	19.00	15/07/2005	6.99	-32.0	19.7	1192.0	1200.0	0.3	3.7	188.8	660.0	Superficial top
T370	400016	6423228	24.00	19.23			7/07/2005	6.49	27.0	18.2	618.0	660.0	1.9	19.4	128.0	380.0	Superficial top
T380(O)	382369	6419864	22.70	5.64			7/07/2005	7.80	-250.0	19.8	620.0	660.0	0.2	2.0	320.0	340.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
T420	399407	6420367	22.00	20.50			7/07/2005	6.20	-58.0	21.3	968.0	940.0	1.4	14.8	115.2	540.0	Superficial top
T430I	385744	6416765	23.17	7.46	15.00	20.00	6/07/2005	6.24	-62.0	19.9	2120.0	2200.0	0.4	4.6	28.0	1400.0	Superficial top
T450I	392489	6417775	17.70	8.73	10.00	14.50	6/07/2005	6.39	-142.0	20.1	1090.0	1100.0	5.9	64.8	134.8	700.0	Superficial top
T530	384378	6410840	31.90	11.31	23.00	29.00	5/07/2005	6.98	-94.0	19.0	2140.0	2100.0	6.3	66.9	542.4	1200.0	Superficial top
T540	387794	6410863	26.00	7.57			5/07/2005	6.06	78.0	21.6	179.0	200.0	3.4	38.0	66.4	150.0	Superficial top
T570	400327	6410250	22.00	34.65			4/07/2005	5.91	-59.0	21.4	210.0	180.0	0.9	11.1	51.6	120.0	Superficial top
T580	386090	6407231	40.00	9.79			6/07/2005	5.98	192.0	21.2	196.0	180.0	3.6	40.3	47.2	110.0	Superficial top
T600	394371	6407100	17.00	21.54	10.00	14.00	4/07/2005	5.66	-193.0	20.2	474.0	490.0	4.2	45.3	65.2	300.0	Superficial top
T670	399280	6403793	15.50	27.32			4/07/2005	6.88		19.2	1194.0	1200.0			52.8	680.0	Superficial top
T75	402155	6449167	37.00	20.36			29/06/2005	5.54	-186.0	22.4	1679.0		1.5	17.2	42.0		Superficial top
T8S (T85)	402225	6445829	35.00	21.79			25/07/2005	5.61	-188.0	21.3	1203.0	1300.0	0.1	1.1	52.4	680.0	Superficial top
TDP1	405340	6468579	4.54	12.20			25/07/2005	5.96	52.0	20.3	2450.0	2500.0	0.7	7.3	88.0	1500.0	Superficial top
TM4C	388874	6442978	6.00	15.00	0.00	6.00	6/04/2004	5.59	-372.0	22.1	637.0	816.0					Superficial top
TM7A	388198	6442303	49.00	24.79	47.00	49.00	25/07/2005	7.15	-134.0	22.9	3420.0	3500.0	1.7	19.5	367.6	1900.0	Superficial bottom
TM7C	388185	6442303	18.20	24.28	13.20	18.20	25/07/2005	6.74	-127.0	21.6	2380.0	2500.0	2.6	28.5	209.2	1300.0	Superficial top
WCM	392785	6491067	11.80	57.14	5.80	11.80	3/08/2005	5.15	-259.0	19.8	412.0	510.0	0.5	4.7	18.4	300.0	Superficial top
WF 12	383335	6480752	60.00	33.00	35.60	58.60	10/08/2005	6.95	-87.0	22.2	1115.0	1100.0	0.2	2.3	314.0	640.0	Superficial top
WH 100	384683	6483681	64.00	35.00			10/08/2005	7.05	-110.0	22.4	1432.0	1400.0	1.9	22.3	318.0	760.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
WH100	384683	6483681	64.00	35.00			9/03/2004	7.15	-18.5	21.4	1395.0	1359.0	7.0				Superficial top
Wilgerup Lake	375726	6505902	6.50	7.77	shallow		9/06/2005	3.83	-132.0	19.6	1838.0		3.0	33.3	?		Superficial top
WM1	391720	6497310	14.40	61.16	2.40	14.40	16/06/2003	6.22	-190.0	20.6	815.0	740.0	2.3			500.0	Superficial top
WM24	393900	6486435	8.20	54.32	2.90	8.20	9/06/2003	5.80	-52.0	19.2	188.0	170.0	5.4			140.0	Superficial top
WM29	390784	6483010	32.90	63.12	20.90	32.90	11/06/2003	6.70	-215.0	16.8	780.0	620.0	2.7			320.0	Superficial top
WM3	392040	6495180	13.10	61.66	1.10	13.10	16/06/2003	5.42	-133.0	18.0	330.0	300.0	1.9			210.0	Superficial top
WM32	397740	6489120	16.70	62.09	4.70	16.70	21/07/2003	4.93	11.6	18.7	295.0	330.0	0.9	10.3		210.0	Superficial top
WM4	385677	6493509	40.00	64.25	27.60	39.60	16/06/2003	5.54	146.0	18.4	260.0	240.0	2.4			140.0	Superficial top
WM5	391180	6493647	16.00	57.24	4.00	16.00	16/06/2003	5.30	-118.0	18.2	323.0	310.0	2.6			200.0	Superficial top
YB 11	373660	6507500	18.30	12.27	14.76	16.76	26/07/2003	7.50	261.2	19.3	481.0	540.0	6.5	71.4		310.0	Superficial top
YN 2	376775	6509817	?	52.93			26/07/2003	6.45	279.0	17.8	375.0	430.0	3.9	43.4		240.0	Superficial top
YN 3	375804	6509679	33.00	33.68			12/09/2005	6.27	143.0	19.8	395.0	390.0	1.9	20.7	74.8	210.0	Superficial top
YN 3	375661	6509538	33.00	33.68			26/07/2003	6.35	292.2	19.0	320.0	360.0	1.4	15.4		180.0	Superficial top
YN 5	375197	6509449	8.96	8.84	2.94	8.96	9/08/2005	6.95	-64.0	18.9	1236.0	1200.0	0.9	10.0	236.0	660.0	Superficial top
YN 5	375051	6509297	8.96	8.84	2.94	8.96	26/07/2003	6.99	139.0	18.6	1480.0	1700.0	5.5	60.8		980.0	Superficial top
YN 6	376168	6508048	?	26.12			26/07/2003	6.73	199.2	18.2	470.0	540.0	5.1	56.0		300.0	Superficial top
YN 7	375239	6508032	?	11.84			26/07/2003	6.60	221.5	18.5	566.0	650.0	4.3	48.0		370.0	Superficial top
YN 8	376090	6506302	?	18.42			26/07/2003	6.30	128.0	18.0	1007.0	1200.0	4.4	45.8		710.0	Superficial top

Bore name	Easting	Northing	Bore depth mbgl	Datum m AHD	Top most mbgl	Bottom mbgl	Date sampled	pH field	Eh	T °C	EC field	EC @25°C lab	DO mg/L	DO %	HCO_3 mg/L	TDS mg/L	Sample type
YSI 1	370786	6507493	53.00	12.27	23.00	53.00	9/08/2005	7.30	119.0	21.2	6580.0	5600.0	6.1	67.4	192.0	3600.0	Superficial top
YSI 1	370786	6507493	53.00	12.27	23.00	53.00	8/03/2004	9.27	131.1	20.0	588.0	510.0	5.1				Superficial top
YY3 (I)	374947	6516911	95.00	52.26	51.00	66.20	8/03/2004	6.80	5.9	20.9	539.0	520.0	5.9				Superficial top
YY3(I)	374947	6516911	95.00	52.26	51.00	66.20	28/07/2005	6.36	-206.0	20.8	541.0	560.0	0.1	0.5	74.0	300.0	Superficial top

Appendix B – Wetlands site information and physico-chemical characteristics of wetlands

Wetlands / Lakes	Easting	Northing	Datum, mAHD	EC, uS/cm	T °C	pH	DO (%)	Eh mV	HCO3 mg/l	CO3 mg/l	Date Sampled
Bibra Lake 425	389289	6448839	15.5	1781.0	19.9	8.68	114.0	147.5	116.0	0.0	17/05/2005
Lake Walyungup 1470	385642	6420174	2.9	37900.0	19.5	9.28	106.8	69.1	853.0	284.0	17/05/2005
North Lake 425	388859	6450358	17.2	871.0	22.5	6.57	-	30.1	20.0	0.0	17/05/2005
Lake Yonderup	375300	6508100	13.9	636.0	17.8	7.25	74.0	130.0	44.0	0.0	18/05/2005
Loch McNess 8754	374900	6508930	13.9	503.0	17.3	8.20	88.4	115.5	60.0	0.0	18/05/2005
Pippidinny Swamp 2	375070	6505391	2.0	1011.0	17.7	8.01	75.0	130.0	145.0	0.0	18/05/2005
Pippidinny Swamp 1	375020	6505391	2.0	2070.00	17.8	8.06	85.50	127.80	140.00	0.00	18/05/2005
Lake Joondalup 8281	384845	6487465	32.4	1280.0	20.0	7.99	65.4	105.5	100.0	0.0	19/05/2005
Lake Mariginiup 1943	387304	6489134	51.2	3420.0	22.6	4.23	92.5	391.0	nd	0.0	19/05/2005
Nowergup Lake	379749	6499834	20.1	417.0	20.8	7.46	75.6	107.0	90.0	0.0	19/05/2005
Gnangara Lake 8386	392289	6482374	45.8	2670.0	16.9	3.55	88.2	480.0	nd	0.0	24/05/2005
Herdsman Lake 619	387058	6467820	7.7	820.0	18.9	7.87	44.9	119.0	102.5	0.0	24/05/2005
Jandabup Lake 1944	390818	6487087	54.5	426.0	17.2	7.07	79.1	167.0	808.0	0.0	24/05/2005
Lake Goollelal 459	387838	6479242	30.0	1010.0	19.3	9.46	110.0	180.0	48.0	9.6	24/05/2005
Lake Gwelup 465	385404	6472614	8.7	337.0	19.9	7.50	95.6	165.0	36.8	0.0	24/05/2005
Lake Monger	389789	6466349	13.1	1052.0	18.8	8.37	69.9	96.8	157.0	0.0	24/05/2005
Lake Forrestdale 602	399938	6441937	24.7	3210.0		9.10			45.0	0.0	30/05/2005

Appendix C – Superficial aquifer – major chemical analysis 2003–07

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
459	20/06/2005				120.0	9.2	130.0	61.0	240.0	110.0	320.0	0.1	0.43	2.05	6.32	0.10	16.0	Super top	Perth Metro
649	22/06/2005				23.0	6.6	21.0	1.9	32.0	11.0	45.0	0.1	5.28	0.09	0.11	0.05	5.8	Super top	Perth Metro
2069	21/07/2005	6.1	210	140	14.0	2.4	17.0	4.0	29.0	17.0	15.0	0.1	13.64	0.23	0.05	0.10	2.6	Super top	Perth Metro
2288	28/06/2005				17.0	5.5	41.0	1.3	59.0	36.0	50.0	0.1	3.43	0.06	0.01	0.15	3.8	Super top	Perth Metro
8281	20/06/2005				53.0	5.8	41.0		66.0	79.0	95.0	0.1	12.76	1.23	0.05	0.05	6.9	Super top	Perth Metro
8282	19/07/2005	8.3	630	350	91.0	6.1	21.0	16.0	22.0	41.0	270.0	0.1	0.44	0.28	0.21	0.05	12.0	Super top	Perth Metro
8283	21/07/2005	8.3	870	490	82.0	5.4	83.0	18.0	110.0	19.0	280.0	0.1	0.88	1.69	0.27	0.05	16.0	Super top	Perth Metro
8386	12/09/2005	5.3	330	220	2.4	6.4	39.0	5.5	74.0	23.0	8.0	0.1	1.30	0.01	0.04	0.05	5.9	Super top	Perth Metro
1/98	9/06/2005				8.8	3.9	25.0	6.7	42.0	11.0	36.5	0.1	0.48	4.29	0.15	0.05	6.2	Super top	Perth Metro
1081	26/03/2004	7.54	2240		217.0	7.1	303.0	15.9	279.0	21.0	367.8		0.05	error		0.24	24.8	Super top	Perth GWA
144B	28/06/2005				98.0	18.0	170.0	13.0	280.0	76.0	360.0	0.1	0.48	0.22	1.10	0.10	4.7	Super top	Perth Metro
2025A	25/03/2004	5.22	913		41.0	28.9	88.4	3.9	120.0	89.3	*14.6*		1.00	error		3.33	2.8	Super top	Perth GWA
2025A	28/06/2005				18.0	13.0	130.0	1.4	200.0	97.0	15.0	0.1	0.14	0.05	0.14	0.35	4.1	Super top	Perth Metro
3578A	27/06/2005				74.0	16.0	200.0	7.3	310.0	120.0	130.0	0.1	8.80	0.07	0.02	0.05	1.1	Super top	Perth Metro
602	15/04/2004	4.24	1404		29.9	30.9	322.0	13.8	217.0	80.4	*39.0*		2.90	error		0.52	4.1	Super top	Perth GWA
8259A	30/04/2007	7.6	120	64	5.2	4.8	21.0	1.3	34.0	9.0	40.0	0.1	0.20	0.04	0.30	0.62	7.0	Super top	Perth Metro
8281	9/03/2004	7.61	1111		134.0	6.9	99.8	18.5	107.0	179.0	*73.0*		71.30	error		16.30	23.2	Super top	Perth GWA

Bores	**Date sampled**	**pH lab**	**EC @25 °C µS/cm**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**HCO_3 mg/L**	**CO_3 mg/L**	**NO_3 mg/L**	**PO_4 mg/L**	**NH_4 mg/L**	**Fe mg/L**	**Si mg/L**	**Sample type**	**Remarks**
8283	26/03/2004	7.35	611		50.1	6.1	78.3	13.2	98.3	20.3	*216.8*		1.30	error		0.20	8.8	Super top	Perth GWA
B270	5/03/2004	7.43	689		56.8	5.7	70.8	1.4	106.0	11.5	*160.0*		1.80	error		0.20	3.8	Super top	Gnangara GWA
B270	26/07/2005	7.4	720	390	61.0	6.2	75.0	2.5	120.0	11.0	160.0	0.1	2.38	0.06	0.01	0.05	6.0	Super top	Perth Metro
CSG6	15/07/2005	8	2900	1400	82.0	67.0	410.0	13.0	580.0	260.0	340.0	0.1	11.88	0.20	52.89	0.05	3.1	Super top	Perth Metro
CSI-3/97	7/04/2004	7.72	1291		100.0	18.7	147.0	10.3	275.0	76.2	*200.0*		36.20	error		0.20	3.9	Super top	Cockburn GWA
CW1	23/06/2003	4.90	200	113	0.6	2.6	30.0	1.5	50.0	2.0	5.0		0.20	0.06	0.37	0.20	10.0	Super top	Gnangara
E 1-89	5/07/2005	7.2	420	210	29.0	17.0	27.0	5.7	31.0	28.0	140.0	0.1	18.48	0.04	0.01	0.05	4.6	Super top	Perth Metro
FL1	30/06/2005				16.0	6.3	76.0	2.6	100.0	32.0	50.0	0.1	14.08	1.78	0.08	0.15	2.2	Super top	Perth Metro
GA 10	15/07/2003	3.60	1000	760	31.0	39.0	62.0	8.2	98.0	700.0	5.0		0.20	0.01	0.17	5.40	33.0	Super top	Gnangara GWA
GA 14	15/07/2003	5.70	280	190	2.6	7.3	43.0	2.8	68.0	19.0	20.0		0.20	0.01	0.15	0.45	9.4	Super top	Gnangara GWA
GA 15	15/07/2003	5.50	190	130	2.6	8.3	20.0	2.6	29.0	15.0	5.0		31.00	0.01	0.01	0.10	13.0	Super top	Gnangara GWA
GA 4	15/07/2003	5.80	280	170	3.8	6.8	40.0	2.8	76.0	6.0	15.0		0.20	0.01	0.17	0.05	10.0	Super top	Gnangara GWA
GA 5	15/07/2003	5.70	270	150	3.8	6.3	40.0	2.6	69.0	18.0	15.0		0.30	0.01	0.01	0.05	9.7	Super top	Gnangara GWA
GA 8	15/07/2003	6.00	520	290	22.0	11.0	68.0	3.6	110.0	17.0	90.0		0.20	0.06	0.12	0.05	10.0	Super top	Gnangara GWA
GA 9	15/07/2003	5.50	630	380	11.0	23.0	67.0	5.6	100.0	120.0	10.0		0.20	0.01	0.26	0.40	15.0	Super top	Gnangara GWA
GA1	17/07/2003	7.70	690	370	69.0	7.3	56.0	2.4	100.0	10.0	190.0		3.50	0.02	0.02	0.05	12.0	Super top	Gnangara GWA
GA11	8/03/2004	8.20	650		78.4	5.6	56.5	1.7	95.9	8.7	*98.7*		1.00	error		1.12	5.2	Super top	Gnangara GWA
GA11	27/07/2005	7.8	730	410	86.0	6.0	52.0	3.1	100.0	8.0	220.0	0.1	0.92	0.03	0.06	0.05	8.2	Super top	Perth Metro
GA12	17/07/2003	6.90	540	290	37.0	6.6	48.0	1.8	99.0	11.0	130.0		0.40	0.01	0.02	0.05	12.0	Super top	Gnangara GWA

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
GA13	17/07/2003	6.80	420	230	24.0	5.8	37.0	2.2	82.0	10.0	90.0		0.60	0.01	0.11	0.05	9.9	Super top	Gnangara GWA
GA17	17/07/2003	6.90	480	260	21.0	3.5	40.0	1.8	97.0	14.0	85.0		0.20	0.01	0.02	0.05	12.0	Super top	Gnangara GWA
GA17	27/07/2005	6.9	510	310	36.0	6.4	49.0	3.8	98.0	12.0	90.0	0.1	0.92	0.02	0.06	0.05	7.7	Super top	Perth Metro
GA18	17/07/2003	5.80	330	190	2.2	6.6	40.0	2.9	86.0	14.0	20.0		0.20	0.01	0.21	0.15	14.0	Super top	Gnangara GWA
GA22	17/07/2003	6.80	460	270	25.0	9.4	25.0	3.0	49.0	60.0	100.0		23.00	0.02	0.03	0.15	6.3	Super top	Gnangara GWA
GA22	27/07/2005	6.9	370	190	20.0	7.6	32.0	3.4	34.0	50.0	70.0	0.1	11.00	0.02	0.01	0.05	6.3	Super top	Perth Metro
GA25	5/03/2004	7.00	793		70.7	13.3	78.5	1.8	117.0	11.2	*240.0*		13.50	error		0.20	3.8	Super top	Gingin GWA
GA26	5/03/2004	6.35	629		10.8	12.2	78.7	3.2	138.0	13.4	*30.0*		0.23	error		0.32	4.4	Super top	Gnangara GWA
GA28	26/07/2005	7.7	820	400	60.0	11.0	65.0	2.4	100.0	12.0	240.0	0.1	11.44	0.11	1.81	0.05	7.5	Super top	Perth Metro
GA33	8/03/2004	8.23	756		73.5	10.6	61.9	2.4	104.0	9.9	*230.0*		6.80	error		0.13	4.6	Super top	Perth GWA
GA33	27/07/2005	7.8	770	390	65.0	10.0	60.0	3.3	110.0	10.0	230.0	0.1	7.48	0.03	0.01	0.05	7.6	Super top	Perth Metro
GB15	17/07/2003	5.80	1400	840	12.0	56.0	140.0	11.0	310.0	136.0	0.1		0.80	0.02	0.57	3.10	21.0	Super top	Gnangara GWA
GB21	16/03/2004	4.16	293		2.3	6.5	43.6	4.1	58.4	11.4	*0.0*		0.23	error		1.07	2.9	Super top	Gnangara GWA
GB21	7/06/2005				2.1	6.2	43.0	1.8	70.0	9.0	27.6	0.1	0.27	0.37	0.36	0.05	6.2	Super top	Perth Metro
GB23	27/07/2005	5.5	290	170	2.1	8.1	39.0	1.6	63.0	32.0	0.1	0.1	0.20	0.03	0.39	0.05	4.5	Super top	Perth Metro
GC 11	21/07/2003	6.20	250	130	2.2	5.3	32.0	5.2	46.0	31.0	10.0		0.30	0.02	0.07	1.50	5.8	Super top	Gnangara GWA
GC 19	15/07/2003	5.70	280	160	2.0	6.0	44.0	2.1	77.0	9.0	15.0		0.70	0.01	0.03	0.05	7.5	Super top	Gnangara GWA
GC17	16/03/2004	6.17	174		0.7	3.9	33.2	0.9	36.1	1.6	*19.5*		0.05	error		1.18	5.2	Super top	Gingin GWA

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
GC17	8/06/2005		146		2.3	5.0	21.0	2.4	32.0	7.0	0.8	0.1	0.22	1.56	0.61	0.05	6.8	Super top	Perth Metro
GC4	7/06/2005				13.0	19.0	120.0	14.0	240.0	52.0	4.0	0.1	0.18	error	1.16	0.05	7.8	Super top	Perth Metro
GD 11	20/06/2005				84.0	21.0	93.0	33.0	140.0	370.0	10.0	0.1	7.92	0.40	0.88	3.30	6.8	Super top	Perth Metro
GD 12	21/06/2005				19.0	25.0	190.0	4.2	300.0	96.0	85.0	0.1	0.66	0.01	0.25	0.05	1.4	Super top	Perth Metro
GD 2	6/06/2003	7.20	690	450	57.0	11.0	64.0	4.0	110.0	110.0	100.0		0.20	0.01	0.07	4.90	16.0	Super top	Gnangara GWA
GD12	24/03/2004	7.05	1908		35.9	44.0	317.0	7.6	317.0	142.0	*26.8*		4.10	error		1.72	13.7	Super top	Swan GWA
GD23	9/06/2003	7.60	1000	600	67.0	32.0	96.0	7.6	170.0	63.0	270.0		0.20	0.04	0.10	0.05	18.0	Super top	Gnangara GWA
GD23	27/06/2005				62.0	14.0	110.0	6.2	200.0	75.0	140.0	0.1	8.36	0.08	0.04	0.05	7.9	Super top	Perth Metro
GD5	27/06/2005				130.0	86.0	510.0	24.0	850.0	440.0	260.0	0.1	0.57	0.37	0.90	0.55	8.6	Super top	Perth Metro
GD8	25/03/2004	7.33	893		23.3	14.8	123.0	6.3	147.0	80.8	*122.0*		4.70	error		0.32	10.1	Super top	Perth GWA
GE 2	13/09/2005	7.8	1400	760	97.0	17.0	150.0	7.4	250.0	65.0	290.0	0.1	17.00	0.01	0.01	0.05	5.6	Super top	Perth Metro
GE3	27/06/2005				87.0	13.0	92.0	2.9	130.0	65.0	260.0	0.1	2.38	0.05	0.12	0.05	7.3	Super top	Perth Metro
GG3 (O)	21/07/2003	5.70	190	100	2.4	3.6	27.0	1.2	43.0	16.0	10.0		0.30	0.01	0.01	0.10	4.8	Super top	Gnangara GWA
GM 16	22/06/2005				71.0	11.0	72.0	4.5	120.0	76.0	170.0	0.1	33.88	0.01	0.01	0.05	5.7	Super top	Perth Metro
GM 2	6/06/2003	7.90	950	560	73.0	8.7	72.0	4.3	130.0	47.0	210.0		11.00	0.01	0.01	0.05	22.0	Super top	Gnangara GWA
GM 7	6/06/2003	7.70	680	410	57.0	10.0	61.0	6.8	100.0	47.0	170.0		13.00	0.05	1.55	0.05	14.0	Super top	Gnangara GWA
GM 9	22/06/2005				62.0	13.0	74.0	11.0	99.0	98.0	170.0	0.1	2.60	0.01	0.01	0.05	9.1	Super top	Perth Metro
GM26	27/06/2005				50.0	10.0	90.0	11.0	120.0	34.0	220.0	0.1	0.62	0.06	0.80	0.05	4.1	Super top	Perth Metro
GN 13	5/06/2003	6.30	190	100	2.2	0.5	25.0	3.5	35.0	1.0	15.0		0.20	0.01	0.01	0.10	0.1	Super top	Gnangara GWA

Bores	**Date sampled**	**pH lab**	**EC @25 °C μS/cm**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**HCO_3 mg/L**	**CO_3 mg/L**	**NO_3 mg/L**	**PO_4 mg/L**	**NH_4 mg/L**	**Fe mg/L**	**Si mg/L**	**Sample type**	**Remarks**
GN23	16/06/2003	5.90	350	230	2.2	6.6	51.0	4.2	97.0	1.0	20.0		0.20	0.02	1.68	3.40	14.0	Super top	Gnangara GWA
GNM11A	7/06/2005				21.0	21.0	57.0	5.5	84.0	160.0	0.4	0.1	0.09	0.31	0.14	0.05	12.0	Super top	Perth Metro
GNM5	16/06/2003	5.70	280	180	5.4	9.8	29.0	3.1	45.0	47.0	15.0		0.20	0.05	0.57	0.45	11.0	Super top	Gnangara GWA
IF16	20/04/2004	6.85	641		140.0	10.9	75.0	0.5	98.6	18.4	*490.0*		0.08	error		0.20	2.9	Super top	Perth GWA
JB 4	2/08/2005	6.4	1200	830	17.0	26.0	150.0	5.7	300.0	55.0	68.0	0.1	0.33	0.09	2.58	0.05	9.9	Super top	Perth Metro
JB 9A	4/06/2003	7.10	350	220	22.0	8.6	37.0	3.3	72.0	1.0	90.0		0.20	0.15	0.36	2.60	14.0	Super btm	Gnangara GWA
JB 9C	4/06/2003	5.90	230	140	2.0	5.5	34.0	2.4	66.0	2.0	15.0		2.50	0.12	0.05	0.10	10.0	Super top	Gnangara GWA
JB5	9/06/2003	6.10	330	210	7.2	12.0	32.0	1.6	66.0	40.0	10.0		0.20	0.13	0.19	1.70	8.1	Super top	Gnangara GWA
JE10C	19/07/2005	6.9	380	340	27.0	9.8	21.0	1.4	54.0	7.0	85.0	0.1	0.92	0.07	0.34	0.30	9.2	Super top	Perth Metro
JE12A	7/04/2004	6.79	126.3		70.9	7.4	47.2	2.0	70.4	2.2	*103.6*		0.05	error		0.25	4.6	Super btm	Jandakot GWA
JE12A	20/07/2005	8.1	580	320	64.0	6.5	42.0	3.0	67.0	0.9	200.0	0.1	0.11	0.11	0.28	0.15	4.9	Super btm	Perth Metro
JE12B	7/04/2004	7.36	1078		122.0	0.0	212.0	16.2	247.0	71.2	*18.2*		1.10	error		0.20	3.3	Super inter	Jandakot GWA
JE12B	20/07/2005	8.3	1400	750	22.0	0.5	260.0	20.0	310.0	73.0	81.6	0.1	11.88	0.06	0.10	0.05	4.3	Super inter	Perth Metro
JE12C	7/04/2004	7.54	283		12.3	5.5	27.8	1.1	51.4	23.9	*9.8*		0.05	error		0.46	2.3	Super top	Jandakot GWA
JE12C	25/07/2005	6.1	260	180	6.1	8.5	27.0	3.0	40.0	29.0	20.0	0.1	0.20	0.04	0.01	0.05	4.4	Super top	Perth Metro
JE22C	14/04/2004	7.31	503		6.7	29.0	250.0	4.1	61.7	25.9	*130.0*		0.09	error		1.41	12.0	Super top	Serpentine GWA
JE4A	30/06/2005				79.0	23.0	200.0	2.1	310.0	7.0	241.6	0.1	0.57	0.43	0.71	0.80	7.6	Super btm	Perth Metro
JE4C	30/06/2005				6.2	16.0	55.0	1.9	91.0	46.0	25.0	0.1	0.40	0.52	0.13	1.30	5.9	Super top	Perth Metro

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
JM12	5/04/2004	7.30	386		7.8	11.0	54.1	1.6	80.2	35.8	*43.7*		1.30	error		0.48	2.6	Super top	Jandakot GWA
JM16	5/04/2004	7.31	284		1.2	5.3	51.7	0.3	75.6	4.4	*30.0*		0.05	error		0.41	3.4	Super top	Perth GWA
JM19	5/04/2004	7.69	243		0.3	10.1	32.6	1.8	62.2	2.2	*33.0*		0.05	error		0.20	2.9	Super top	Jandakot GWA
JM22	30/06/2005				1.7	7.5	46.0	1.0	63.0	40.0	10.0	0.1	0.10	0.10	0.53	0.50	6.6	Super top	Perth Metro
JM5	16/04/2004	5.99	230		42.3	17.7	85.5	11.9	121.0	24.0	*4.9*		0.05	error		0.84	2.4	Super top	Perth GWA
JM5	29/06/2005				43.0	21.0	84.0	4.7	180.0	53.0	110.0	0.1	1.50	0.25	0.06	0.10	2.6	Super top	Perth Metro
JM51	20/04/2004	5.58	307		1.4	6.5	39.8	1.1	65.0	15.1	*4.9*		17.20	error		0.20	4.4	Super top	Jandakot GWA
JM66A	16/04/2004	7.17	1275		66.0	18.7	130.0	3.9	137.0	0.1	*240.0*		0.07	error		0.73	5.6	Super btm	Jandakot GWA
JM66C	16/04/2004	7.98	529		3.9	2.9	12.2	0.5	27.1	2.1	*6.1*		2.50	error		0.20	2.0	Super top	Jandakot GWA
JM66C	21/07/2005	6.1	140	100	3.8	2.8	15.0	2.6	25.0	7.0	10.0	0.1	0.97	0.08	0.04	0.05	2.8	Super top	Perth Metro
JM7	6/04/2004	7.12	317		1.7	9.9	42.5	1.1	70.0	0.1	6.1		0.05	error		0.23	2.7	Super top	Jandakot GWA
JM7	29/06/2005				1.6	7.4	37.0	0.8	70.0	18.0	5.0	0.1	0.09	0.05	0.44	0.35	3.8	Super top	Perth Metro
JP 14	12/09/2005	7.7	750	420	69.0	7.2	58.0	3.2	120.0	9.0	190.0	0.1	0.80	0.01	0.06	0.23	7.7	Super top	Perth Metro
JP 18C	6/06/2003	6.50	830	440	18.0	14.0	110.0	5.0	240.0	1.0	55.0		0.20	0.01	0.34	6.00	0.3	Super top	Gnangara GWA
JP13 (I)	9/03/2004	4.73	852		8.5	5.2	66.0	0.4	110.0	0.3	*46.3*		0.34	error		109.00	0.5	Super top	Wanneroo GWA
JP15	9/03/2004	8.12	861		60.2	11.4	105.0	4.3	128.0	21.1	*99.8*		0.17	error		1.15	5.6	Super top	Perth GWA
JP15	28/07/2005	7.9	910	490	55.0	9.9	91.0	5.2	160.0	7.0	189.0	0.1	0.20	0.04	0.27	0.05	9.6	Super top	Perth Metro
JP3	9/03/2004	7.97	283		55.0	9.7	85.0	6.7	125.0	5.0	*200.0*		0.92	error		0.75	1.2	Super top	Perth GWA
L10A	1/05/2007	8.1	500	280	62.0	4.5	31.0	4.0	89.0	8.0	220.0	0.1	0.20	0.01	0.35	1.40	17.0	Super btm	Perth Metro

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO$_4$ mg/L	HCO$_3$ mg/L	CO$_3$ mg/L	NO$_3$ mg/L	PO$_4$ mg/L	NH$_4$ mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
L10C	11/06/2003	4.20	300	210	3.0	8.2	33.0	0.7	68.0	21.0	5.0		0.20	1.26	0.63	0.40	8.2	Super top	Gnangara GWA
L10C	1/05/2007	7.3	290	190	1.8	7.8	31.0	0.5	68.0	9.0	1.0	0.1	0.20	0.01	0.61	0.23	7.0	Super top	Perth Metro
L160C	18/03/2004	6.37	439		11.7	11.2	63.1	4.4	97.5	13.3	*80.0*		0.10	error		0.66	5.2	Super top	Swan GWA
L240C	18/03/2004	6.91	274		10.7	1.1	45.4	4.4	75.9	0.9	*34.6*		0.18	error		0.66	0.5	Super top	Swan GWA
L50C	21/07/2003	6.30	240	150	2.2	4.5	38.0	2.7	65.0	6.0	15.0		0.50	0.01	0.18	0.45	8.5	Super top	Gnangara GWA
LB5	16/04/2004	5.16	672		3.4	14.6	102.0	2.6	115.0	46.8	*4.9*		0.07	error		0.47	5.3	Super top	Cockburn GWA
LN 2/89	9/08/2005	6	460	250	13.0	4.8	45.0	4.5	88.0	29.0	22.0	0.1	0.34	0.08	0.77	0.35	9.7	Super top	Perth Metro
LWIS 6/90	10/08/2005	7.7	660	360	51.0	6.9	56.0	4.4	110.0	4.0	160.0	0.1	0.07	0.09	0.30	0.05	11.0	Super top	Perth Metro
MM 31	22/06/2005				53.0	61.0	29.0	2.7	38.0	400.0	15.0	0.1	0.07	0.01	0.77	0.70	5.7	Super top	Perth Metro
MM 45	22/06/2005				30.0	18.0	110.0	5.7	150.0	30.0	160.0	0.1	0.05	0.01	0.17	0.05	14.0	Super top	Perth Metro
MM 52	21/06/2005				28.0	10.0	77.0	10.0	78.0	23.0	160.0	0.1	1.94	0.37	0.09	0.50	12.0	Super top	Perth Metro
MM10	11/06/2003	4.70	320	180	4.6	7.8	35.0	1.7	61.0	36.0	1.0		0.50	0.01	0.26	4.50	16.0	Super top	Gnangara GWA
MM12	11/06/2003	6.10	410	210	3.2	7.6	58.0	2.2	95.0	27.0	15.0		0.20	0.02	0.45	0.25	10.0	Super top	Gnangara GWA
MM14	6/06/2003	6.80	960	570	60.0	24.0	67.0	29.0	110.0	160.0	55.0		110.0	0.67	3.87	0.05	8.8	Super top	Gnangara GWA
MM16	12/06/2003	6.00	1800	650	46.0	28.0	98.0	41.0	160.0	120.0	25.0		140.0	0.01	0.36	0.45	15.0	Super top	Gnangara GWA
MM18	11/06/2003	3.80	390	210	12.0	11.0	32.0	2.9	52.0	60.0	1.0		4.40	0.01	0.50	7.90	12.0	Super top	Gnangara GWA
MM28	20/04/2004	7.07	393	216	1.5	7.6	60.0	3.0	92.8	21.5	*4.9*		1.70	error		0.20	3.3	Super top	Perth GWA
MM49B	21/07/2003	4.40	700	430	8.4	29.0	66.0	3.5	95.0	150.0	0.1		0.30	0.01	0.37	18.00	14.0	Super top	Gnangara GWA

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
MM52	24/03/2004	7.22	732		33.8	11.9	112.0	6.7	105.	19.2	*95.1*		0.27	error		1.70	7.3	Super top	Mirrabooka GWA
MM53	12/06/2003	4.70	700	340	15.0	22.0	39.0	2.6	75.0	110.0	0.1		0.20	0.01	0.43	9.80	20.0	Super top	Gnangara GWA
MM59B	11/06/2003	6.10	170	110	0.7	3.9	20.0	1.4	36.0	15.0	5.0		0.20	0.01	0.05	0.10	7.2	Super top	Gnangara GWA
MS 14	4/06/2003	7.80	1100	610	71.0	25.0	95.0	12.0	210.0	42.0	170.0		29.00	0.01	0.02	0.05	5.4	Super top	Gnangara GWA
MS10	7/05/2007	6.5	1700	960	30.0	35.0	240.0	17.0	330.0	260.0	30.0	0.1	0.20	0.02	1.68	19.00	15.0	Super top	Perth Metro
MS7	9/06/2003	7.40	2000	1300	45.0	57.0	300.0	11.0	470.0	220.0	140.0		1.30	0.07	3.35	0.60	31.0	Super top	Gnangara GWA
MT1D	7/05/2007	6.8	470	300	8.8	8.0	65.0	3.4	130.0	8.0	35.0	0.1	0.20	0.01	0.45	0.22	12.0	Super btm	Perth Metro
MT1S	9/06/2005				6.0	11.0	41.0	3.0	67.0	41.0	1.6	0.1	0.22	0.03	0.17	0.30	4.7	Super top	Perth Metro
NL424	29/06/2005				24.0	19.0	130.0	8.3	200.0	91.0	60.0	0.1	2.07	0.26	0.48	0.35	6.0	Super top	Perth Metro
NR 3A	5/06/2003	5.90	290	190	3.4	5.2	42.0	2.6	72.0	21.0	10.0		2.40	0.07	0.01	0.65	11.0	Super btm	Gnangara GWA
NR 3B	5/06/2003	4.50	364	193	5.7	5.2	38.0	1.7	75.0	22.0	5.0		0.20	0.12	0.49	0.60	9.0	Super inter	Gnangara GWA
NR 3C	5/06/2003	4.40	240	140	14.0	4.5	25.0	1.9	49.0	27.0	5.0		0.20	0.06	0.12	0.50	5.7	Super top	Gnangara GWA
NR10C	21/07/2003	4.10	230	190	2.2	4.4	32.0	2.4	54.0	14.0	5.0		0.80	0.05	0.15	2.90	3.5	Super top	Gnangara GWA
NR1B	23/06/2003	5.40	190	140	1.9	3.7	24.0	1.2	46.0	2.0	5.0		12.00	0.70	0.08	0.10	6.4	Super inter	Gnangara GWA
NR1C	23/06/2003	5.90	410	300	3.4	15.0	29.0	2.6	68.0	23.0	20.0		0.30	0.52	1.42	2.10	18.0	Super top	Gnangara GWA
NR2C	18/03/2004	6.55	485		3.1	13.0	60.4	4.4	92.1	98.7	*3.7*		0.29	error		0.36	3.4	Super top	Swan GWA
NR6C	1/05/2007	7.7	210	100	1.4	3.5	28.0	0.9	45.0	10.0	1.0	0.1	0.40	0.01	0.28	0.13	7.0	Super top	Perth Metro
NR7A	9/06/2003	6.90	460	290	22.0	7.2	56.0	3.4	100.0	1.0	80.0		0.20	0.14	0.50	0.30	15.0	Super btm	Gnangara GWA
NR7B	9/06/2003	7.00	510	320	20.0	8.8	63.0	3.3	110.0	1.0	75.0		0.20	0.07	0.50	0.20	13.0	Super inter	Gnangara GWA

Bores	**Date sampled**	**pH lab**	**EC @25 $^{\circ}$C µS/cm**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**HCO_3 mg/L**	**CO_3 mg/L**	**NO_3 mg/L**	**PO_4 mg/L**	**NH_4 mg/L**	**Fe mg/L**	**Si mg/L**	**Sample type**	**Remarks**
NR7C	9/06/2003	6.20	340	230	3.3	7.2	45.0	1.4	81.0	24.0	15.0		0.30	0.04	0.07	0.30	11.0	Super top	Gnangara GWA
PCM 21	9/08/2005	6.2	340	200	1.7	5.5	39.0	1.4	75.0	10.0	9.0	0.1	0.27	0.08	0.23	0.15	3.6	Super top	Perth Metro
PCM21	24/06/2003	6.20	220	140	1.2	4.1	32.0	0.8	63.0	2.0	0.1		0.20	0.13	0.28	27.0?	2.4	Super top	Gnangara GWA
PE2A	17/03/2004	6.43	338		11.2	5.3	42.2	2.2	81.6	8.5	*17.1*		0.21	error		0.20	5.0	Super btm	Gnangara GWA
PE2B	17/03/2004	6.91	307		6.1	5.1	42.6	1.0	64.6	5.4	*19.5*		1.10	error		1.33	3.5	Super inter	Gnangara GWA
PM 26	15/07/2003	6.00	310	180	12.0	6.6	40.0	3.2	67.0	13.0	50.0		5.50	0.02	0.02	0.05	12.0	Super top	Gnangara GWA
PM 31	26/07/2003	7.30	610	350	48.0	10.0	66.0	3.4	91.0	50.0	140.0		2.70	0.05	0.01	0.05	13.0	Super top	Gnangara GWA
PM 33	15/07/2003	7.30	720	410	78.0	8.6	56.0	3.8	98.0	35.0	240.0		9.40	0.02	0.01	0.05	9.8	Super top	Gnangara GWA
PM 35	10/08/2005	6.3	500	280	4.3	8.0	66.0	3.9	96.0	29.0	38.0	0.1	0.26	0.08	0.22	0.05	5.7	Super top	Perth Metro
PM12	16/06/2003	6.20	270	230	5.6	4.6	42.0	3.0	71.0	2.0	25.0		0.20	0.07	1.11	0.85	14.0	Super top	Gnangara GWA
PM16	24/06/2003	6.60	430	300	2.1	7.9	63.0	3.4	110.0	18.0	10.0		0.20	0.02	0.01	0.05	11.0	Super top	Gnangara GWA
PM16	28/07/2005	5.7	410	250	2.6	5.7	54.0	4.5	98.0	14.0	10.0	0.1	0.75	0.04	0.13	0.05	6.9	Super top	Perth Metro
PM18	24/06/2003	6.30	280	160	1.5	4.8	43.0	1.2	77.0	9.0	15.0		0.70	0.04	0.03	0.20	7.0	Super top	Gnangara GWA
PM19	24/06/2003	7.00	250	150	1.6	4.7	38.0	1.7	63.0	8.0	13.4		0.20	0.01	0.15	0.70	9.3	Super top	Gnangara GWA
PM3	24/06/2003	6.10	1000	630	5.6	33.0	140.0	3.1	230.0	130.0	25.0		0.20	0.02	0.61	0.35	6.5	Super top	Gnangara GWA
PM5	17/03/2004	6.84	530		2.6	9.8	86.5	3.1	114.0	9.0	*3.7*		0.31	error		0.36	2.4	Super top	Gnangara GWA
PM5	8/06/2005				1.4	5.5	42.0	1.8	70.0	13.0	0.4	0.1	0.20	0.01	0.18	0.05	4.0	Super top	Perth Metro
PM6	23/06/2003	5.90	320	160	2.1	4.6	34.0	3.3	58.0	14.0	20.0		0.20	0.03	0.22	0.25	14.0	Super top	Gnangara GWA

Bores	**Date sampled**	**pH lab**	**EC @25 °C µS/cm**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**HCO_3 mg/L**	**CO_3 mg/L**	**NO_3 mg/L**	**PO_4 mg/L**	**NH_4 mg/L**	**Fe mg/L**	**Si mg/L**	**Sample type**	**Remarks**
PM6	8/06/2005				2.2	5.6	34.0	3.4	60.0	20.0	15.0	0.1	0.04	0.15	0.25	0.10	5.9	Super top	Perth Metro
PM7	4/05/2007	6.4	320	200	5.7	9.5	38.0	2.0	52.0	52.0	25.0	0.1	0.20	0.52	0.17	0.32	9.0	Super top	Perth Metro
PM8	8/06/2005				0.9	4.2	31.0	0.8	50.0	10.0	15.0	0.1	0.02	0.01	0.21	0.15	3.0	Super top	Perth Metro
PP4 Shallow	4/05/2007	5.2	230	190	12.0	8.9	66.0	2.2	93.0	75.0	10.0	0.1	1.60	6.13	0.26	0.28	7.0	Super top	Perth Metro
SE5	7/07/2005	6.9	2700	1500	23.0	52.0	470.0	13.0	770.0	93.0	160.0	0.1	0.53	0.07	0.14	0.05	16.0	Super top	Perth Metro
Shirley Balla	21/07/2005	4	460	350	5.2	11.0	41.0	2.3	79.0	7.0	5.0	0.1	0.18	0.43	0.23	0.30	5.8	Super top	Perth Metro
T 500	13/09/2005	6.5	870	610	21.0	18.0	110.0	4.7	200.0	20.0	78.0	0.1	4.10	0.03	0.59	0.05	6.4	Super top	Perth Metro
T110 (O)	19/07/2005	5.4	510	270	6.2	7.5	75.0	3.5	140.0	0.9	10.0	0.1	0.11	0.07	0.92	0.20	4.9	Super top	Perth Metro
T115	15/04/2004	6.26	166.4		119.0	53.0	385.0	1.7	470.0	134.0	*285.4*		0.06	error		1.80	11.7	Super top	Perth GWA
T120 (O)	14/04/2004	6.28			9.9	31.7	210.0	2.3	400.0	1.4	*120.0*			error		444?	0.5	Super top	Perth GWA
T130 (I)	15/07/2005	8	900	460	82.0	11.0	82.0	3.7	120.0	19.0	280.0	0.1	0.20	0.10	0.26	0.05	3.6	Super top	Perth Metro
T130 (O)	7/04/2004	8.25	277		29.0	9.5	77.0	2.2	104.0	0.2	*63.3*		0.14	error		0.23	0.5	Super top	Cockburn GWA
T140 (O)	7/04/2004	6.81	607		17.0	19.1	75.0	13.5	104.0	130.0	*5.0*		0.05	error		4.58	2.9	Super top	Jandakot GWA
T150 (O)	14/04/2004	7.78			2.3	4.8	24.8	1.9	39.6	9.7	*3.7*		8.60	error		0.20	2.9	Super top	Jandakot GWA
T161 (I)	14/04/2004	3.96			3.2	10.1	96.0	2.5	109.0	5.3	*9.8*		1.50	error		0.34	5.0	Super top	Serpentine GWA
T161 (I)	19/07/2005	6.6	780	420	5.1	13.0	130.0	2.3	200.0	0.9	35.0	0.1	0.08	0.07	0.67	0.15	7.2	Super top	Perth Metro
T200 (O)	20/07/2005	6.2	610	410	10.0	12.0	90.0	2.7	150.0	22.0	30.0	0.1	0.23	0.04	0.53	0.80	5.6	Super top	Perth Metro
T220	14/04/2004	6.06	211		2.4	6.7	49.7	1.3			*11.0*			error		6.44	10.0	Super top	Serpentine

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
																			GWA
T260 (O)	19/07/2005	6.8	350	210	4.7	6.5	55.0	3.1	73.0	11.0	35.0	0.1	0.08	0.11	0.27	0.05	3.7	Super top	Perth Metro
T340 (O)	15/07/2005	8	1200	660	120.0	20.0	120.0	6.7	170.0	110.0	320.0	0.1	1.98	0.10	0.09	0.05	4.5	Super top	Perth Metro
T370	7/07/2005	7.2	660	380	27.0	19.0	110.0	2.9	110.0	78.0	120.0	0.1	0.92	0.27	0.01	0.15	6.2	Super top	Perth Metro
T380(O)	7/07/2005	8.2	660	340	35.0	43.0	54.0	2.1	62.0	16.0	310.0	0.1	0.02	0.09	2.06	0.05	7.8	Super top	Perth Metro
T420	7/07/2005	6.6	940	540	14.0	19.0	150.0	4.3	240.0	30.0	90.0	0.1	0.07	0.14	0.37	0.05	14.0	Super top	Perth Metro
T430I	6/07/2005	4.4	2200	1400	200.0	25.0	130.0	4.8	720.0	78.0	5.0	0.1	0.37	0.40	0.98	180?	0.3	Super top	Perth Metro
T450I	6/07/2005	6.6	1100	700	25.0	20.0	160.0	6.5	280.0	0.9	110.0	0.1	0.23	0.09	1.21	1.50	7.6	Super top	Perth Metro
T530	5/07/2005	7.4	2100	1200	120.0	60.0	270.0	10.0	470.0	21.0	540.0	0.1	4.40	0.11	0.55	0.05	7.0	Super top	Perth Metro
T540	5/07/2005	6.8	200	150	4.1	5.2	23.0	4.0	31.0	15.0	25.0	0.1	10.56	0.03	0.11	0.10	4.5	Super top	Perth Metro
T570	4/07/2005	6.6	180	120	2.5	5.1	29.0	2.4	35.0	22.0	17.0	0.1	8.36	0.05	0.04	0.05	5.3	Super top	Perth Metro
T580	6/07/2005	6.7	180	110	4.0	7.9	26.0	5.6	41.0	21.0	30.0	0.1	17.60	0.04	0.01	0.15	5.0	Super top	Perth Metro
T600	4/07/2005	5.8	490	300	1.8	9.8	65.0	5.0	120.0	2.0	48.0	0.1	0.18	0.07	0.54	2.30	8.8	Super top	Perth Metro
T670	4/07/2005	7.2	1200	680	4.2	28.0	220.0	4.3	330.0	41.0	45.0	0.1	3.04	0.02	0.03	0.25	7.1	Super top	Perth Metro
T75	29/06/2005				35.0	34.0	270.0	7.8	460.0	94.0	45.0	0.1	0.23	0.06	1.02	0.95	6.1	Super top	Perth Metro
T85	25/07/2005	6	1300	680	6.5	29.0	180.0	4.0	320.0	47.0	30.0	0.1	0.09	0.18	0.35	0.25	8.2	Super top	Perth Metro
TDP1	25/07/2005	6.5	2500	1500	20.0	61.0	370.0	29.0	500.0	420.0	90.0	0.1	20.24	0.11	5.55	0.30	14.0	Super top	Perth Metro
TM4C	6/04/2004	7.96	816		16.7	8.0	95.7	8.2	104.0	72.6	*7.3*		0.05	error		0.82	11.9	Super top	Cockburn GWA
TM7A	25/07/2005	7.7	3500	1900	110.0	42.0	490.0	16.0	890.0	58.0	367.6	0.1	0.08	2.21	7.74	0.05	15.0	Super btm	Perth Metro

Bores	Date sampled	pH lab	EC @25 °C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L	Sample type	Remarks
TM7C	25/07/2005	7.2	2500	1300	70.0	42.0	350.0	12.0	590.0	100.0	250.0	0.1	0.04	0.31	0.68	0.15	7.6	Super top	Perth Metro
WCM	3/08/2005	5.3	510	300	6.9	23.0	41.0	2.0	38.0	150.0	5.0	0.1	0.79	0.09	0.68	0.08	4.1	Super top	Perth Metro
WF 12	10/08/2005	7.50	1100	640	57.0	18.0	110.0	4.8	180.0	19.0	220.0	0.1	0.13	0.08	0.28	0.05	10.0	Super top	Perth Metro
WH100	10/08/2005	7.50	1400	760	61.0	18.0	170.0	6.7	300.0	2.0	300.0	0.1	0.13	0.07	1.55	0.05	9.1	Super top	Perth Metro
WH100	9/03/2004	7.94	1359		172.0	19.8	189.0	7.6	162.0	2.7	*141.4*		4.10	error		32.5?	10.8	Super top	Perth GWA
Lake Wilgarup	9/06/2005				93.0	21.0	170.0	6.6	250.0	570.0	5.0	0.1	0.17	0.01	8.13	61.00	23.0	Super top	Perth Metro
WM1	16/06/2003	6.40	740	500	30.0	13.0	100.0	4.8	180.0	12.0	110.0		0.20	0.08	1.68	1.10	20.0	Super top	Gnangara GWA
WM24	9/06/2003	5.80	170	140	4.1	6.4	15.0	1.8	18.0	37.0	5.0		0.20	0.67	0.27	0.35	10.0	Super top	Gnangara GWA
WM29	11/06/2003	6.70	620	320	16.0	31.0	57.0	9.4	90.0	31.0	200.0		0.20	4.90	15.48	0.35	8.5	Super top	Gnangara GWA
WM3	16/06/2003	5.90	300	210	1.5	4.4	48.0	2.0	81.0	3.0	25.0		0.20	0.04	0.75	0.30	14.0	Super top	Gnangara GWA
WM32	21/07/2003	5.00	330	210	2.5	4.9	52.0	2.3	90.0	8.0	5.0		0.30	0.03	0.45	0.25	9.7	Super top	Gnangara GWA
WM4	16/06/2003	6.00	240	140	3.4	4.6	35.0	2.9	45.0	33.0	20.0		2.40	0.04	0.01	0.05	14.0	Super top	Gnangara GWA
WM5	16/06/2003	5.80	310	200	2.3	9.7	40.0	1.8	56.0	43.0	18.0		0.20	0.04	0.75	0.55	12.0	Super top	Gnangara GWA
YB 11	26/07/2003	7.50	540	310	54.0	6.2	48.0	3.2	93.0	10.0	170.0		0.30	0.05	0.02	0.10	14.0	Super top	Gnangara GWA
YN 2	26/07/2003	6.60	430	240	31.0	5.4	48.0	1.9	85.0	10.0	90.0		3.20	0.02	0.01	0.05	11.0	Super top	Gnangara GWA
YN 3	26/07/2003	6.60	360	180	19.0	8.0	41.0	2.4	76.0	9.0	65.0		0.30	0.01	0.01	0.05	9.2	Super top	Gnangara GWA
YN 3	12/09/2005	6.70	390	210	15.0	3.9	45.0	1.9	87.0	7.0	58.0	0.1	1.40	0.01	0.01	0.05	6.2	Super top	Perth Metro
YN 5	26/07/2003	8.00	1700	980	100.0	17.0	190.0	3.1	420.0	33.0	230.0		0.60	0.01	0.02	0.35	11.0	Super top	Gnangara GWA
YN 5	9/08/2005	7.40	1200	660	61.0	12.0	160.0	2.2	250.0	11.0	240.0	0.1	1.41	0.09	0.03	0.05	5.8	Super top	Perth Metro

Bores	**Date sampled**	**pH lab**	**EC @25 °C µS/cm**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**HCO_3 mg/L**	**CO_3 mg/L**	**NO_3 mg/L**	**PO_4 mg/L**	**NH_4 mg/L**	**Fe mg/L**	**Si mg/L**	**Sample type**	**Remarks**
YN 6	26/07/2003	7.00	540	300	51.0	5.8	53.0	3.1	100.0	7.0	130.0		1.30	0.03	0.01	0.05	15.0	Super top	Gnangara GWA
YN 7	26/07/2003	6.60	650	370	48.0	9.3	69.0	3.0	130.0	50.0	85.0		0.80	0.02	0.01	0.05	13.0	Super top	Gnangara GWA
YN 8	26/07/2003	7.00	1200	710	100.0	21.0	98.0	5.7	160.0	50.0	140.0		200.00	0.01	0.01	0.05	11.0	Super top	Gnangara GWA
YSI 1	9/08/2005	7.60	5600	3600	190.0	100.0	920.0	12.0	2000.0	180.0	170.0	0.1	3.74	0.10	0.01	0.05	5.9	Super top	Perth Metro
YSI1	8/03/2004	7.87	510		57.7	13.2	117.0	2.6	53.9	0.5	*31.4*		0.61	error		0.20	3.5	Super top	Perth GWA
YY3 (I)	8/03/2004	7.96	520		13.3	9.2	69.2	2.0	109.0	0.5	*20.7*		0.15	error		3.13	3.5	Super top	Gnangara GWA
YY3(I)	28/07/2005	6.80	560	300	16.0	11.0	75.0	4.4	120.0	2.0	75.0	0.1	0.20	0.04	0.41	0.10	6.4	Super top	Perth Metro

Note: HCO_3 values in italics have been calculated.

Appendix D – Wetlands – major chemical analysis 2005

Wetlands	Date sampled	Date analysed	pH lab	EC@25°C μS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	NO_3 mg/L	PO_4 mg/L	NH_4 mg/L	Fe mg/L	Si mg/L
Bibra Lake 425	17/05/2005	26/05–10/06	8.2	1 700	1 100	76.0	40.0	240.0	18.0	380.0	190	170.0	0.1	0.38	0.05	0.22	0.10	1.1
Lake Walyungup 1470	17/05/2005	26/05–10/06	8.8	33 000	26 000	18.0	1200.0	7900.0	260.0	13 000.0	2900	920.0	290.0	0.79	0.14	1.15	0.05	1.7
North Lake 425	17/05/2005	26/05–10/06	6.6	740	470	15.0	25.0	90.0	11.0	160.0	120	20.0	0.1	0.66	0.07	0.57	0.20	4
Lake Yonderup	18/05/2005	26/05–10/06	7.4	560	380	43.0	7.0	60.0	3.2	110.0	63	80.0	0.1	0.20	0.02	0.04	0.05	7.2
Loch McNess 8754	18/05/2005	26/05–10/06	7.9	460	300	29.0	6.2	59.0	4.4	100.0	12	85.0	0.1	0.03	0.01	0.04	0.05	7.6
Pipidinny Swamp No.	18/05/2005	26/05–10/06	7.8	18 000	14 000	820.0	400.0	3300.0	92.0	6 400.0	1700	220.0	0.1	1.01	0.09	1.42	0.10	4.5
Pipidinny Swamp No.	18/05/2005	26/05–10/06	7.7	960	620	66.0	12.0	110.0	6.8	200.0	57	170.0	0.1	0.24	0.02	0.27	0.05	8
Lake Joondalup 8281	19/05/2005	26/05–10/06	7.9	1 100	780	58.0	26.0	150.0	14.0	240.0	170	140.0	0.1	0.48	0.19	0.41	0.30	5.2
Lake Mariginiup 1943	19/05/2005	26/05–10/06	4.2	2 900	2 500	190.0	160.0	340.0	23.0	520.0	1200	0.1	0.0	7.48	0.04	7.61	0.15	14
Lake Nowergup	19/05/2005	26/05–10/06	7.8	380	250	37.0	6.6	32.0	5.1	59.0	5	140.0	0.1	0.06	0.02	0.21	0.05	4.8
Gnangara Lake 8386	24/05/2005	26/05–10/06	3.5	2 200	1 700	49.0	65.0	280.0	6.0	470.0	210	5.0	0.1	25.52	0.04	10.19	0.14	15
Herdsman Lake 619	24/05/2005	26/05–10/06	8.2	680	460	45.0	18.0	81.0	9.7	130.0	30	220.0	0.1	0.15	0.25	1.10	0.05	11
Jandabup Lake 1944	24/05/2005	26/05–10/06	7.2	320	240	10.0	8.6	52.0	3.5	90.0	42	25.0	0.1	0.18	0.02	0.04	0.16	3.4
Lake Goollelal 459	24/05/2005	26/05–10/06	9.1	810	580	45.0	23.0	11.0	13.0	180.0	150	75.0	10.0	0.16	0.01	0.03	0.05	8.7
Lake Gwelup 465	24/05/2005	26/05–10/06	7.6	280	210	47.0	2.7	8.6	4.0	9.0	100	55.0	0.1	0.05	0.01	0.02	0.05	2.7
Lake Monger	24/05/2005	26/05–10/06	8.3	780	550	35.0	21.0	120.0	13.0	220.0	48	170.0	0.1	0.53	0.11	0.98	0.05	1.3
Lake Forrestdale 602	30/05/2005	02–13/06	8.4	4 200	3 600	500.0	79.0	480.0	28.0	780.0	1700	45.0	2.0	0.27	0.05	0.09	0.05	7.2

Appendix E – Rainwater – major chemical analysis 2003–08

Rainfall sites	Date sampled	Date analysed	Distance to ocean km	Easting	Northing	Elevation m AHD	pH lab	EC @25°C µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	Fe mg/L
Lake Pinjar	3/09/2003	3/09/2003	13.5	387956	6502085	56.9	7.3	71	30	0.6	1.2	9.3	0.7	16	3	5	0	<0.05
Hamilton Hill	8/06/2005	14-28/09/2005	1.8	384106	6449947	5.9	5.8	26	16	<0.5	<0.5	2.1	<0.5	6	1	<5	<1	<0.05
Bibra Lake	23/06/2005	5-12/07/2005	6.8	390155	6447907	23.2			10.1	0.5	0.5	2	0.5	9	0.9	<5	<1	<0.05
Duncraig	6/09/2005	14-28/09/2005	3.2	384951	6477462	11.5	7.3	46	32	1	<0.5	4.6	0.6	13	3	<5	<1	<0.05
Mt Lawley	6/09/2005	14-28/09/2005	11.2	393144	6466170	23.3	6	70	44	0.7	1	8.1	<0.5	17	2	<5	<1	<0.05
Riverton	6/09/2005	14-28/09/2005	13.5	394888	6454994	10.5	6.4	110	54	1.1	1.6	14	0.6	26	3	<5	<1	<0.05
Mariginiup	11/09/2006	13/09- 16/10/2006	9.5	388437	6489482	43.0	6	23	14	<1	<1	2.1	0.2	4	1	<5	<1	<0.05
Sinatra Rd	11/09/2006	13/09- 16/10/2006	11	384366	6503730	46.0	5.9	21	13	<1	<1	1.8	0.2	5	1	5	<1	<0.05
Wilgarup	11/09/2006	13/09- 16/10/2006	4.2	375733	6505910	7.0	6	23	14	<1	<1	2.5	0.2	10	1	5	<1	<0.05
North Lake	29/07/08	5/09/08	7.5	389604	6450210	30.0	5.7	30	20	<1	<1	<10	<1	6	<5	2	<1	0.01
Forrestdale	29/07/08	5/09/08	16.5	400542	6440790	25.0	8.6	40	10	<1	1	13	<1	6	<5	9	3	0.02
Egerton	28/07/08	5/09/08	23.5	403346	6484469	50.0	5.9	50	20	<1	1	<10	<1	12	<5	3	<1	0.04
Lake Bambun	28/07/08	5/09/08	29.2	394134	6522803	72.0	6.2	50	20	<1	1	<10	<1	11	<5	3	<1	0.01
Yeal Wetlands	28/07/08	5/09/08	24.3	386000	6526126	63.0	6.3	50	20	1	1	<10	<1	11	<5	4	<1	0.11
Bindiar Lake	28/07/08	5/09/08	17.2	381791	6519857	60.0	6.1	50	20	<1	1	<10	<1	11	<5	3	<1	<0.002
Loch McNess	28/07/08	5/09/08	5	374140	6509532	10.0	6.4	40	10	<1	<1	<10	<1	9	<5	4	<1	0.00
Highhill, PM4	28/07/08	5/09/08	20	391091	6508176	90.0	6.3	40	<10	<1	<1	<10	<1	9	<5	4	<1	0.03
Joondalup	28/07/08	5/09/08	7	384862	6489366	40.0	6.4	50	<10	1	1	<10	<1	11	<5	4	<1	0.01

Appendix F – Superficial aquifer bores and wetlands – minor chemical analysis 2003–07

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
459	20/06/2005	Super top													0.8			5.0	
649	22/06/2005	Super top													0.2			5.0	
2069	21/07/2005	Super top	140												0.2			5.0	
2288	28/06/2005	Super top													0.2			5.0	
8281	20/06/2005	Super top													0.2			5.0	
8282	19/07/2005	Super top	350												0.2			10.0	
8283	21/07/2005	Super top	490												0.2			5.0	
8386	12/09/2005	Super top	220	0.0005	0.005						50			0.001	0.2	0.005		1.0	
1/98	9/06/2005	Super top													0.2			5.0	
1081	26/03/2004	Super top				2349	129	0.284	39.6	79.8	12.7	3.44	3.92		0.62		155	4.8	35.6
144B	28/06/2005	Super top													0.8			5.0	
2025A	25/03/2004	Super top				295	30.1	0.213	4.64	35.7	24.6	4.09	2.39		0.35		514	4.8	28.1
2025A	28/06/2005	Super top													0.5			5.0	
3578A	27/06/2005	Super top													0.4			5.0	
602	15/04/2004	Super top				115	16.8	0.159	13.7	4.51	32.3	3.97	2.34		6.5		355	1.5	82.1
8259A	30/04/2007	Super top	64	0.0005	0.005						40			0.001	0.2	0.005		1.0	
8281	9/03/2004	Super top				486	104	0.349	26.2	54.7	2684	119	16.9		0.1		13 462	10.4	30.2
8283	26/03/2004	Super top				265	30.7	0.232	15.1	8.38	20.1	5.58	1.44		0.1		198	1.8	54.1
B270	5/03/2004	Super top				112	5.39	0.392	3.42	13.8	8.70	6.17	3.98		0.35		284	2.0	35.6
B270	26/07/2005	Super top	390	0.0005	0.005						50			0.001	0.3	0.005		5.0	
CSG6	15/07/2005	Super top	1400												1			5.0	
CSI-3/97	7/04/2004	Super top				387	10.2	0.074	7.63	25.8	22.7	4.81	4.90		1.3		182	3.8	44.9
CW1	23/06/2003	Super top	113												0.2			4.0	
E 1-89	5/07/2005	Super top	210	0.0005	0.005						50			0.001	0.2	0.005		5.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
FL1	30/06/2005	Super top													0.3			5.0	
GA 10	15/07/2003	Super top	760												0.4			4.0	
GA 14	15/07/2003	Super top	190												0.4			4.0	
GA 15	15/07/2003	Super top	130												0.3			4.0	
GA 4	15/07/2003	Super top	170												0.4			4.0	
GA 5	15/07/2003	Super top	150												0.2			4.0	
GA 8	15/07/2003	Super top	290												0.5			4.0	
GA 9	15/07/2003	Super top	380												0.4			4.0	
GA1	17/07/2003	Super top	370												0.6			4.0	
GA11	8/03/2004	Super top				96.9	31.6	0.387	4.62	27.1	46.7	12.0	4.86		0.28		500	3.0	33.6
GA11	27/07/2005	Super top	410	0.0005	0.005						50			0.001	0.3	0.005		5.0	
GA12	17/07/2003	Super top	290												0.5			4.0	
GA13	17/07/2003	Super top	230												0.4			4.0	
GA17	17/07/2003	Super top	260												0.5			4.0	
GA17	27/07/2005	Super top	310	0.0005	0.005						50			0.001	0.2	0.005		5.0	
GA18	17/07/2003	Super top	190												0.4			4.0	
GA22	17/07/2003	Super top	270												0.4			4.0	
GA22	27/07/2005	Super top	190								0				0.2			5.0	
GA25	5/03/2004	Super top				604	2.17	0.459	3.92	25.5	14.0	5.31	3.50		0.43		169	2.9	37.3
GA26	5/03/2004	Super top				30.3	10.4	0.509	6.76	71.3	32.7	8.60	4.54		0.52		395	2.2	22.8
GA28	26/07/2005	Super top	400	0.0005	0.005						50			0.001	0.4	0.005		5.0	
GA33	8/03/2004	Super top				342	6.69	0.411	5.16	28.0	23.7	5.04	5.18		0.37		116	2.4	43.4
GA33	27/07/2005	Super top	390	0.0005	0.005						50			0.001	0.3	0.005		5.0	
GB15	17/07/2003	Super top	840												0.9			4.0	
GB21	16/03/2004	Super top				16.6	20.5	0.263	2.07	10.5	51.6	7.32	62.7		0.21		2 957	3.8	28.8

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
GB21	7/06/2005	Super top													0.4			5.0	
GB23	27/07/2005	Super top	170	0.0005	0.005						50			0.001	0.2	0.005		5.0	
GC 11	21/07/2003	Super top	130												0.5			4.0	
GC 19	15/07/2003	Super top	160												0.2			4.0	
GC17	16/03/2004	Super top				8.88	12.3	0.241	2.61	8.62	47.7	6.94	4.42		0.1		2 542	2.9	22.9
GC17	8/06/2005	Super top													0.2			5.0	
GC4	7/06/2005	Super top													0.7			5.0	
GD 11	20/06/2005	Super top													0.6			5.0	
GD 12	21/06/2005	Super top													1.1			5.0	
GD 2	6/06/2003	Super top	450												0.4			4.0	
GD12	24/03/2004	Super top				250	277	0.227	6.94	59.0	19.3	17.0	3.89		1.6		89	4.1	49.9
GD23	9/06/2003	Super top	600												0.5			4.0	
GD23	27/06/2005	Super top													0.6			5.0	
GD5	27/06/2005	Super top													2			5.0	
GD8	25/03/2004	Super top				94.9	23.3	0.230	4.80	38.6	17.0	5.95	3.50		0.1		108	3.1	27.4
GE 2	13/09/2005	Super top	760	0.0005	0.005						50			0.001	0.6	0.005		2.0	
GE3	27/06/2005	Super top													0.6			10.0	
GG3 (O)	21/07/2003	Super top	100												0.4			4.0	
GM 16	22/06/2005	Super top													0.4			5.0	
GM 2	6/06/2003	Super top	560												0.3			4.0	
GM 7	6/06/2003	Super top	410												0.4			4.0	
GM 9	22/06/2005	Super top													0.4			5.0	
GM26	27/06/2005	Super top													0.5			5.0	
GN 13	5/06/2003	Super top	100												0.3			4.0	
GN23	16/06/2003	Super top	230												0.3			4.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
GNM11A	7/06/2005	Super top													0.3			5.0	
GNM5	16/06/2003	Super top	180												0.2			4.0	
IF16	20/04/2004	Super top				384	22.6	0.226	4.81	133	5.10	3.12	1.82		0.52		171	4.8	47.5
JB 4	2/08/2005	Super top	830												0.6			5.0	
JB 9A	4/06/2003	Super btm	220												0.2			4.0	
JB 9C	4/06/2003	Super top	140												0.2			4.0	
JB5	9/06/2003	Super top	210												0.2			4.0	
JE10C	19/07/2005	Super top	340												0.2			5.0	
JE12A	7/04/2004	Super btm				207	16.7	0.209	3.49	40.6	19.3	9.28	2.68		0.1		282	3.1	39.2
JE12A	20/07/2005	Super btm	320												0.2			5.0	
JE12B	7/04/2004	Super inter				460	6.36	0.216	21.6	43.4	2.28	1.73	2.83		27.3		6 504	4.9	17.2
JE12B	20/07/2005	Super inter	750												28			5.0	
JE12C	7/04/2004	Super top				17.3	11.1	0.077	2.09	10.7	6.94	3.07	3.42		0.1		217	3.4	24.1
JE12C	25/07/2005	Super top	180	0.0005	0.005						50			0.001	0.2	0.005		5.0	
JE22C	14/04/2004	Super top				80.2	16.8	0.223	3.90	31.4	35.7	18.1	5.93		0.98		5 124	6.1	27.7
JE4A	30/06/2005	Super btm													0.9			5.0	
JE4C	30/06/2005	Super top													0.4			5.0	
JM12	5/04/2004	Super top				37.7	24.5	0.174	2.24	16.2	44.1	7.14	3.70		0.1		505	4.0	18.1
JM16	5/04/2004	Super top				15.1	12.1	0.192	1.56	11.6	18.7	4.38	2.28		0.1		922	3.4	20.9
JM19	5/04/2004	Super top				8.61	10.1	0.138	3.45	2.05	17.4	4.40	1.91		0.1		330	3.7	27.5
JM22	30/06/2005	Super top													0.3			5.0	
JM5	16/04/2004	Super top				130	22.9	0.123	8.50	7.35	33.9	5.83	0.486		0.1		401	5.4	64.6
JM5	29/06/2005	Super top													0.3			5.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
JM51	20/04/2004	Super top				11.3	9.51	0.157	1.18	4.53	4.84	6.08	0.838		0.1		179	4.5	41.1
JM66A	16/04/2004	Super btm				362	28.2	0.196	8.10	32.0	10.2	4.38	1.07		0.04		291	5.0	31.7
JM66C	16/04/2004	Super top				26.1	11.0	0.076	2.36	2.93	17.4	11.1	2.57		0.1		438	3.7	35.1
JM66C	21/07/2005	Super top	100												0.2			5.0	
JM7	6/04/2004	Super top				17.0	18.7	0.211	2.01	27.5	21.5	2.81	2.82		0.1		458	3.6	10.7
JM7	29/06/2005	Super top													0.3			5.0	
JP 14	12/09/2005	Super top	420	0.0005	0.005						100			0.001	0.3	0.005		7.0	
JP 18C	6/06/2003	Super top	440												0.7			4.0	
JP13 (I)	9/03/2004	Super top				29.2	356.5	0.345	2.57	15.8	39.7	5.18	4.44		0.69		184	3.1	33.6
JP15	9/03/2004	Super top				184	136	0.412	10.3	30.6	32.1	5.46	3.60		0.47		280	2.0	31.8
JP15	28/07/2005	Super top	490	0.0005	0.005						50			0.001	0.5	0.005		5.0	
JP3	9/03/2004	Super top				54.5	235	0.379	11.1	24.1	35.5	3.40	5.87		0.1		274	3.2	57.8
L10A	1/05/2007	Super btm	280	0.0005	0.005						10			0.001	0.2	0.005		1.0	
L10C	11/06/2003	Super top	210												0.2			4.0	
L10C	1/05/2007	Super top	190	0.0005	0.005						30			0.001	0.2	0.005		1.0	
L160C	18/03/2004	Super top				63.0	13.5	0.285	6.43	31.0	58.0	116	16.5		0.37		724	3.2	28.7
L240C	18/03/2004	Super top				202	21.9	0.319	12.7	22.2	52.3	3.07	2.74		0.19		145	3.1	35.9
L50C	21/07/2003	Super top	150												0.4			4.0	
LB5	16/04/2004	Super top				15.1	13.8	0.162	5.02	32.6	17.3	3.61	1.80		0.35		414	5.3	33.1
LN 2/89	9/08/2005	Super top	250												0.3			44.0	
LWIS 6/90 (SIM 6/90)	10/08/2005	Super top	360												0.3			5.0	
MM 31	22/06/2005	Super top													0.3			5.0	
MM 45	22/06/2005	Super top													0.5			5.0	
MM 52	21/06/2005	Super top													0.5			5.0	
MM10	11/06/2003	Super top	180												0.2			4.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
MM12	11/06/2003	Super top	210												0.4			4.0	
MM14	6/06/2003	Super top	570												0.4			4.0	
MM16	12/06/2003	Super top	650												0.7			4.0	
MM18	11/06/2003	Super top	210												0.2			4.0	
MM28	20/04/2004	Super top	216			15.7	11.8	0.348	9.56	139	23.6	9.95	1.65		0.18		227	3.7	33.2
MM49B	21/07/2003	Super top	430												0.6			4.0	
MM52	24/03/2004	Super top				87.9	41.6	0.233	12.4	42.1	182	8.56	3.94		0.56		681	5.0	50.2
MM53	12/06/2003	Super top	340												0.3			4.0	
MM59B	11/06/2003	Super top	110												0.2			4.0	
MS 14	4/06/2003	Super top	610												0.9			4.0	
MS10	7/05/2007	Super top	960	0.0005	0.005						20			0.001	1.3	0.005		1.0	
MS7	9/06/2003	Super top	1300												0.2			4.0	
MT1D	7/05/2007	Super btm	300	0.0005	0.005						10			0.001	0.2	0.005		1.0	
MT1S	9/06/2005	Super top													0.2			5.0	
NL424	29/06/2005	Super top													0.7			5.0	
NR 3A	5/06/2003	Super btm	190												0.2			4.0	
NR 3B	5/06/2003	Super inter	193												0.4			4.0	
NR 3C	5/06/2003	Super top	140												0.2			4.0	
NR10C	21/07/2003	Super top	190												0.3			4.0	
NR1B	23/06/2003	Super inter	140												0.2			4.0	
NR1C	23/06/2003	Super top	300												0.4			4.0	
NR2C	18/03/2004	Super top				26.6	5.75	0.353	3.98	11.3	40.1	4.89	3.03		0.25		401	1.6	44.7
NR6C	1/05/2007	Super top	100	0.0005	0.005						30			0.001	0.2	0.005		1.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
NR7A	9/06/2003	Super btm	290												0.2			4.0	
NR7B	9/06/2003	Super inter	320												0.4			4.0	
NR7C	9/06/2003	Super top	230												0.5			4.0	
PCM 21	9/08/2005	Super top	200												0.2			5.0	
PCM21	24/06/2003	Super top	140												0.2			4.0	
PE2A	17/03/2004	Super btm				41.1	8.46	0.322	5.88	46.3	54.2	4.60	2.59		0.21		163	2.8	34.4
PE2B	17/03/2004	Super inter				18.2	70.6	0.404	6.28	55.3	38.2	3.21	2.64		0.22		68	1.6	21.0
PM 26	15/07/2003	Super top	180												0.6			4.0	
PM 31	26/07/2003	Super top	350												0.5			4.0	
PM 33	15/07/2003	Super top	410												0.6			4.0	
PM 35	10/08/2005	Super top	280												0.2			5.0	
PM12	16/06/2003	Super top	230												0.3			4.0	
PM16	24/06/2003	Super top	300												0.3			4.0	
PM16	28/07/2005	Super top	250	0.0005	0.005						50			0.001	0.2	0.005		5.0	
PM18	24/06/2003	Super top	160												0.3			4.0	
PM19	24/06/2003	Super top	150												0.3			4.0	
PM3	24/06/2003	Super top	630												0.6			4.0	
PM5	17/03/2004	Super top				16.2	6.80	0.219	2.52	23.7	43.3	3.76	3.48		0.33		195	3.0	12.6
PM5	8/06/2005	Super top													0.2			5.0	
PM6	23/06/2003	Super top	160												0.2			4.0	
PM6	8/06/2005	Super top													0.3			5.0	
PM7	4/05/2007	Super top	200	0.0005	0.005						30			0.001	0.2	0.005		1.0	
PM8	8/06/2005	Super top													0.2			5.0	
PP4 Shallow	4/05/2007	Super top	190	0.0005	0.005						20			0.001	0.2	0.005		1.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
SE5	7/07/2005	Super top	1500	0.0005	0.005						50			0.001	2.6	0.005		5.0	
SHIRLEY BALLA	21/07/2005	Super top	350												0.3			5.0	
T 500	13/09/2005	Super top	610	0.0005	0.005						50			0.001	0.7	0.005		1.0	
T110 (O)	19/07/2005	Super top	270												0.4			5.0	
T115	15/04/2004	Super top				388	42.7	0.219	6.76	80.6	29.7	3.33	1.85		3.5		344	6.4	48.3
T120 (O)	14/04/2004	Super top				70.8	27885	0.219	5.15	53.1	29.4	0.58	1.38		2.8		265	8.5	6.96
T130 (I)	15/07/2005	Super top	460												0.3			10.0	
T130 (O)	7/04/2004	Super top				71.6	60.5	0.134	3.05	11.3	18.7	1.96	1.75		0.3		151	3.4	23.3
T140 (O)	7/04/2004	Super top				94.5	38.4	0.242	10.2	78.1	34.1	3.11	3.82		0.1		348	4.6	38.9
T150 (O)	14/04/2004	Super top				10.1	12.4	0.01	1.98	5.71	31.1	5.17	1.38		0.1		729	3.5	27.5
T161 (I)	14/04/2004	Super top				25.0	10.3	0.139	3.76	15.0	35.6	5.63	1.97		0.33		280	3.8	33.5
T161 (I)	19/07/2005	Super top	420												0.5			5.0	
T200 (O)	20/07/2005	Super top	410												0.4			5.0	
T220	14/04/2004	Super top				22.6	472	0.164	6.24	34.2	40.9	4.29	1.61				200	3.3	23.2
T260 (O)	19/07/2005	Super top	210												0.2			5.0	
T340 (O)	15/07/2005	Super top	660												0.3			5.0	
T370	7/07/2005	Super top	380	0.0005	0.005						50			0.001	0.4	0.005		5.0	
T380(O)	7/07/2005	Super top	340	0.0005	0.005						50			0.001	0.3	0.005		5.0	
T420	7/07/2005	Super top	540	0.0005	0.005						50			0.001	0.7	0.01		5.0	
T430I	6/07/2005	Super top	1400	0.0005	I/S						0				2.2			5.0	
T450I	6/07/2005	Super top	700	0.0005	0.005						50			0.001	1	0.005		5.0	
T530	5/07/2005	Super top	1200	0.0005	0.005						50			0.001	1.4	0.005		5.0	
T540	5/07/2005	Super top	150	0.0005	0.005						50			0.001	0.3	0.005		5.0	
T570	4/07/2005	Super top	120	0.0005	0.005						50			0.001	0.3	0.005		5.0	
T580 not 560	6/07/2005	Super top	110	0.0005	0.005						50			0.001	0.3	0.005		5.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
T600	4/07/2005	Super top	300	0.0005	0.005						50			0.001	0.5	0.005		5.0	
T670	4/07/2005	Super top	680	0.0005	0.005						50			0.001	1.2	0.005		5.0	
T75	29/06/2005	Super top													0.9			5.0	
T8S (T85)	25/07/2005	Super top	680	0.0005	0.005						50			0.001	0.95	0.005		5.0	
TDP1	25/07/2005	Super top	1500	0.0005	0.005						50			0.001	0.4	0.005		5.0	
TM4C	6/04/2004	Super top				84.0	11.7	0.247	6.98	19.9	48.0	20.5	7.12		0.59		615	1.7	37.5
TM7A	25/07/2005	Super btm	1900	0.0005	0.005						50			0.001	2.3	0.005		5.0	
TM7C	25/07/2005	Super top	1300	0.0005	0.005						50			0.001	1.8	0.005		5.0	
WCM	3/08/2005	Super top	300												0.2			5.0	
WF 12	10/08/2005	Super top	640												0.6			36.0	
WH 100	10/08/2005	Super top	760												0.9			18.0	
WH100	9/03/2004	Super top				215	154	0.545	9.26	17.3	75.1	21.2	4.40		0.77		471	52.0	38.8
Wilgerup Lake	9/06/2005	Super top													0.6			5.0	
WM1	16/06/2003	Super top	500												0.6			4.0	
WM24	9/06/2003	Super top	140												0.2			4.0	
WM29	11/06/2003	Super top	320												0.2			4.0	
WM3	16/06/2003	Super top	210												0.2			4.0	
WM32	21/07/2003	Super top	210												0.5			4.0	
WM4	16/06/2003	Super top	140												0.2			4.0	
WM5	16/06/2003	Super top	200												0.3			4.0	
YB 11	26/07/2003	Super top	310												0.2			4.0	
YN 2	26/07/2003	Super top	240												0.5			4.0	
YN 3	26/07/2003	Super top	180												0.4			4.0	
YN 3	12/09/2005	Super top	210	0.0005	0.005						50			0.001	0.2	0.005		1.0	
YN 5	26/07/2003	Super top	980												0.7			4.0	
YN 5	9/08/2005	Super top	660												0.5			5.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
YN 6	26/07/2003	Super top	300												0.4			4.0	
YN 7	26/07/2003	Super top	370												0.6			4.0	
YN 8	26/07/2003	Super top	710												0.6			4.0	
YSI 1	9/08/2005	Super top	3600												6.9			5.0	
YSI1	8/03/2004	Super top				432	3.21	0.440	7.98	31.7	15.3	7.43	4.00				156	2.7	24.9
YY3 (I)	8/03/2004	Super top				34.6	42.3	0.353	5.97	28.8	27.5	3.98	4.17		0.34		197	2.1	25.2
YY3(I)	28/07/2005	Super top	300	0.0005	0.005						50			0.001	0.3	0.005		5.0	
Bibra Lake	17/05/2005	Wetlands	1100	0.0005	0.005									0.001	1	0.005		5.0	
Lake Walyungup	17/05/2005	Wetlands	26000	0.0005	0.005									0.001	23	0.005		5.0	
North Lake	17/05/2005	Wetlands	470	0.0005	0.005									0.001	0.5	0.005		5.0	
Lake Yonderup	18/05/2005	Wetlands	380	0.0005	0.005									0.001	0.4	0.005		5.0	
Loch McNess	18/05/2005	Wetlands	300	0.0005	0.005									0.001	0.3	0.005		5.0	
Pipidinny Swamp No. 1	18/05/2005	Wetlands	14000	0.0005	0.005									0.002	12	0.005		15.0	
Pipidinny Swamp No. 2	18/05/2005	Wetlands	620	0.0005	0.005									0.001	0.5	0.005		5.0	
Lake Joondalup	19/05/2005	Wetlands	780	0.0005	0.005									0.001	0.7	0.005		5.0	
Lake Mariginiup	19/05/2005	Wetlands	2500	0.0005	0.005									0.001	2.7	0.005		5.0	
Lake Nowergup	19/05/2005	Wetlands	250	0.0005	0.005									0.001	0.2	0.005		5.0	
Gnangara Lake	24/05/2005	Wetlands	1700	0.0005	0.005									0.001	1.8	0.005		5.0	
Herdsman Lake	24/05/2005	Wetlands	460	0.0005	0.005									0.001	0.6	0.005		5.0	
Jandabup Lake	24/05/2005	Wetlands	240	0.0005	0.005									0.001	0.3	0.005		5.0	
Lake Goollelal	24/05/2005	Wetlands	580	0.0005	0.005									0.001	0.7	0.005		5.0	
Lake Gwelup	24/05/2005	Wetlands	210	0.0005	0.005									0.001	0.2	0.005		5.0	
Lake Monger	24/05/2005	Wetlands	550	0.0005	0.005									0.001	0.8	0.005		5.0	

Site	Date sampled	St	TDS mg/L	Hg mg/L	Se mg/L	Sr ppb	Mn ppb	Cs ppb	Rb ppb	Ba ppb	Zn ppb	Cu ppb	Ni ppb	Cd mg/L	Br mg/L	Pb mg/L	Al ppb	As ppb	B ppb
Lake Forrestdale	30/05/2005	Wetlands	3600	0.0005	0.005						50			0.001	1.2	0.005		5.0	

Note: ppb – parts per billion

Appendix G – Superficial aquifer bores – historical and recent salinity data

Site	Location	Date sampled	Easting	Northing	Cond field μS/cm	Cond @25 C lab μS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
649	Perth metro	22/06/2005	395174	6473247	321			190.0	484.1	828	uncomp EC (lab)	1996	-294.1
2069	Perth metro	21/07/2005	397139	6469799	189	210	140	111.9	124.0	212	uncomp EC (lab)	1991	-12.1
2288	Perth metro	28/06/2005	400116	6464360	318			188.3	570.1	975	uncomp EC (lab)	1991	-381.8
8283	Perth metro	21/07/2005	388209	6452184	868	870	490	513.9	859.5	1470	uncomp EC (lab)	1991	-345.6
1/98	Perth metro	9/06/2005	402787	6496568	218			129.1	140.3	240	uncomp EC (lab)	2001	-11.3
B270	Perth metro	26/07/2005	367727	6524667	675	720	390	399.6	390.0	390	TDS calc@180-HCO_3	1992	9.6
GA 10	Gnangara GWA	15/07/2003	382335	6517936	889	1000	760	526.3	341.0	341	TDS calc@180-HCO_3	1986	185.3
GA 14	Gnangara GWA	15/07/2003	378325	6519339	256	280	190	151.6	153.0	153	TDS calc@180-HCO_3	1986	-1.4
GA 15	Gnangara GWA	15/07/2003	380550	6520142	168	190	130	99.5	210.0	210	TDS calc@180-HCO_3	1986	-110.5
GA 4	Gnangara GWA	15/07/2003	380433	6513524	247	280	170	146.2	126.0	126	TDS calc@180-HCO_3	1982	20.2
GA 5	Gnangara GWA	15/07/2003	383703	6513588	240	270	150	142.1	150.0	150	TDS calc@180-HCO_3	1986	-7.9
GA 8	Gnangara GWA	15/07/2003	377675	6516311	458	520	290	271.1	278.0	278	TDS calc@180-HCO_3	1986	-6.9
GA 9	Gnangara GWA	15/07/2003	383945	6516420	535	630	380	316.7	250.0	250	TDS calc@180-HCO_3	1986	66.7
GA1	Gnangara GWA	17/07/2003	370868	6514980	625	690	370	370.0	430.0	430	TDS calc@180-HCO_3	1980	-60.0
GA11	Perth metro	27/07/2005	368595	6519709	678	730	410	401.4	346.0	346	TDS calc@180-HCO_3	1982	55.4
GA12	Gnangara GWA	17/07/2003	371138	6519531	490	540	290	290.1	290.0	290	TDS calc@180-HCO_3	1980	0.1
GA13	Gnangara GWA	17/07/2003	374840	6519990	384	420	230	227.3	221.0	221	TDS calc@180-HCO_3	1986	6.3
GA17	Perth metro	27/07/2005	372559	6522392	485	510	310	287.1	329.2	563	Cond calc 25deg C	1986	-42.1
GA17	Gnangara GWA	17/07/2003	372420	6522243	444	480	260	262.9	329.2	563	Cond calc 25deg C	1986	-66.3
GA18	Gnangara GWA	17/07/2003	377150	6522612	295	330	190	174.6	241.5	413	Cond calc 25deg C	1986	-66.8
GA22	Perth metro	27/07/2005	375208	6525069	349	370	190	264.6	157.0	157	TDS calc@180-HCO_3	1982	107.6
GA25	Gingin GWA	5/03/2004	363139	6528109	861	793		509.7	430.0	430	TDS calc@180-HCO_3	1979	79.7

Site	Location	Date sampled	Easting	Northing	Cond field μS/cm	Cond @25 C lab μS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
GA26	Gnangara GWA	5/03/2004	371807	6528074	696	629		412.0	299.0	299	TDS calc@180-HCO_3	1986	113.0
GA28	Perth metro	26/07/2005	360682	6528336	784	820	400	464.1	401.0	401	TDS calc@180-HCO_3	1983	63.1
GA33	Perth metro	27/07/2005	368586	6511729	747	770	390	442.2	403.4	690	uncomp EC (lab)	1989	38.8
GB15	Gnangara GWA	17/07/2003	377618	6527807	1187	1400	840	702.7	750.0	750	TDS calc@180-HCO_3	1981	-47.3
GB21	Gnangara GWA	16/03/2004	384439	6524929	283	293		167.5	185.0	185	TDS calc@180-HCO_3	1983	-17.5
GB21	Perth metro	7/06/2005	384439	6524929	251			148.6	185.0	185	TDS calc@180-HCO_3	1983	-36.4
GB23	Perth metro	27/07/2005	383649	6522639	273	290	170	161.6	110.0	110	TDS calc@180-HCO_3	1981	51.6
GC 11	Gnangara GWA	21/07/2003	387159	6519921	202	250	130	119.6	108.0	108	TDS calc@180-HCO_3	1983	11.6
GC 19	Gnangara GWA	15/07/2003	389668	6513454	244	280	160	144.5	140.0	140	TDS calc@180-HCO_3	1978	4.5
GC17	Gingin GWA	16/03/2004	395948	6516980	174	169		103.2	650.0	650	TDS calc@180-HCO_3	1977	-546.8
GC4	Perth metro	7/06/2005	390667	6524840	996			589.7	692.0	692	TDS calc@180-HCO_3	1983	-102.3
GD 11	Perth metro	20/06/2005	394831	6481668	1069			632.9	400.0	400	TDS calc@180-HCO_3	1980	232.9
GD 12	Perth metro	21/06/2005	406189	6480749	1210				3350.0	3350	TDS solid evap@180oC	1993	
GD 2	Gnangara GWA	6/06/2003	386714	6482424	805	690	450	476.6	290.0	290	TDS calc@180-HCO_3	1980	186.6
GD12	Swan GWA	24/03/2004	406189	6480749	1951	1908		1155.0	2101.8	3690	uncomp EC (in situ)	2000	-946.8
GD5	Perth metro	27/06/2005	386081	6467163	3740			2214.2	1824.3	3120	uncomp EC (lab)	1991	389.9
GD8	Perth GWA	25/03/2004	401501	6470165	903	893		534.6	360.0	360	TDS calc@180-HCO_3	1980	174.6
GE 2	Perth metro	13/09/2005	383006	6459695	1414	1400	760	837.1	597.6	1022	uncomp EC (lab)	1991	239.6
GE3	Perth metro	27/06/2005	385821	6461699	902			534.0	487.1	833	uncomp EC (lab)	1991	47.0
GG3 (O)	Gnangara GWA	21/07/2003	397132	6510134	163	190	100	96.5	93.6	160	uncomp EC (lab)	1980	2.9
GM 16	Perth metro	22/06/2005	389361	6473848	778			460.6	350.8	600	uncomp EC (lab)	1992	109.8
GM 2	Gnangara GWA	6/06/2003	386606	6476084	1073	950	560	635.2	421.0	720	uncomp EC (lab)	1992	214.3
GM 7	Gnangara GWA	6/06/2003	388797	6475726	779	680	410	461.2	422.2	722	uncomp EC (lab)	1992	39.0
GM 9	Perth metro	22/06/2005	386423	6474049	676			400.2	485.3	830	uncomp EC (lab)	1992	-85.1
GM26	Perth metro	27/06/2005	387447	6470000	805			476.6	290.0	290	TDS calc@180-HCO_3	1981	186.6

Site	Location	Date sampled	Easting	Northing	Cond field μS/cm	Cond @25 C lab μS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
GN 13	Gnangara GWA	5/06/2003	394830	6491603	206	190	100	121.7	142.1	243	uncomp EC (lab)	1991	-20.4
GN23	Gnangara GWA	16/06/2003	389200	6499320	384	350	230	227.3	176.0	301	uncomp EC (lab)	1991	51.3
JB 4	Perth metro	2/08/2005	389845	6486158	1132	1200	830	670.2	430.0	430	TDS calc@180-0.5HCO_3	1980	240.2
JB5	Gnangara GWA	9/06/2003	391132	6486310	372	330	210	220.2	115.0	115	TDS calc@180-0.5HCO_3	1982	105.2
JE12C	Jandakot GWA	25/07/2005	391650	6438966	219	260	180	129.7	143.3	245	uncomp EC (lab)	1995	-13.6
JE22C	Serpentine GWA	14/04/2004	392520	6434584	483	503		285.9	806.9	1380	uncomp EC (lab)	1998	-520.9
JM12	Jandakot GWA	5/04/2004	391437	6447453	389	386		230.3	181.8	311	uncomp EC (lab)	1992	48.5
JM16	Perth GWA	5/04/2004	398446	6446981	276	284		163.4	193.0	330	EC comp 25deg lab	1993	-29.6
JM19	Jandakot GWA	5/04/2004	394501	6445398	234	243		138.5	118.1	202	uncomp EC (lab)	1993	20.4
JM22	Perth metro	30/06/2005	397523	6444745	281			166.4	101.7	174	uncomp EC (lab)	1992	64.6
JM5	Perth GWA	16/04/2004	397495	6450610	729	230		431.6	352.6	603	uncomp EC (lab)	1987	79.0
JM51	Jandakot GWA	20/04/2004	392062	6444181	258	307		152.7	161.4	276	uncomp EC (lab)	1993	-8.6
JM7	Perth metro	29/06/2005	393538	6448869	271			160.4	99.4	170	uncomp EC (lab)	1993	61.0
JP 14	Perth metro	12/09/2005	374514	6501009	768	750	420	454.7	433.8	742	uncomp EC (lab)	1991	20.8
JP 18C	Gnangara GWA	6/06/2003	383530	6490265	825	830	440	488.4	616.3	1054	uncomp EC (lab)	1989	-127.9
JP13 (I)	Wanneroo GWA	9/03/2004	384852	6496529	855	852		506.2	432.0	432	TDS calc@180-HCO_3	1983	74.2
JP3	Perth GWA	9/03/2004	380402	6493063	679	283		402.0	589.4	1008	uncomp EC (lab)	1989	-187.4
L10C	Perth metro	1/05/2007	398712	6485744	238	290	190	182.9	145.0	145	TDS calc@180-HCO_3	1985	37.9
L160C	Swan GWA	18/03/2004	404682	6487726	438	439		259.3	168.0	168	TDS calc@180-HCO_3	1985	91.3
L240C	Swan GWA	18/03/2004	402329	6490024	267	274		158.1	94.0	165	uncomp EC (in situ)	2000	64.1
L50C	Gnangara GWA	21/07/2003	402141	6485086	218	240	150	129.1	119.0	119	TDS calc@180-HCO_3	1985	10.1
LB5	Cockburn GWA	16/04/2004	389703	6440329	592	672		350.5	339.1	580	uncomp EC (lab)	1994	11.4
MM 31	Perth metro	22/06/2005	397809	6476605	766			453.5	132.7	227	uncomp EC (lab)	1992	320.8
MM 45	Perth metro	22/06/2005	402194	6473890	763			451.7	492.9	843	uncomp EC (lab)	2000	-41.2

Site	Location	Date sampled	Easting	Northing	Cond field μS/cm	Cond @25 C lab μS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
MM10	Gnangara GWA	11/06/2003	395565	6482635	333	320	180	197.1	326.8	559	uncomp EC (lab)	1991	-129.7
MM14	Gnangara GWA	6/06/2003	389482	6480567	1083	960	570	641.2	340.0	340	TDS calc@180-HCO$_3$	1990	301.2
MM16	Gnangara GWA	12/06/2003	393375	6480637	1207	1800	650	714.6	150.3	257	uncomp EC (lab)	1992	564.3
MM18	Gnangara GWA	11/06/2003	397441	6480676	422	390	210	249.8	279.5	478	uncomp EC (lab)	1992	-29.7
MM49B	Gnangara GWA	21/07/2003	400673	6477569	616	700	430	364.7	480.6	822	uncomp EC (lab)	1992	-115.9
MM53	Gnangara GWA	12/06/2003	398804	6478901	556	700	340	329.2	356.7	610	uncomp EC (lab)	1992	-27.5
MS 14	Gnangara GWA	4/06/2003	388398	6488361	1156	1100	610	684.4	557.2	953	uncomp EC (lab)	1991	127.2
MS7	Gnangara GWA	9/06/2003	386708	6489554	2323	2000	1300	1375.3	1333.1	2280	uncomp EC (lab)	1991	42.2
NR1C	Gnangara GWA	23/06/2003	395073	6501314	319	410	300	188.9	110.0	110	TDS calc@180-HCO$_3$	1980	78.9
NR2C	Swan GWA	18/03/2004	399619	6498229	464	485		274.7	268.3	471	uncomp EC (in situ)	2000	6.4
NR6C	Perth metro	1/05/2007	398956	6490825	183	210	100	108.5	104.1	178	uncomp EC (lab)	1991	4.4
PM 26	Gnangara GWA	15/07/2003	380374	6510185	275	310	180	162.8	200.0	200	TDS calc@180-HCO$_3$	1987	-37.2
PM 33	Gnangara GWA	15/07/2003	381032	6498436	610	720	410	361.1	370.0	370	TDS calc@180-HCO$_3$	1990	-8.9
PM12	Gnangara GWA	16/06/2003	390406	6499451	298	270	230	176.4	184.0	184	TDS calc@180-HCO$_3$	1986	-7.6
PM16	Perth metro	28/07/2005	386149	6509166	452	410	250	303.1	196.5	336	uncomp EC (lab)	1987	106.7
PM18	Gnangara GWA	24/06/2003	386150	6506157	337	280	160	199.5	119.0	119	TDS calc@180-HCO$_3$	1986	80.5
PM19	Gnangara GWA	24/06/2003	383894	6505497	294	250	150	174.1	204.6	350	Cond calc 25deg C	1981	-30.6
PM3	Gnangara GWA	24/06/2003	393260	6509295	1222	1000	630	723.5	501.1	857	uncomp EC (lab)	1986	222.4
PM5	Perth metro	8/06/2005	393390	6506467	270			159.8	181.3	310	uncomp EC (lab)	1986	-21.4
PM6	Perth metro	8/06/2005	389194	6504700	250			169.9	157.9	270	uncomp EC (lab)	2000	12.0
PM7	Perth metro	4/05/2007	391980	6503669	329	320	200	194.8	174.8	299	uncomp EC (lab)	1987	20.0
PM8	Perth metro	8/06/2005	395224	6503644	193			114.3	116.4	199	uncomp EC (lab)	1987	-2.1
PP4 Shallow	Perth metro	4/05/2007	388982	6493797	226	230	190	133.8	89.4	157	uncomp EC (in situ)	2000	44.4
T 500	Perth metro	13/09/2005	392021	6413959	858	870	610	508.0	216.9	371	uncomp EC (lab)	1992	291.0
T120 (O)	Perth GWA	14/04/2004	403669	6439124	1570			929.5	1777.5	3040	uncomp EC (lab)	1991	-848.0
T130 (I)	Perth metro	15/07/2005	387464	6435175	856	900	460	506.8	500.0	500	TDS calc@180-HCO$_3$	1974	6.8

Site	Location	Date sampled	Easting	Northing	Cond field µS/cm	Cond @25 C lab µS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
T140 (O)	Jandakot GWA	7/04/2004	390984	6435919	683	607		404.4	631.5	1080	Cond calc 25deg C	1993	-227.1
T150 (O)	Jandakot GWA	14/04/2004	395255	6435695	153			90.6	520.0	520	TDS calc@180-HCO_3	1981	-429.4
T200 (O)	Perth metro	20/07/2005	393823	6432664	562	610	410	332.7	504.0	504	TDS calc@180-HCO_3	1983	-171.3
T220	Serpentine GWA	14/04/2004	401711	6432975	343	211		203.1	459.0	785	uncomp EC (lab)	1991	-255.9
T260 (O)	Perth metro	19/07/2005	397035	6429527	321	350	210	190.0	207.0	354	uncomp EC (lab)	1991	-16.9
T340 (O)	Perth metro	15/07/2005	387543	6422648	1192	1200	660	705.7	1630.0	1630	TDS calc@180-HCO_3	1986	-924.3
T370	Perth metro	7/07/2005	400016	6423228	618	660	380	365.9	1040.8	1780	Cond calc 25deg C	1993	-674.9
T420	Perth metro	7/07/2005	399407	6420367	968	940	540	573.1	964.8	1650	uncomp EC (lab)	1987	-391.7
T430I	Perth metro	6/07/2005	385744	6416765	2120	2200	1400	1255.1	797.5	1364	uncomp EC (lab)	1992	457.6
T530	Perth metro	5/07/2005	384378	6410840	2140	2100	1200	1266.9	1151.9	1970	Cond calc 25deg C	1993	115.1
T540	Perth metro	5/07/2005	387794	6410863	179	200	150	106.0	124.0	212	uncomp EC (lab)	1992	-18.0
T570	Perth metro	4/07/2005	400327	6410250	210	180	120	124.3	164.9	282	Cond calc 25deg C	1993	-40.6
T580 not 560	Perth metro	6/07/2005	386090	6407231	196	180	110	116.0	104.7	179	uncomp EC (lab)	1992	11.4
T600	Perth metro	4/07/2005	394371	6407100	474	490	300	280.6	230.0	230	TDS calc@180-HCO_3	1981	50.6
T670	Perth metro	4/07/2005	399280	6403793	1194	1200	680	706.9	1122.6	1920	uncomp EC (lab)	1993	-415.7
T8S (T85)	Lake Thomson	25/07/2005	402225	6445829	1203	1300	680	712.2	806.9	1380	uncomp EC (lab)	1991	-94.7
TM4C	Cockburn GWA	6/04/2004	388874	6442978	637	816		377.1	445.0	761	uncomp EC (lab)	1990	-67.8
TM7C	Perth metro	25/07/2005	388185	6442303	2380	2500	1300	1409.0	684.7	1171	uncomp EC (lab)	1990	724.3
WF 12	Perth metro	10/08/2005	383335	6480752	1115	1100	640	660.1	541.1	950	uncomp EC (in situ)	1994	119.0
WH 100	Perth metro	10/08/2005	384683	6483681	1432	1400	760	847.8	859.5	1470	uncomp EC (lab)	1991	-11.7
WH100	Perth GWA	9/03/2004	384683	6483681	1395	1359		847.8	859.5	1470	uncomp EC (lab)	1991	-11.7
WM1	Gnangara GWA	16/06/2003	391720	6497310	815	740	500	482.5	262.0	262	TDS calc@180-HCO_3	1986	220.5
WM24	Gnangara GWA	9/06/2003	393900	6486435	188	170	140	111.3	141.5	242	uncomp EC (lab)	1986	-30.2
WM29	Gnangara GWA	11/06/2003	390784	6483010	780	620	320	461.8	288.3	493	uncomp EC (lab)	1986	173.5
WM3	Gnangara GWA	16/06/2003	392040	6495180	330	300	210	195.4	440.0	440	TDS calc@180-HCO_3	1986	-244.6

Site	Location	Date sampled	Easting	Northing	Cond field µS/cm	Cond @25 C lab µS/cm	TDS lab mg/L	TDS predicted	TDS converted from historical data	Salinity historical	Salinity units[1]	Salinity date measured	TDS differences mg/L
WM32	Gnangara GWA	21/07/2003	397740	6489120	295	330	210	174.6	159.0	159	TDS calc@180-HCO_3	1986	15.6
WM4	Gnangara GWA	16/06/2003	385677	6493509	260	240	140	153.9	159.6	273	uncomp EC (lab)	1990	-5.7
WM5	Gnangara GWA	16/06/2003	391180	6493647	323	310	200	191.2	239.1	409	uncomp EC (lab)	1991	-47.9
YB 11	Gnangara GWA	26/07/2003	373660	6507500	481	540	310	284.8	244.9	430	uncomp EC (in situ)	1975	39.8
YN 2	Gnangara GWA	26/07/2003	376775	6509817	375	430	240	222.0	321.6	550	uncomp EC (lab)	1994	-99.6
YN 3	Gnangara GWA	26/07/2003	375661	6509538	320	360	180	189.4	198.2	339	uncomp EC (lab)	1994	-8.8
YN 5	Gnangara GWA	26/07/2003	375051	6509297	1480	1700	980	731.7	352.6	603	uncomp EC (lab)	1994	379.2
YN 6	Gnangara GWA	26/07/2003	376168	6508048	470	540	300	278.3	326.3	558	uncomp EC (lab)	1994	-48.0
YN 7	Gnangara GWA	26/07/2003	375239	6508032	566	650	370	335.1	290.0	496	uncomp EC (lab)	1994	45.1
YY3(I)	Perth metro	28/07/2005	374947	6516911	541	560	300	320.3	87.7	150	uncomp EC (lab)	1980	232.6

Appendix H – Superficial aquifer – chemical analysis results from AquaChem software

Sample ID and date	**SiO_2 mmol/L**	**HCO_3-/SiO_2**		**SiO2/(Na+K-Cl)**		**(Na+K-Cl)/(Na+K-Cl+Ca)**		**(Na/(Na+Cl)**		**Mg/(Ca+Mg) Second figure is HCO_3/Si**		**Ca/(Ca+SO_4) Second figure is pH**		**HCO_3/sum anions**		**SI Calcite**	
*1/98, 9/06/2005	0.10	3.97	Silicate weathering	-1.49	Cation exchange	-0.19	Plagioklase weathering unlikely	0.48	Analysis error	0.422 3.97	Ferromagnesian Minerals	0.657 6.17	Calcium source other than gypsum – carbonate or silicates	0.24	Seawater or brine	-2.89	Undersaturated with respect to calcite
144B, 28/06/2005	0.08	75.43	Carbonate weathering	-0.25	Cation exchange	-0.07	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.232 75.42	Limestone-dolomite weathering	0.755 7.40	Calcium source other than gypsum – carbonate or silicates	0.40	Seawater or brine	0.34	Oversaturated with respect to calcite
2025A, 28/06/2005	0.07	3.60	Silicate weathering	0.43	Cation exchange	0.15	Plagioklase weathering unlikely	0.50	Halite solution	0.544 3.60	Granitic weathering	0.308 5.87		0.04	Seawater or brine	-3.24	Undersaturated with respect to calcite
2069, 21/07/2005	0.04	5.68	Ambiguous	-0.73	Cation exchange	-0.09	Plagioklase weathering unlikely	0.48	Analysis error	0.220 5.68	Ambiguous	0.664 6.10	Calcium source other than gypsum – carbonate or silicates	0.17	Seawater or brine	-3.00	Undersaturated with respect to calcite
2288, 28/06/2005	0.06	12.96	Carbonate weathering	0.38	Cation exchange	0.16	Plagioklase weathering unlikely	0.52	Na source other than halite – albite, ion exchange	0.348 12.96	Limestone-dolomite weathering	0.531 6.64	Gypsum dissolution	0.28	Seawater or brine	-1.88	Undersaturated with respect to calcite
3578A, 27/06/2005	0.02	106.53	Carbonate weathering	0.10	Cation exchange	0.05	Plagioklase weathering unlikely	0.50	Halite solution	0.263 106.53	Limestone-dolomite weathering	0.596 6.84	Calcium source other than gypsum – carbonate or silicates	0.16	Seawater or brine	-0.82	Undersaturated with respect to calcite
459, 20/06/2005	0.27	19.69	Carbonate weathering	-0.27	Cation exchange	-0.19	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.112 19.69	Limestone-dolomite weathering	0.723 7.76	Calcium source other than gypsum – carbonate or silicates	0.40	Seawater or brine	0.67	Oversaturated with respect to calcite
649, 22/06/2005	0.10	7.64	Ambiguous	2.82	Ferromagnesian Minerals	0.05	Plagioklase weathering unlikely	0.50	Halite solution	0.456 7.64	Ambiguous	0.739 6.93	Calcium source other than gypsum – carbonate or silicates	0.40	Seawater or brine	-1.75	Undersaturated with respect to calcite
8259A, 30/04/2007	0.12	5.63	Ambiguous	-5.25	Cation exchange	-0.08	Plagioklase weathering	0.49	Analysis error	0.577 5.63	Ambiguous	0.607 5.59	Calcium source other than gypsum – carbonate or	0.38	Seawater or brine	-3.46	Undersaturated with respect to

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
							unlikely						silicates				calcite
8281, 20/06/2005	0.12	13.56	Carbonate weathering	-3.52	Cation exchange	-0.01	Plagioklase weathering unlikely	0.49	Analysis error	0.153 13.56	Limestone-dolomite weathering	0.616 7.25	Calcium source other than gypsum – carbonate or silicates	0.35	Seawater or brine	-0.59	Undersaturated with respect to calcite
8282, 19/07/2005	0.20	21.34	Carbonate weathering	0.63	Cation exchange	0.07	Plagioklase weathering unlikely	0.60	Na source other than halite – albite, ion exchange	0.100 21.34	Limestone-dolomite weathering	0.842 8.30	Calcium source other than gypsum – carbonate or silicates	0.80	Seawater or brine	1.07	Oversaturated with respect to calcite
8283, 21/07/2005	0.27	17.23	Carbonate weathering	0.44	Cation exchange	0.13	Plagioklase weathering unlikely	0.54	Na source other than halite – albite, ion exchange	0.098 17.23	Limestone-dolomite weathering	0.912 8.30	Calcium source other than gypsum – carbonate or silicates	0.58	Seawater or brine	1.04	Oversaturated with respect to calcite
8386, 12/09/2005	0.10	1.34	Silicate weathering	-0.28	Cation exchange	1.53	Plagioklase weathering unlikely	0.45	Analysis error	0.815 1.34	Granitic weathering	0.200 5.30	Pyrite oxidation	0.05	Seawater or brine	-4.87	Undersaturated with respect to calcite
B270, 26/07/2005	0.10	26.26	Carbonate weathering	-2.56	Cation exchange	-0.01	Plagioklase weathering unlikely	0.49	Halite solution	0.144 26.26	Limestone-dolomite weathering	0.930 7.40	Calcium source other than gypsum – carbonate or silicates	0.43	Seawater or brine	-0.14	Undersaturated with respect to calcite
Bibra Lake 425, 17/05/2005	0.02	152.18	Carbonate weathering	-1.52	Cation exchange	0.00	Plagioklase weathering unlikely	0.49	Halite solution	0.465 152.18	Limestone-dolomite weathering	0.489 8.20	Gypsum dissolution	0.18	Seawater or brine	0.62	Oversaturated with respect to calcite
CSG6, 15/07/2005	0.05	108.00	Carbonate weathering	0.03	Cation exchange	0.32	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.574 108.00	Dolomite dissolution, calcite precipitation or seawater	0.430 8.00		0.22	Seawater or brine	0.70	Oversaturated with respect to calcite
CSI-3/97, 7/04/2004	0.06	50.89	Carbonate weathering	-0.05	Cation exchange	-0.32	Plagioklase weathering unlikely	0.45	Reverse softening, seawater	0.236 50.89	Limestone-dolomite weathering	0.759 7.25	Calcium source other than gypsum – carbonate or silicates	0.26	Seawater or brine	-0.06	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
CW1, 23/06/2003	0.17	0.49	Silicate weathering	-2.31	Cation exchange	1.71	Plagioklase weathering unlikely	0.48	Analysis error	0.877 0.49	Granitic weathering	0.418 4.90	Pyrite oxidation	0.05	Seawater or brine	-6.00	Undersaturated with respect to calcite
E 1-89, 5/07/2005	0.08	29.97	Carbonate weathering	0.23	Cation exchange	0.19	Plagioklase weathering unlikely	0.57	Na source other than halite – albite, ion exchange	0.492 29.97	Dolomite weathering	0.713 6.99	Calcium source other than gypsum – carbonate or silicates	0.61	Seawater or brine	-0.89	Undersaturated with respect to calcite
FL1, 30/06/2005	0.04	22.38	Carbonate weathering	0.06	Cation exchange	0.42	Plagioklase weathering possible	0.54	Na source other than halite – albite, ion exchange	0.394 22.38	Limestone-dolomite weathering	0.545 6.73	Gypsum dissolution	0.20	Seawater or brine	-1.91	Undersaturated with respect to calcite
GA 10, 15/07/2003	0.55	0.15	Silicate weathering	347.24	Ferromagnesian Minerals	0.00	Plagioklase weathering unlikely	0.49	Halite solution	0.675 0.15	Granitic weathering	0.243 3.60	Pyrite oxidation	0.02	Seawater or brine	-5.19	Undersaturated with respect to calcite
GA 14, 15/07/2003	0.16	2.10	Silicate weathering	836.47	Ferromagnesian Minerals	0.00	Plagioklase weathering unlikely	0.49	Halite solution	0.822 2.10	Granitic weathering	0.247 5.70		0.13	Seawater or brine	-4.06	Undersaturated with respect to calcite
GA 15, 15/07/2003	0.22	0.38	Silicate weathering	2.92	Ferromagnesian Minerals	0.36	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.840 0.38	Granitic weathering	0.293 5.50		0.05	Seawater or brine	-4.83	Undersaturated with respect to calcite
GA 4, 15/07/2003	0.17	1.48	Silicate weathering	-0.46	Cation exchange	2.12	Plagioklase weathering unlikely	0.45	Analysis error	0.747 1.48	Granitic weathering	0.603 5.80	Calcium source other than gypsum – carbonate or silicates	0.10	Seawater or brine	-3.90	Undersaturated with respect to calcite
GA 5, 15/07/2003	0.16	1.52	Silicate weathering	-1.00	Cation exchange	-5.83	Plagioklase weathering unlikely	0.47	Analysis error	0.732 1.52	Granitic weathering	0.336 5.70		0.10	Seawater or brine	-4.02	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
GA 8, 15/07/2003	0.17	8.86	Ambiguous	-2.40	Cation exchange	-0.07	Plagioklase weathering unlikely	0.49	Analysis error	0.452 8.86	Ambiguous	0.756 6.00	Calcium source other than gypsum – carbonate or silicates	0.31	Seawater or brine	-2.22	Undersaturated with respect to calcite
GA 9, 15/07/2003	0.25	0.66	Silicate weathering	1.48	Albite weathering	0.24	Plagioklase weathering possible	0.51	Halite solution	0.775 0.66	Granitic weathering	0.180 5.50		0.04	Seawater or brine	-4.03	Undersaturated with respect to calcite
GA1, 17/07/2003	0.20	15.59	Carbonate weathering	-0.62	Cation exchange	-0.10	Plagioklase weathering unlikely	0.46	Analysis error	0.149 15.59	Limestone-dolomite weathering	0.943 7.70	Calcium source other than gypsum – carbonate or silicates	0.51	Seawater or brine	0.28	Oversaturated with respect to calcite
GA11, 27/07/2005	0.14	26.42	Carbonate weathering	-0.27	Cation exchange	-0.13	Plagioklase weathering unlikely	0.45	Analysis error	0.103 26.42	Limestone-dolomite weathering	0.963 7.80	Calcium source other than gypsum – carbonate or silicates	0.55	Seawater or brine	0.53	Oversaturated with respect to calcite
GA12, 17/07/2003	0.20	10.67	Carbonate weathering	-0.31	Cation exchange	-0.48	Plagioklase weathering unlikely	0.43	Analysis error	0.214 10.67	Limestone-dolomite weathering	0.897 6.90	Calcium source other than gypsum – carbonate or silicates	0.42	Seawater or brine	-0.89	Undersaturated with respect to calcite
GA13, 17/07/2003	0.17	8.95	Ambiguous	-0.51	Cation exchange	-0.37	Plagioklase weathering unlikely	0.45	Analysis error	0.285 8.95	Ambiguous	0.852 6.80	Calcium source other than gypsum – carbonate or silicates	0.41	Seawater or brine	-1.35	Undersaturated with respect to calcite
GA17, 27/07/2005	0.13	11.51	Carbonate weathering	-0.22	Cation exchange	-0.48	Plagioklase weathering unlikely	0.44	Analysis error	0.227 11.51	Limestone-dolomite weathering	0.878 6.90	Calcium source other than gypsum – carbonate or silicates	0.34	Seawater or brine	-1.06	Undersaturated with respect to calcite
GA18, 17/07/2003	0.23	1.41	Silicate weathering	-0.36	Cation exchange	2.27	Plagioklase weathering unlikely	0.42	Analysis error	0.602 1.41	Granitic weathering	0.552 5.80	Calcium source other than gypsum – carbonate or silicates	0.11	Seawater or brine	-3.52	Undersaturated with respect to calcite
GA22, 27/07/2005	0.11	10.94	Carbonate weathering	0.22	Cation exchange	0.32	Plagioklase weathering possible	0.59	Na source other than halite –ion exchange	0.385 10.94	Limestone-dolomite weathering	0.489 6.90	Gypsum dissolution	0.41	Seawater or brine	-1.41	Undersaturated with respect to calcite
GA25, 3/05/2004	0.06	62.03	Carbonate weathering	0.31	Cation exchange	0.05	Plagioklase weathering unlikely	0.51	Halite solution	0.237 62.03	Limestone-dolomite weathering	0.938 7.00	Calcium source other than gypsum – carbonate or silicates	0.52	Seawater or brine	-0.33	Undersaturated with respect to calcite

Sample ID and date	**SiO_2 mmol/L**	**HCO_3-/SiO_2**		**SiO2/(Na+K-Cl)**		**(Na+K-Cl)/(Na+K-Cl+Ca)**		**(Na/(Na+Cl)**		**Mg/(Ca+Mg) Second figure is HCO_3/Si**		**Ca/(Ca+SO_4) Second figure is pH**		**HCO_3/sum anions**		**SI Calcite**	
GA26, 3/05/2004	0.07	12.55	Carbonate weathering	-0.19	Cation exchange	-2.43	Plagioklase weathering unlikely	0.47	Analysis error	0.651 12.55	Dolomite dissolution, calcite precipitation or seawater	0.659 6.35	Calcium source other than gypsum – carbonate or silicates	0.18	Seawater or brine	-2.39	Undersaturated with respect to calcite
GA28, 26/07/2005	0.13	31.51	Carbonate weathering	1.58	Albite weathering	0.03	Plagioklase weathering unlikely	0.50	Halite solution	0.232 31.51	Limestone-dolomite weathering	0.923 7.70	Calcium source other than gypsum – carbonate or silicates	0.56	Seawater or brine	0.34	Oversaturated with respect to calcite
GA33, 27/07/2005	0.13	29.80	Carbonate weathering	-0.30	Cation exchange	-0.15	Plagioclase weathering unlikely	0.46	Analysis error	0.202 29.80	Limestone-dolomite weathering	0.940 7.80	Calcium source other than gypsum – carbonate or silicates	0.53	Seawater or brine	0.44	Oversaturated with respect to calcite
GB15, 17/07/2003	0.35	0.01	Silicate weathering	-0.14	Cation exchange	1.32	Plagioklase weathering unlikely	0.41	Reverse softening, seawater	0.885 0.00	Granitic weathering	0.174 5.80		0.00	Seawater or brine	-5.43	Undersaturated with respect to calcite
GB21, 6/07/2005	0.10	4.38	Silicate weathering	-1.84	Cation exchange	-1.16	Plagioklase weathering unlikely	0.49	Analysis error	0.830 4.38	Granitic weathering	0.359 5.96		0.18	Seawater or brine	-3.74	Undersaturated with respect to calcite
GB23, 27/07/2005	0.08	0.02	Silicate weathering	-2.01	Cation exchange	-0.55	Plagioklase weathering unlikely	0.49	Analysis error	0.864 0.02	Granitic weathering	0.136 5.50		0.00	Seawater or brine	-6.16	Undersaturated with respect to calcite
GC 11, 21/07/2003	0.10	1.70	Silicate weathering	0.74	Cation exchange	0.54	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.799 1.70	Granitic weathering	0.145 6.20		0.09	Seawater or brine	-3.93	Undersaturated with respect to calcite
GC 19, 15/07/2003	0.13	1.97	Silicate weathering	-0.60	Cation exchange	1.91	Plagioklase weathering unlikely	0.47	Analysis error	0.832 1.97	Granitic weathering	0.347 5.70		0.10	Seawater or brine	-4.30	Undersaturated with respect to calcite
GC17, 6/08/2005	0.11	1.45	Silicate weathering	3.31	Ferromagnesian Minerals	0.23	Plagioklase weathering possible	0.50	Halite solution	0.782 1.45	Granitic weathering	0.208 5.97		0.13	Seawater or brine	-4.06	Undersaturated with respect to calcite
GC4, 6/07/2005	0.13	0.51	Silicate weathering	-0.09	Cation exchange	1.85	Plagioklase weathering unlikely	0.44	Reverse softening, seawater	0.707 0.50	Granitic weathering	0.375 6.26		0.01	Seawater or brine	-3.55	Undersaturated with respect to calcite

Sample ID and date	SiO$_2$ mmol/L	HCO$_3$-/SiO$_2$		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO$_3$/Si		Ca/(Ca+SO$_4$) Second figure is pH		HCO$_3$/sum anions		SI Calcite	
GD 11, 20/06/2005	0.11	1.45	Silicate weathering	0.57	Cation exchange	0.05	Plagioklase weathering unlikely	0.51	Halite solution	0.292 1.45	Ferromagnesian Minerals	0.352 5.82		0.02	Seawater or brine	-2.89	Undersaturated with respect to calcite
GD 12, 21/06/2005	0.02	59.79	Carbonate weathering	1.67	Albite weathering	0.01	Plagioklase weathering unlikely	0.49	Halite solution	0.685 59.79	Dolomite dissolution, calcite precipitation or seawater	0.322 6.77	Calcium removal – ion exchange or calcite precipitation	0.13	Seawater or brine	-1.60	Undersaturated with respect to calcite
GD 2, 6/06/2003	0.27	6.15	Ambiguous	-1.08	Cation exchange	-0.10	Plagioklase weathering unlikely	0.47	Analysis error	0.241 6.15	Ambiguous	0.554 7.20	Calcium source other than gypsum – carbonate or silicates	0.28	Seawater or brine	-0.61	Undersaturated with respect to calcite
GD23, 27/06/2005	0.13	17.45	Carbonate weathering	-0.18	Cation exchange	-0.31	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.271 17.45	Limestone-dolomite weathering	0.664 7.35	Calcium source other than gypsum – carbonate or silicates	0.26	Seawater or brine	-0.28	Undersaturated with respect to calcite
GD5, 27/06/2005	0.14	29.77	Carbonate weathering	-0.12	Cation exchange	-0.23	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.522 29.77	Dolomite dissolution, calcite precipitation or seawater	0.414 7.25	Calcium removal – ion exchange or calcite precipitation	0.13	Seawater or brine	0.01	Saturated with respect to calcite
GD8, 25/03/2004	0.17	7.80	Ambiguous	0.13	Cation exchange	0.54	Plagioklase weathering possible	0.56	Na source other than halite – albite, ion exchange	0.512 7.80	Ambiguous	0.409 7.33	Calcium removal – ion exchange or calcite precipitation	0.21	Seawater or brine	-0.94	Undersaturated with respect to calcite
GE 2, 13/09/2005	0.09	50.99	Carbonate weathering	-0.26	Cation exchange	-0.08	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.224 50.99	Limestone-dolomite weathering	0.781 7.80	Calcium source other than gypsum – carbonate or silicates	0.37	Seawater or brine	0.64	Oversaturated with respect to calcite
GE3, 27/06/2005	0.12	35.07	Carbonate weathering	0.28	Cation exchange	0.09	Plagioklase weathering unlikely	0.52	Na source other than halite – albite, ion exchange	0.198 35.07	Limestone-dolomite weathering	0.762 7.39	Calcium source other than gypsum – carbonate or silicates	0.49	Seawater or brine	0.18	Oversaturated with respect to calcite
GG3 (O), 21/07/2003	0.08	2.05	Silicate weathering	-9.50	Cation exchange	-0.08	Plagioklase weathering unlikely	0.49	Halite solution	0.712 2.05	Granitic weathering	0.264 5.70		0.11	Seawater or brine	-4.36	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
GM 16, 22/06/2005	0.10	29.37	Carbonate weathering	-0.55	Cation exchange	-0.05	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.203 29.37	Limestone-dolomite weathering	0.691 7.29	Calcium source other than gypsum – carbonate or silicates	0.37	Seawater or brine	-0.19	Undersaturated with respect to calcite
GM 2, 6/06/2003	0.37	9.40	Ambiguous	-0.81	Cation exchange	-0.14	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.164 9.40	Ambiguous	0.788 7.90	Calcium source other than gypsum – carbonate or silicates	0.44	Seawater or brine	0.52	Oversaturated with respect to calcite
GM 7, 6/06/2003	0.23	11.96	Carbonate weathering	-2.34	Cation exchange	-0.04	Plagioklase weathering unlikely	0.49	Analysis error	0.224 11.96	Limestone-dolomite weathering	0.744 7.70	Calcium source other than gypsum – carbonate or silicates	0.44	Seawater or brine	0.14	Oversaturated with respect to calcite
GM 9, 22/06/2005	0.15	18.40	Carbonate weathering	0.30	Cation exchange	0.14	Plagioklase weathering unlikely	0.54	Na source other than halite – albite, ion exchange	0.257 18.40	Limestone-dolomite weathering	0.602 6.95	Calcium source other than gypsum – carbonate or silicates	0.42	Seawater or brine	-0.58	Undersaturated with respect to calcite
GM26, 27/06/2005	0.07	52.84	Carbonate weathering	0.11	Cation exchange	0.20	Plagioklase weathering possible	0.54	Na source other than halite – albite, ion exchange	0.248 52.84	Limestone-dolomite weathering	0.779 6.64	Calcium source other than gypsum – carbonate or silicates	0.49	Seawater or brine	-0.83	Undersaturated with respect to calcite
GN 13, 5/06/2003	0.00	147.71	Carbonate weathering	0.01	Cation exchange	0.54	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.273 147.71	Limestone-dolomite weathering	0.841 6.30	Calcium source other than gypsum – carbonate or silicates	0.20	Seawater or brine	-3.60	Undersaturated with respect to calcite
GN23, 16/06/2003	0.23	1.41	Silicate weathering	-0.51	Cation exchange	1.31	Plagioklase weathering unlikely	0.45	Analysis error	0.832 1.41	Granitic weathering	0.841 6.96	Calcium source other than gypsum – carbonate or silicates	0.11	Seawater or brine	-2.87	Undersaturated with respect to calcite
Gnangara Lake 8386, 24/05/2005	0.25	n/a		-0.33	Cation exchange	-0.46	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	n/a		0.359 3.50	Pyrite oxidation	n/a		n/a	
GNM11A, 6/07/2005	0.20	0.03	Silicate weathering	1.15	Albite weathering	0.14	Plagioklase weathering unlikely	0.51	Na source other than halite – albite, ion	0.622 0.03	Granitic weathering	0.239 5.77		0.00	Seawater or brine	-4.62	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
									exchange								
GNM5, 16/06/2003	0.18	1.34	Silicate weathering	7.50	Ferromagnesian Minerals	0.08	Plagioklase weathering unlikely	0.50	Halite solution	0.750 1.34	Granitic weathering	0.216 5.70		0.12	Seawater or brine	-3.87	Undersaturated with respect to calcite
Herdsman Lake 619, 24/05/2005	0.18	19.69	Carbonate weathering	-3.43	Cation exchange	-0.02	Plagioklase weathering unlikely	0.49	Halite solution	0.397 19.69	Limestone-dolomite weathering	0.782 8.20	Calcium source other than gypsum – carbonate or silicates	0.48	Seawater or brine	0.61	Oversaturated with respect to calcite
IF16, 20/04/2004	0.05	166.96	Carbonate weathering	0.09	Cation exchange	0.08	Plagioklase weathering unlikely	0.54	Na source other than halite – albite, ion exchange	0.114 166.96	Limestone-dolomite weathering	0.948 6.85	Calcium source other than gypsum – carbonate or silicates	0.73	Seawater or brine	0.11	Oversaturated with respect to calcite
Jandabup Lake 1944, 24/05/2005	0.06	7.24	Ambiguous	-0.26	Cation exchange	-0.78	Plagioklase weathering unlikely	0.47	Analysis error	0.586 7.24	Ambiguous	0.363 7.20	Calcium removal – ion exchange or calcite precipitation	0.12	Seawater or brine	-1.93	Undersaturated with respect to calcite
JB 4, 8/02/2005	0.17	6.76	Ambiguous	-0.09	Cation exchange	1.92	Plagioklase weathering unlikely	0.44	Reverse softening, seawater	0.716 6.76	Ambiguous	0.425 6.40		0.11	Seawater or brine	-2.08	Undersaturated with respect to calcite
JB 9A, 4/06/2003	0.23	6.33	Ambiguous	-0.61	Cation exchange	-0.53	Plagioklase weathering unlikely	0.44	Analysis error	0.392 6.33	Ambiguous	0.981 7.10	Calcium source other than gypsum – carbonate or silicates	0.42	Seawater or brine	-1.10	Undersaturated with respect to calcite
JB 9C, 4/06/2003	0.17	1.48	Silicate weathering	-0.48	Cation exchange	1.41	Plagioklase weathering unlikely	0.44	Analysis error	0.819 1.48	Granitic weathering	0.705 5.90	Calcium source other than gypsum – carbonate or silicates	0.11	Seawater or brine	-4.07	Undersaturated with respect to calcite
JB5, 9/06/2003	0.14	1.22	Silicate weathering	-0.31	Cation exchange	5.80	Plagioklase weathering unlikely	0.43	Analysis error	0.733 1.22	Granitic weathering	0.301 6.10		0.07	Seawater or brine	-3.51	Undersaturated with respect to calcite
JE10C, 19/07/2005	0.15	9.10	Ambiguous	-0.26	Cation exchange	-0.77	Plagioklase weathering unlikely	0.38	Analysis error	0.374 9.10	Ambiguous	0.902 6.90	Calcium source other than gypsum – carbonate or silicates	0.46	Seawater or brine	-1.21	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
JE12A, 20/07/2005	0.08	40.19	Carbonate weathering	-0.81	Cation exchange	-0.03	Plagioklase weathering unlikely	0.48	Analysis error	0.143 40.19	Limestone-dolomite weathering	0.994 8.10	Calcium source other than gypsum – carbonate or silicates	0.62	Seawater or brine	0.68	Oversaturated with respect to calcite
JE12B, 20/07/2005	0.07	18.69	Carbonate weathering	0.03	Cation exchange	0.72	Plagioklase weathering possible	0.56	Na source other than halite – albite, ion exchange	0.036 18.69	Limestone-dolomite weathering	0.419 8.30		0.12	Seawater or brine	-0.05	Saturated with respect to calcite
JE12C, 7/04/2004	0.04	4.11	Silicate weathering	-0.19	Cation exchange	-0.52	Plagioklase weathering unlikely	0.46	Analysis error	0.425 4.11	Ferromagnesian Minerals	0.552 7.54	Calcium source other than gypsum – carbonate or silicates	0.09	Seawater or brine	-1.94	Undersaturated with respect to calcite
JE12C, 25/07/2005	0.07	4.48	Silicate weathering	0.96	Cation exchange	0.20	Plagioklase weathering possible	0.51	Na source other than halite – albite, ion exchange	0.697 4.48	Granitic weathering	0.335 6.10		0.19	Seawater or brine	-3.24	Undersaturated with respect to calcite
JE22C, 14/04/2004	0.20	10.67	Carbonate weathering	-0.32	Cation exchange	2.15	Plagioklase weathering unlikely	0.39	Analysis error	0.877 10.67	Dolomite dissolution, calcite precipitation or seawater	0.383 5.02	Pyrite oxidation	0.51	Seawater or brine	-3.52	Undersaturated with respect to calcite
JE4A, 30/06/2005	0.13	31.30	Carbonate weathering	0.71	Cation exchange	0.04	Plagioklase weathering unlikely	0.50	Halite solution	0.324 31.30	Limestone-dolomite weathering	0.964 7.94	Calcium source other than gypsum – carbonate or silicates	0.31	Seawater or brine	0.61	Oversaturated with respect to calcite
JE4C, 30/06/2005	0.10	4.17	Silicate weathering	-0.87	Cation exchange	-0.58	Plagioklase weathering unlikely	0.48	Analysis error	0.810 4.17	Granitic weathering	0.244 6.13		0.12	Seawater or brine	-3.19	Undersaturated with respect to calcite
JM12, 5/04/2004	0.04	16.37	Carbonate weathering	0.29	Cation exchange	0.28	Plagioklase weathering possible	0.51	Halite solution	0.699 16.37	Dolomite dissolution, calcite precipitation or seawater	0.343 6.26		0.21	Seawater or brine	-2.73	Undersaturated with respect to calcite
JM16, 5/04/2004	0.06	8.82	Ambiguous	0.32	Cation exchange	0.75	Plagioklase weathering possible	0.51	Na source other than halite –	0.884 8.82	Ambiguous	0.385 5.86		0.18	Seawater or brine	-4.09	Undersaturated with respect to calcite

Sample ID and date	SiO$_2$ mmol/L	HCO$_3$-/SiO$_2$		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO$_3$/Si		Ca/(Ca+SO$_4$) Second figure is pH		HCO$_3$/sum anions		SI Calcite	
									albite, ion exchange								
JM19, 5/04/2004	0.05	11.38	Carbonate weathering	-0.16	Cation exchange	1.05	Plagioklase weathering unlikely	0.45	Analysis error	0.984 11.38	Dolomite dissolution, calcite precipitation or seawater	0.228 6.30		0.23	Seawater or brine	-4.22	Undersaturated with respect to calcite
JM22, 30/06/2005	0.11	1.49	Silicate weathering	0.40	Cation exchange	0.76	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.879 1.49	Granitic weathering	0.092 5.84		0.07	Seawater or brine	-4.39	Undersaturated with respect to calcite
JM5, 29/06/2005	0.04	41.66	Carbonate weathering	-0.03	Cation exchange	-1.63	Plagioklase weathering unlikely	0.42	Reverse softening, seawater	0.446 41.66	Limestone-dolomite weathering	0.660 6.40	Calcium source other than gypsum – carbonate or silicates	0.24	Seawater or brine	-1.47	Undersaturated with respect to calcite
JM51, 20/04/2004	0.07	0.22	Silicate weathering	-1.26	Cation exchange	-4.67	Plagioklase weathering unlikely	0.49	Analysis error	0.883 0.22	Granitic weathering	0.183 5.58		0.01	Seawater or brine	-5.93	Undersaturated with respect to calcite
JM66C, 21/07/2005	0.05	5.77	Ambiguous	-1.29	Cation exchange	-0.23	Plagioklase weathering unlikely	0.48	Analysis error	0.549 5.77	Ambiguous	0.565 6.10	Calcium source other than gypsum – carbonate or silicates	0.25	Seawater or brine	-3.49	Undersaturated with respect to calcite
JM7, 29/06/2005	0.06	1.30	Silicate weathering	-0.20	Cation exchange	1.33	Plagioklase weathering unlikely	0.45	Analysis error	0.884 1.30	Granitic weathering	0.176 5.76		0.04	Seawater or brine	-4.77	Undersaturated with respect to calcite
JP 14, 9/12/2005	0.13	24.30	Carbonate weathering	-0.16	Cation exchange	-0.30	Plagioklase weathering unlikely	0.43	Analysis error	0.147 24.30	Limestone-dolomite weathering	0.948 7.70	Calcium source other than gypsum – carbonate or silicates	0.47	Seawater or brine	0.29	Oversaturated with respect to calcite
JP 18C, 6/06/2003	0.01	180.53	Carbonate weathering	0.00	Cation exchange	1.93	Plagioklase weathering unlikely	0.41	Analysis error	0.562 180.53	Dolomite dissolution, calcite precipitation or seawater	0.977 6.50	Calcium source other than gypsum – carbonate or silicates	0.12	Seawater or brine	-2.03	Undersaturated with respect to calcite
JP13 (I), 9/03/2004	0.01	91.18	Carbonate weathering	-0.05	Cation exchange	-0.60	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.502 91.18	Dolomite weathering	0.985 6.40	Calcium source other than gypsum – carbonate or	0.20	Seawater or brine	-2.48	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
													silicates				
JP15, 28/07/2005	0.16	19.39	Carbonate weathering	-0.35	Cation exchange	-0.20	Plagioklase weathering unlikely	0.47	Analysis error	0.229 19.39	Limestone-dolomite weathering	0.950 7.90	Calcium source other than gypsum – carbonate or silicates	0.40	Seawater or brine	0.37	Oversaturated with respect to calcite
JP3, 9/03/2004	0.02	166.90	Carbonate weathering	0.07	Cation exchange	0.09	Plagioklase weathering unlikely	0.51	Na source other than halite – albite, ion exchange	0.226 166.90	Limestone-dolomite weathering	0.963 7.97	Calcium source other than gypsum – carbonate or silicates	0.48	Seawater or brine	0.46	Oversaturated with respect to calcite
L10C, 11/06/2003	0.14	0.12	Silicate weathering	-0.31	Cation exchange	1.51	Plagioklase weathering unlikely	0.43	Analysis error	0.818 0.12	Granitic weathering	0.255 4.20	Pyrite oxidation	0.01	Seawater or brine	-6.10	Undersaturated with respect to calcite
L160C, 18/03/2004	0.09	15.24	Carbonate weathering	1.33	Albite weathering	0.10	Plagioklase weathering unlikely	0.50	Halite solution	0.612 15.24	Dolomite dissolution, calcite precipitation or seawater	0.678 6.37	Calcium source other than gypsum – carbonate or silicates	0.31	Seawater or brine	-2.14	Undersaturated with respect to calcite
L240C, 18/03/2004	0.01	68.16	Carbonate weathering	-0.07	Cation exchange	-0.28	Plagio weathering unlikely	0.48	Analysis error	0.145 68.16	Limestone-dolomite weathering	0.965 6.91	Calcium source other than gypsum – carbonate or silicates	0.21	Seawater or brine	-1.94	Undersaturated with respect to calcite
L50C, 21/07/2003	0.14	1.74	Silicate weathering	-1.02	Cation exchange	4.86	Plagioklase weathering unlikely	0.47	Analysis error	0.771 1.74	Granitic weathering	0.468 6.30	Gypsum dissolution	0.11	Seawater or brine	-3.63	Undersaturated with respect to calcite
Lake Forrestdale 602, 30/05/2005	0.12	6.15	Ambiguous	-0.20	Cation exchange	-0.02	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.207 6.15	Ambiguous	0.413 8.40		0.02	Gypsum dissolution	0.77	Oversaturated with respect to calcite
Lake Goollelal 459, 24/05/2005	0.15	8.49	Ambiguous	-0.85	Cation exchange	-0.08	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.457 8.49	Ambiguous	0.418 9.10		0.15	Seawater or brine	0.99	Oversaturated with respect to calcite
Lake Gwelup 465, 24/05/2005	0.05	20.06	Carbonate weathering	0.35	Cation exchange	0.05	Plagioklase weathering unlikely	0.60	Na source other than halite – albite, ion	0.087 20.06	Limestone-dolomite weathering	0.530 7.60	Gypsum dissolution	0.41	Seawater or brine	-0.51	Undersaturated with respect to calcite

Sample ID and date	**SiO_2 mmol/L**	**HCO_3-/SiO_2**		**SiO2/(Na+K-Cl)**		**(Na+K-Cl)/(Na+K-Cl+Ca)**		**(Na/(Na+Cl)**		**Mg/(Ca+Mg) Second figure is HCO_3/Si**		**Ca/(Ca+SO_4) Second figure is pH**		**HCO_3/sum anions**		**SI Calcite**	
									exchange								
Lake Joondalup 8281, 19/05/2005	0.09	26.51	Carbonate weathering	-1.11	Cation exchange	-0.03	Plagioklase weathering unlikely	0.49	Halite solution	0.425 26.51	Limestone-dolomite weathering	0.450 7.90		0.21	Seawater or brine	0.17	Oversaturated with respect to calcite
Lake Mariginiup 1943, 19/05/2005	0.23	0.01	Silicate weathering	0.47	Cation exchange	0.05	Plagioklase weathering unlikely	0.50	Halite solution	0.581 0.01	Granitic weathering	0.275 4.20	Pyrite oxidation	0.00	Gypsum dissolution	n/a	
Lake Monger, 24/05/2005	0.02	128.77	Carbonate weathering	-0.03	Cation exchange	-0.95	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.497 128.77	Dolomite weathering	0.636 8.30	Calcium source other than gypsum – carbonate or silicates	0.29	Seawater or brine	0.46	Oversaturated with respect to calcite
Lake Walyungup 1470, 17/05/2005	0.03	532.90	Carbonate weathering	0.00	Cation exchange	1.07	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.991 532.90	Dolomite dissolution, calcite precipitation or seawater	0.015 8.80		0.04	Gypsum dissolution	0.82	Oversaturated with respect to calcite
Lake Yonderup, 18/05/2005	0.12	10.94	Carbonate weathering	-0.28	Cation exchange	-0.25	Plagioklase weathering unlikely	0.46	Analysis error	0.212 10.94	Limestone-dolomite weathering	0.620 7.40	Calcium source other than gypsum – carbonate or silicates	0.26	Seawater or brine	-0.63	Undersaturated with respect to calcite
LB5, 16/04/2004	0.09	19.32	Carbonate weathering	0.07	Cation exchange	0.89	Plagioklase weathering unlikely	0.58	Na source other than halite – albite, ion exchange	0.878 19.32	Dolomite dissolution, calcite precipitation or seawater	0.147 5.16	Pyrite oxidation	0.31	Seawater or brine	-3.79	Undersaturated with respect to calcite
LN 2/89, 9/08/2005	0.16	2.23	Silicate weathering	-0.34	Cation exchange	-2.73	Plagioklase weathering unlikely	0.44	Analysis error	0.378 2.23	Ferromagnesian Minerals	0.518 6.00	Gypsum dissolution	0.11	Seawater or brine	-3.05	Undersaturated with respect to calcite
Loch McNess 8754, 18/05/2005	0.13	11.01	Carbonate weathering	-0.67	Cation exchange	-0.15	Plagioklase weathering unlikely	0.48	Analysis error	0.261 11.01	Limestone-dolomite weathering	0.853 7.90	Calcium source other than gypsum – carbonate or silicates	0.32	Seawater or brine	-0.25	Undersaturated with respect to calcite
LWIS 6/90 (SIM 6/90), 10/08/2005	0.18	14.32	Carbonate weathering	-0.30	Cation exchange	-0.31	Plagioklase weathering unlikely	0.44	Analysis error	0.182 14.32	Limestone-dolomite weathering	0.968 7.70	Calcium source other than gypsum – carbonate or	0.45	Seawater or brine	0.12	Oversaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
													silicates				
MM 31, 22/06/2005	0.10	2.59	Silicate weathering	0.43	Cation exchange	0.08	Plagioklase weathering unlikely	0.54	Na source other than halite – albite, ion exchange	0.655 2.59	Granitic weathering	0.261 6.03		0.05	Seawater or brine	-2.71	Undersaturated with respect to calcite
MM 45, 22/06/2005	0.23	11.25	Carbonate weathering	0.35	Cation exchange	0.31	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.497 11.25	Dolomite weathering	0.705 7.06	Calcium source other than gypsum – carbonate or silicates	0.37	Seawater or brine	-0.79	Undersaturated with respect to calcite
MM 52, 21/06/2005	0.20	13.13	Carbonate weathering	0.16	Cation exchange	0.47	Plagioklase weathering possible	0.60	Na source other than halite – albite, ion exchange	0.371 13.13	Limestone-dolomite weathering	0.745 6.98	Calcium source other than gypsum – carbonate or silicates	0.51	Seawater or brine	-0.87	Undersaturated with respect to calcite
MM10, 6/11/2003	0.27	0.06	Silicate weathering	-1.67	Cation exchange	-2.27	Plagioklase weathering unlikely	0.47	Analysis error	0.737 0.06	Granitic weathering	0.234 4.70	Pyrite oxidation	0.01	Seawater or brine	-5.76	Undersaturated with respect to calcite
MM12, 6/11/2003	0.17	1.48	Silicate weathering	-1.80	Cation exchange	-1.37	Plagioklase weathering unlikely	0.49	Analysis error	0.797 1.48	Granitic weathering	0.221 6.10		0.08	Seawater or brine	-3.71	Undersaturated with respect to calcite
MM14, 6/06/2003	0.15	6.15	Ambiguous	-1.29	Cation exchange	-0.04	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.397 6.15	Ambiguous	0.473 6.80	Gypsum dissolution	0.12	Seawater or brine	-1.30	Undersaturated with respect to calcite
MM16, 6/12/2003	0.25	1.64	Silicate weathering	-1.77	Cation exchange	-0.07	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.501 1.64		0.479 6.00	Gypsum dissolution	0.05	Seawater or brine	-2.57	Undersaturated with respect to calcite
MM18, 6/11/2003	0.20	0.08	Silicate weathering	-5.09	Cation exchange	-0.07	Plagioklase weathering unlikely	0.49	Analysis error	0.602 0.08	Granitic weathering	0.324 3.80	Pyrite oxidation	0.01	Seawater or brine	-5.58	Undersaturated with respect to calcite
MM28, 20/04/2004	0.05	1.47	Silicate weathering	0.92	Cation exchange	0.45	Plagioklase weathering possible	0.50	Halite solution	0.896 1.47	Granitic weathering	0.140 5.83		0.03	Seawater or brine	-4.86	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
MM49B, 21/07/2003	0.23	0.01	Silicate weathering	0.88	Cation exchange	0.39	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.851 0.01	Granitic weathering	0.118 4.40	Pyrite oxidation	0.00	Seawater or brine	-5.81	Undersaturated with respect to calcite
MM52, 24/03/2004	0.12	12.83	Carbonate weathering	0.06	Cation exchange	0.55	Plagioklase weathering possible	0.62	Na source other than halite – albite, ion exchange	0.367 12.83	Limestone-dolomite weathering	0.808 7.22	Calcium source other than gypsum – carbonate or silicates	0.33	Seawater or brine	-0.80	Undersaturated with respect to calcite
MM53, 12/06/2003	0.33	0.01	Silicate weathering	-0.89	Cation exchange	-1.01	Plagioklase weathering unlikely	0.45	Analysis error	0.707 0.00	Granitic weathering	0.246 4.70	Pyrite oxidation	0.00	Seawater or brine	-5.53	Undersaturated with respect to calcite
MM59B, 6/11/2003	0.12	0.14	Silicate weathering	-0.97	Cation exchange	1.40	Plagioklase weathering unlikely	0.46	Analysis error	0.902 0.14	Granitic weathering	0.101 6.10		0.01	Seawater or brine	-5.49	Undersaturated with respect to calcite
MS 14, 4/06/2003	0.09	31.00	Carbonate weathering	-0.05	Cation exchange	-0.91	Plagioklase weathering unlikely	0.41	Reverse softening, seawater	0.367 31.00	Limestone-dolomite weathering	0.802 7.80	Calcium source other than gypsum – carbonate or silicates	0.29	Seawater or brine	0.28	Oversaturated with respect to calcite
MS10, 5/07/2007	0.25	1.97	Silicate weathering	0.18	Cation exchange	0.48	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.658 1.97	Granitic weathering	0.217 6.50		0.04	Seawater or brine	-2.20	Undersaturated with respect to calcite
MS7, 9/06/2003	0.52	4.45	Silicate weathering	4.10	Ferromagnesian Minerals	0.05	Plagioklase weathering unlikely	0.50	Halite solution	0.676 4.45	Granitic weathering	0.329 7.40	Calcium removal – ion exchange or calcite precipitation	0.13	Seawater or brine	-0.53	Undersaturated with respect to calcite
MT1D, 5/07/2007	0.20	2.87	Silicate weathering	-0.26	Cation exchange	2.34	Plagioklase weathering unlikely	0.44	Analysis error	0.600 2.87	Granitic weathering	0.725 5.92	Calcium source other than gypsum – carbonate or silicates	0.13	Seawater or brine	-3.07	Undersaturated with respect to calcite
MT1S, 6/09/2005	0.08	3.35	Silicate weathering	-1.29	Cation exchange	-0.26	Plagioklase weathering unlikely	0.49	Analysis error	0.751 3.35	Granitic weathering	0.260 5.70		0.10	Seawater or brine	-3.78	Undersaturated with respect to calcite
NL424, 29/06/2005	0.10	9.85	Ambiguous	0.63	Cation exchange	0.12	Plagioklase weathering	0.50	Halite solution	0.566 9.85	Ambiguous	0.387 6.57	Calcium removal – ion exchange or calcite	0.13	Seawater or brine	-1.88	Undersaturated with respect to

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
							unlikely						precipitation				calcite
North Lake 425, 17/05/2005	0.07	4.92	Silicate weathering	-0.13	Cation exchange	-1.99	Plagioklase weathering unlikely	0.47	Analysis error	0.733 4.92	Granitic weathering	0.230 6.60	Calcium removal – ion exchange or calcite precipitation	0.05	Seawater or brine	-2.45	Undersaturated with respect to calcite
Lake Nowergup, 19/05/2005	0.08	28.72	Carbonate weathering	-0.34	Cation exchange	-0.15	Plagioklase weathering unlikely	0.46	Analysis error	0.227 28.72	Limestone-dolomite weathering	0.947 7.80	Calcium source other than gypsum – carbonate or silicates	0.57	Seawater or brine	0.03	Saturated with respect to calcite
NR 3A, 5/06/2003	0.18	0.90	Silicate weathering	-1.16	Cation exchange	-12.66	Plagioklase weathering unlikely	0.47	Analysis error	0.716 0.90	Granitic weathering	0.279 5.90		0.07	Seawater or brine	-4.03	Undersaturated with respect to calcite
NR 3B, 5/06/2003	0.15	0.55	Silicate weathering	-0.36	Cation exchange	3.09	Plagioklase weathering unlikely	0.44	Analysis error	0.601 0.55	Granitic weathering	0.383 4.50	Pyrite oxidation	0.03	Seawater or brine	-5.37	Undersaturated with respect to calcite
NR 3C, 5/06/2003	0.10	0.86	Silicate weathering	-0.36	Cation exchange	-0.62	Plagioklase weathering unlikely	0.44	Analysis error	0.346 0.86	Ferromagnesian Minerals	0.554 4.40	Calcium source other than gypsum – carbonate or silicates	0.05	Seawater or brine	-5.05	Undersaturated with respect to calcite
NR10C, 21/07/2003	0.06	1.41	Silicate weathering	-0.61	Cation exchange	-6.76	Plagioklase weathering unlikely	0.48	Analysis error	0.767 1.41	Granitic weathering	0.273 4.10	Pyrite oxidation	0.05	Seawater or brine	-6.02	Undersaturated with respect to calcite
NR1B, 23/06/2003	0.11	0.77	Silicate weathering	-0.47	Cation exchange	1.72	Plagioklase weathering unlikely	0.45	Analysis error	0.763 0.77	Granitic weathering	0.695 5.40	Calcium source other than gypsum – carbonate or silicates	0.05	Seawater or brine	-5.03	Undersaturated with respect to calcite
NR1C, 23/06/2003	0.30	1.09	Silicate weathering	-0.48	Cation exchange	1.37	Plagioklase weathering unlikely	0.40	Analysis error	0.879 1.09	Granitic weathering	0.261 5.90		0.13	Seawater or brine	-3.75	Undersaturated with respect to calcite
NR2C, 18/03/2004	0.06	1.06	Silicate weathering	0.59	Cation exchange	0.39	Plagioklase weathering possible	0.50	Halite solution	0.875 1.06	Granitic weathering	0.102 5.65		0.02	Seawater or brine	-4.96	Undersaturated with respect to calcite
NR6C, 5/01/2007	0.12	0.14	Silicate weathering	-5.76	Cation exchange	-0.41	Plagioklase weathering unlikely	0.49	Analysis error	0.805 0.14	Granitic weathering	0.251 5.32	Pyrite oxidation	0.01	Seawater or brine	-5.79	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
NR7A, 9/06/2003	0.25	5.25	Ambiguous	-0.77	Cation exchange	-0.42	Plagioklase weathering unlikely	0.46	Analysis error	0.351 5.25	Ambiguous	0.981 6.90	Calcium source other than gypsum – carbonate or silicates	0.32	Seawater or brine	-1.37	Undersaturated with respect to calcite
NR7B, 6/09/2003	0.22	5.68	Ambiguous	-0.74	Cation exchange	-0.41	Plagioklase weathering unlikely	0.47	Analysis error	0.420 5.68	Ambiguous	0.980 7.00	Calcium source other than gypsum – carbonate or silicates	0.28	Seawater or brine	-1.34	Undersaturated with respect to calcite
NR7C, 6/09/2003	0.18	0.45	Silicate weathering	-0.66	Cation exchange	2.46	Plagioklase weathering unlikely	0.46	Analysis error	0.783 0.45	Granitic weathering	0.248 6.20		0.03	Seawater or brine	-4.07	Undersaturated with respect to calcite
PCM 21, 8/09/2005	0.06	2.46	Silicate weathering	-0.16	Cation exchange	1.29	Plagioklase weathering unlikely	0.45	Analysis error	0.842 2.46	Granitic weathering	0.289 6.20		0.06	Seawater or brine	-4.05	Undersaturated with respect to calcite
Pipidinny Swamp 1, 18/05/2005	0.08	48.14	Carbonate weathering	0.00	Cation exchange	-4.38	Plagioklase weathering unlikely	0.44	Reverse softening, seawater	0.446 48.14	Limestone-dolomite weathering	0.535 7.80	Gypsum dissolution	0.02	Gypsum dissolution	0.92	Oversaturated with respect to calcite
Pipidinny Swamp 2, 18/05/2005	0.13	20.93	Carbonate weathering	-0.18	Cation exchange	-0.29	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.231 20.93	Limestone-dolomite weathering	0.735 7.70	Calcium source other than gypsum – carbonate or silicates	0.31	Seawater or brine	0.14	Oversaturated with respect to calcite
PM 26, 15/07/2003	0.20	4.10	Silicate weathering	-1.89	Cation exchange	-0.21	Plagioklase weathering unlikely	0.48	Analysis error	0.476 4.10	Ferromagnesian Minerals	0.689 6.00	Calcium source other than gypsum – carbonate or silicates	0.28	Seawater or brine	-2.71	Undersaturated with respect to calcite
PM 31, 26/07/2003	0.22	10.61	Carbonate weathering	0.57	Cation exchange	0.14	Plagioklase weathering unlikely	0.53	Na source other than halite – albite, ion exchange	0.256 10.60	Limestone-dolomite weathering	0.697 7.30	Calcium source other than gypsum – carbonate or silicates	0.42	Seawater or brine	-0.42	Undersaturated with respect to calcite
PM 33, 15/07/2003	0.16	24.12	Carbonate weathering	-0.61	Cation exchange	-0.07	Plagioklase weathering unlikely	0.47	Analysis error	0.154 24.12	Limestone-dolomite weathering	0.842 7.30	Calcium source other than gypsum – carbonate or silicates	0.55	Seawater or brine	0.00	Saturated with respect to calcite
PM 35, 10/08/2005	0.10	6.57	Ambiguous	0.40	Cation exchange	0.52	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.754 6.56	Ambiguous	0.262 6.30		0.17	Seawater or brine	-2.97	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
PM12, 16/06/2003	0.23	1.76	Silicate weathering	-1.81	Cation exchange	-0.86	Plagioklase weathering unlikely	0.48	Analysis error	0.575 1.76	Granitic weathering	0.870 6.20	Calcium source other than gypsum – carbonate or silicates	0.17	Seawater or brine	-3.12	Undersaturated with respect to calcite
PM16, 28/07/2005	0.12	1.43	Silicate weathering	-0.32	Cation exchange	1.58	Plagioklase weathering unlikely	0.46	Analysis error	0.783 1.43	Granitic weathering	0.308 5.70		0.05	Seawater or brine	-4.32	Undersaturated with respect to calcite
PM18, 24/06/2003	0.12	2.11	Silicate weathering	-0.46	Cation exchange	1.42	Plagioklase weathering unlikely	0.46	Analysis error	0.841 2.11	Granitic weathering	0.285 6.30		0.10	Seawater or brine	-3.82	Undersaturated with respect to calcite
PM19, 24/06/2003	0.16	1.42	Silicate weathering	-1.89	Cation exchange	41.20	Plagioklase weathering unlikely	0.48	Analysis error	0.829 1.42	Granitic weathering	0.324 7.00	Calcium removal – ion exchange or calcite precipitation	0.11	Seawater or brine	-3.14	Undersaturated with respect to calcite
PM3, 24/06/2003	0.11	3.79	Silicate weathering	-0.45	Cation exchange	-6.48	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.907 3.79	Granitic weathering	0.094 6.10		0.05	Seawater or brine	-3.34	Undersaturated with respect to calcite
PM5, 8/06/2005	0.07	0.10	Silicate weathering	-0.66	Cation exchange	3.26	Plagioklase weathering unlikely	0.48	Analysis error	0.866 0.10	Granitic weathering	0.205 6.01		0.00	Seawater or brine	-5.48	Undersaturated with respect to calcite
PM6, 8/06/2005	0.10	2.50	Silicate weathering	-0.56	Cation exchange	2.67	Plagioklase weathering unlikely	0.47	Analysis error	0.808 2.50	Granitic weathering	0.209 6.25		0.11	Seawater or brine	-3.69	Undersaturated with respect to calcite
PM7, 5/04/2007	0.15	2.74	Silicate weathering	0.66	Cation exchange	0.45	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.733 2.74	Granitic weathering	0.208 5.45	Pyrite oxidation	0.17	Seawater or brine	-3.89	Undersaturated with respect to calcite
PM8, 8/06/2005	0.05	4.92	Silicate weathering	-1.82	Cation exchange	-1.57	Plagioklase weathering unlikely	0.49	Analysis error	0.885 4.92	Granitic weathering	0.177 5.91		0.14	Seawater or brine	-4.40	Undersaturated with respect to calcite
PP4 Shallow, 5/04/2007	0.12	1.41	Silicate weathering	0.36	Cation exchange	0.35	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.550 1.41	Granitic weathering	0.277 5.20	Pyrite oxidation	0.05	Seawater or brine	-4.18	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
SE5, 7/07/2005	0.27	9.85	Ambiguous	-0.35	Cation exchange	-1.90	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.788 9.85	Ambiguous	0.372 6.90	Calcium removal – ion exchange or calcite precipitation	0.10	Seawater or brine	-1.19	Undersaturated with respect to calcite
SHIRLEY BALLA, 21/07/2005	0.10	6.56	Ambiguous	-0.24	Cation exchange	2.86	Plagioklase weathering unlikely	0.45	Analysis error	0.777 6.56	Ambiguous	0.640 4.00	Calcium source other than gypsum – carbonate or silicates	0.22	Seawater or brine	-5.14	Undersaturated with respect to calcite
T 500, 13/09/2005	0.11	12.00	Carbonate weathering	-0.15	Cation exchange	-2.34	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.586 12.00	Dolomite dissolution, calcite precipitation or seawater	0.716 6.50	Calcium source other than gypsum – carbonate or silicates	0.18	Seawater or brine	-1.85	Undersaturated with respect to calcite
T110 (O), 19/07/2005	0.08	2.01	Silicate weathering	-0.14	Cation exchange	2.05	Plagioklase weathering unlikely	0.45	Analysis error	0.666 2.01	Granitic weathering	0.943 5.40	Calcium source other than gypsum – carbonate or silicates	0.04	Seawater or brine	-4.24	Undersaturated with respect to calcite
T120 (O), 14/04/2004	0.01	236.33	Carbonate weathering	0.00	Cation exchange	1.35	Plagioklase weathering unlikely	0.45	Reverse softening, seawater	0.841 236.33	Dolomite dissolution, calcite precipitation or seawater	0.944 6.28	Calcium source other than gypsum – carbonate or silicates	0.15	Seawater or brine	-2.27	Undersaturated with respect to calcite
T130 (I), 15/07/2005	0.06	76.59	Carbonate weathering	0.22	Cation exchange	0.06	Plagioklase weathering unlikely	0.51	Na source other than halite – albite, ion exchange	0.181 76.59	Limestone-dolomite weathering	0.912 8.00	Calcium source other than gypsum – carbonate or silicates	0.56	Seawater or brine	0.79	Oversaturated with respect to calcite
T140 (O), 7/04/2004	0.05	1.69	Silicate weathering	0.12	Cation exchange	0.33	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.649 1.69	Granitic weathering	0.239 5.89		0.02	Seawater or brine	-3.85	Undersaturated with respect to calcite
T150 (O), 14/04/2004	0.05	3.36	Silicate weathering	-4.58	Cation exchange	-0.10	Plagioklase weathering unlikely	0.49	Halite solution	0.776 3.36	Granitic weathering	0.358 5.73		0.11	Seawater or brine	-4.49	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
T161 (I), 19/07/2005	0.12	6.24	Ambiguous	0.76	Cation exchange	0.38	Plagioklase weathering possible	0.50	Halite solution	0.808 6.24	Ambiguous	0.931 6.60	Calcium source other than gypsum – carbonate or silicates	0.12	Seawater or brine	-2.53	Undersaturated with respect to calcite
T200 (O), 20/07/2005	0.09	5.28	Ambiguous	-0.43	Cation exchange	-0.76	Plagioklase weathering unlikely	0.48	Analysis error	0.664 5.28	Ambiguous	0.521 6.20	Gypsum dissolution	0.10	Seawater or brine	-2.81	Undersaturated with respect to calcite
T220, 14/04/2004	0.17	0.99	Silicate weathering	-1.15	Cation exchange	5.70	Plagioklase weathering unlikely	0.48	Analysis error	0.822 0.99	Granitic weathering	0.222 6.06		0.05	Seawater or brine	-4.08	Undersaturated with respect to calcite
T260 (O), 19/07/2005	0.06	9.32	Ambiguous	0.16	Cation exchange	0.63	Plagioklase weathering possible	0.54	Na source other than halite – albite, ion exchange	0.695 9.31	Ambiguous	0.506 6.80	Gypsum dissolution	0.21	Seawater or brine	-2.43	Undersaturated with respect to calcite
T340 (O), 15/07/2005	0.08	70.02	Carbonate weathering	0.13	Cation exchange	0.09	Plagioklase weathering unlikely	0.52	Na source other than halite – albite, ion exchange	0.216 70.02	Limestone-dolomite weathering	0.723 8.00	Calcium source other than gypsum – carbonate or silicates	0.47	Seawater or brine	0.93	Oversaturated with respect to calcite
T370, 7/07/2005	0.10	20.65	Carbonate weathering	0.06	Cation exchange	0.57	Plagioklase weathering possible	0.61	Na source other than halite – albite, ion exchange	0.537 20.65	Dolomite dissolution, calcite precipitation or seawater	0.453 7.20	Gypsum dissolution	0.35	Seawater or brine	-0.84	Undersaturated with respect to calcite
T380(O), 7/07/2005	0.13	39.14	Carbonate weathering	0.20	Cation exchange	0.27	Plagioklase weathering possible	0.57	Na source other than halite – albite, ion exchange	0.670 39.14	Dolomite dissolution, calcite precipitation or seawater	0.840 8.20	Calcium source other than gypsum – carbonate or silicates	0.73	Seawater or brine	0.65	Oversaturated with respect to calcite
T420, 7/07/2005	0.23	6.33	Ambiguous	-2.99	Cation exchange	-0.13	Plagioklase weathering unlikely	0.49	Halite solution	0.691 6.33	Ambiguous	0.528 6.60	Gypsum dissolution	0.17	Seawater or brine	-1.83	Undersaturated with respect to calcite
T420, 7/07/2005	0.23	6.33	Ambiguous	-2.99	Cation exchange	-0.13	Plagioklase weathering unlikely	0.49	Halite solution	0.691 6.33	Ambiguous	0.528 6.60	Gypsum dissolution	0.17	Seawater or brine	-1.83	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
T450I, 7/06/2005	0.13	14.25	Carbonate weathering	-0.17	Cation exchange	-1.56	Plagioklase weathering unlikely	0.47	Reverse softening, seawater	0.569 14.25	Dolomite dissolution, calcite precipitation or seawater	0.985 6.60	Calcium source other than gypsum – carbonate or silicates	0.19	Seawater or brine	-1.51	Undersaturated with respect to calcite
T530, 7/05/2005	0.12	75.96	Carbonate weathering	-0.10	Cation exchange	-0.25	Plagioklase weathering unlikely	0.47	Reverse softening, seawater	0.452 75.96	Limestone-dolomite weathering	0.932 7.40	Calcium source other than gypsum – carbonate or silicates	0.40	Seawater or brine	0.51	Oversaturated with respect to calcite
T540, 7/05/2005	0.08	5.47	Ambiguous	0.49	Cation exchange	0.43	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.677 5.47	Ambiguous	0.396 6.80	Calcium removal – ion exchange or calcite precipitation	0.25	Seawater or brine	-2.60	Undersaturated with respect to calcite
T570, 7/04/2005	0.09	3.16	Silicate weathering	0.29	Cation exchange	0.71	Plagioklase weathering possible	0.56	Na source other than halite – albite, ion exchange	0.771 3.16	Granitic weathering	0.214 6.60	Calcium removal – ion exchange or calcite precipitation	0.17	Seawater or brine	-3.18	Undersaturated with respect to calcite
T580 not 560, 7/06/2005	0.08	5.91	Ambiguous	24.53	Ferromagnesian Minerals	0.01	Plagioklase weathering unlikely	0.49	Halite solution	0.685 5.91	Ambiguous	0.406 6.70	Calcium removal – ion exchange or calcite precipitation	0.23	Seawater or brine	-2.48	Undersaturated with respect to calcite
T600, 7/04/2005	0.15	5.37	Ambiguous	-0.30	Cation exchange	1.23	Plagioklase weathering unlikely	0.46	Analysis error	0.900 5.37	Ambiguous	0.683 5.80	Calcium source other than gypsum – carbonate or silicates	0.19	Seawater or brine	-3.73	Undersaturated with respect to calcite
T670, 7/04/2005	0.12	6.24	Ambiguous	0.23	Cation exchange	0.71	Plagioklase weathering possible	0.51	Halite solution	0.917 6.24	Ambiguous	0.197 7.20	Calcium removal – ion exchange or calcite precipitation	0.07	Seawater or brine	-2.11	Undersaturated with respect to calcite
T75, 29/06/2005	0.10	7.26	Ambiguous	-0.11	Cation exchange	-1.14	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.616 7.26	Ambiguous	0.471 6.18	Gypsum dissolution	0.05	Seawater or brine	-2.21	Undersaturated with respect to calcite
T85, 25/07/2005	0.14	3.60	Silicate weathering	-0.14	Cation exchange	1.48	Plagioklase weathering unlikely	0.47	Reverse softening, seawater	0.880 3.60	Granitic weathering	0.249 6.00		0.05	Seawater or brine	-3.25	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
TDP1, 25/07/2005	0.23	6.33	Ambiguous	0.10	Cation exchange	0.71	Plagioklase weathering possible	0.53	Na source other than halite – albite, ion exchange	0.834 6.33	Ambiguous	0.102 6.50		0.07	Seawater or brine	-1.97	Undersaturated with respect to calcite
TM4C, 6/04/2004	0.20	7.48	Ambiguous	0.15	Cation exchange	0.62	Plagioklase weathering possible	0.59	Na source other than halite – albite, ion exchange	0.442 7.48	Ambiguous	0.355 6.22		0.29	Seawater or brine	-2.12	Undersaturated with respect to calcite
TM7A, 25/07/2005	0.25	24.13	Carbonate weathering	-0.08	Cation exchange	-1.45	Plagioklase weathering unlikely	0.46	Reverse softening, seawater	0.386 24.13	Limestone-dolomite weathering	0.820 7.70	Calcium source other than gypsum – carbonate or silicates	0.19	Seawater or brine	0.63	Oversaturated with respect to calcite
TM7C, 25/07/2005	0.13	32.39	Carbonate weathering	-0.12	Cation exchange	-0.42	Plagioklase weathering unlikely	0.48	Reverse softening, seawater	0.497 32.39	Dolomite weathering	0.626 7.20	Calcium source other than gypsum – carbonate or silicates	0.19	Seawater or brine	-0.21	Undersaturated with respect to calcite
WCM, 3/08/2005	0.07	1.20	Silicate weathering	0.09	Cation exchange	0.69	Plagioklase weathering possible	0.63	Na source other than halite – albite, ion exchange	0.846 1.20	Granitic weathering	0.099 5.30	Pyrite oxidation	0.03	Seawater or brine	-4.67	Undersaturated with respect to calcite
WF 12, 10/08/2005	0.17	21.66	Carbonate weathering	-0.98	Cation exchange	-0.06	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.342 21.66	Limestone-dolomite weathering	0.878 7.50	Calcium source other than gypsum – carbonate or silicates	0.41	Seawater or brine	0.06	Oversaturated with respect to calcite
WH 100, 10/08/2005	0.15	32.46	Carbonate weathering	-0.17	Cation exchange	-0.41	Plagioklase weathering unlikely	0.47	Reverse softening, seawater	0.327 32.46	Limestone-dolomite weathering	0.986 7.50	Calcium source other than gypsum – carbonate or silicates	0.37	Seawater or brine	0.20	Oversaturated with respect to calcite
Wilgerup Lake, 9/06/2005	0.38	0.21	Silicate weathering	0.72	Cation exchange	0.10	Plagioklase weathering unlikely	0.51	Na source other than halite – albite, ion exchange	0.271 0.21	Ferromagnesian Minerals	0.393 4.03	Pyrite oxidation	0.01	Seawater or brine	-4.59	Undersaturated with respect to calcite
WM1, 16/06/2003	0.33	5.42	Ambiguous	-0.54	Cation exchange	-0.70	Plagioklase weathering unlikely	0.46		0.417 5.42	Ambiguous	0.857 6.40	Calcium source other than gypsum – carbonate or	0.26	Seawater or brine	-1.60	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
													silicates				
WM24, 9/06/2003	0.17	0.49	Silicate weathering	1.03	Albite weathering	0.44	Plagioklase weathering possible	0.56	Na source other than halite – albite, ion exchange	0.720 0.49	Granitic weathering	0.210 5.80		0.08	Seawater or brine	-4.33	Undersaturated with respect to calcite
WM29, 11/06/2003	0.14	23.17	Carbonate weathering	33.81	Ferromagnesian minerals	0.01	Plagioklase weathering unlikely	0.49	Halite solution	0.762 23.17	Dolomite dissolution, calcite precipitation or seawater	0.553 6.70	Calcium source other than gypsum – carbonate or silicates	0.53	Seawater or brine	-1.38	Undersaturated with respect to calcite
WM3, 16/06/2003	0.23	1.76	Silicate weathering	-1.62	Cation exchange	2.09	Plagioklase weathering unlikely	0.48	Analysis error	0.829 1.76	Granitic weathering	0.545 5.90	Gypsum dissolution	0.15	Seawater or brine	-4.00	Undersaturated with respect to calcite
WM32, 21/07/2003	0.16	0.51	Silicate weathering	-0.74	Cation exchange	2.33	Plagioklase weathering unlikely	0.47	Analysis error	0.764 0.51	Granitic weathering	0.428 5.00	Pyrite oxidation	0.03	Seawater or brine	-5.32	Undersaturated with respect to calcite
WM4, 16/06/2003	0.23	1.41	Silicate weathering	0.80	Cation exchange	0.63	Plagioklase weathering possible	0.55	Na source other than halite – albite, ion exchange	0.690 1.41	Granitic weathering	0.198 6.00		0.17	Seawater or brine	-3.64	Undersaturated with respect to calcite
WM5, 16/06/2003	0.20	1.48	Silicate weathering	0.98	Cation exchange	0.64	Plagioklase weathering possible	0.52	Na source other than halite – albite, ion exchange	0.874 1.48	Granitic weathering	0.114 5.80		0.13	Seawater or brine	-4.08	Undersaturated with respect to calcite
YB 11, 26/07/2003	0.23	11.96	Carbonate weathering	-0.48	Cation exchange	-0.22	Plagioklase weathering unlikely	0.44	Analysis error	0.159 11.96	Limestone-dolomite weathering	0.928 7.50	Calcium source other than gypsum – carbonate or silicates	0.51	Seawater or brine	-0.07	Undersaturated with respect to calcite
YN 2, 26/07/2003	0.18	8.06	Ambiguous	-0.71	Cation exchange	-0.20	Plagioklase weathering unlikely	0.47	Analysis error	0.223 8.06	Ambiguous	0.881 6.60	Calcium source other than gypsum – carbonate or silicates	0.37	Seawater or brine	-1.47	Undersaturated with respect to calcite

Sample ID and date	SiO_2 mmol/L	HCO_3-/SiO_2		SiO2/(Na+K-Cl)		(Na+K-Cl)/(Na+K-Cl+Ca)		(Na/(Na+Cl)		Mg/(Ca+Mg) Second figure is HCO_3/Si		Ca/(Ca+SO_4) Second figure is pH		HCO_3/sum anions		SI Calcite	
YN 3, 26/07/2003	0.15	6.96	Ambiguous	-0.49	Cation exchange	-0.50	Plagioklase weathering unlikely	0.45	Analysis error	0.410 6.96	Ambiguous	0.835 6.60	Calcium source other than gypsum – carbonate or silicates	0.32	Seawater or brine	-1.79	Undersaturated with respect to calcite
YN 3, 9/12/2005	0.10	9.21	Ambiguous	-0.23	Cation exchange	-0.56	Plagioklase weathering unlikely	0.44	Analysis error	0.205 9.21	Ambiguous	0.895 6.70	Calcium source other than gypsum – carbonate or silicates	0.27	Seawater or brine	-1.61	Undersaturated with respect to calcite
YN 5, 26/07/2003	0.18	20.59	Carbonate weathering	-0.05	Cation exchange	-2.08	Plagioklase weathering unlikely	0.41	Reverse softening, seawater	0.219 20.59	Limestone-dolomite weathering	0.879 8.00	Calcium source other than gypsum – carbonate or silicates	0.24	Seawater or brine	0.71	Oversaturated with respect to calcite
YN 5, 9/08/2005	0.10	40.75	Carbonate weathering	1.12	Albite weathering	0.03	Plagioklase weathering unlikely	0.50	Halite solution	0.245 40.75	Limestone-dolomite weathering	0.930 7.40	Calcium source other than gypsum – carbonate or silicates	0.35	Seawater or brine	-0.03	Saturated with respect to calcite
YN 6, 26/07/2003	0.25	8.53	Ambiguous	-0.55	Cation exchange	-0.22	Plagioklase weathering unlikely	0.45	Analysis error	0.158 8.53	Ambiguous	0.946 7.00	Calcium source other than gypsum – carbonate or silicates	0.42	Seawater or brine	-0.71	Undersaturated with respect to calcite
YN 7, 26/07/2003	0.22	6.44	Ambiguous	-0.37	Cation exchange	-0.33	Plagioklase weathering unlikely	0.45	Analysis error	0.242 6.44	Ambiguous	0.697 6.60	Calcium source other than gypsum – carbonate or silicates	0.25	Seawater or brine	-1.35	Undersaturated with respect to calcite
YN 8, 26/07/2003	0.18	12.53	Carbonate weathering	-1.30	Cation exchange	-0.03	Plagioklase weathering unlikely	0.49	Reverse softening, seawater	0.257 12.53	Limestone-dolomite weathering	0.827 7.00	Calcium source other than gypsum – carbonate or silicates	0.22	Seawater or brine	-0.48	Undersaturated with respect to calcite
YSI 1, 9/08/2005	0.10	28.37	Carbonate weathering	-0.01	Cation exchange	2.61	Plagioklase weathering unlikely	0.42	Reverse softening, seawater	0.465 28.37	Limestone-dolomite weathering	0.717 7.60	Calcium source other than gypsum – carbonate or silicates	0.05	Seawater or brine	0.31	Oversaturated with respect to calcite
YY3(I), 28/07/2005	0.11	11.54	Carbonate weathering	-2.73	Cation exchange	-0.05	Plagioklase weathering unlikely	0.49	Halite solution	0.531 11.54	Dolomite dissolution, calcite precipitation or seawater	0.950 6.80	Calcium source other than gypsum – carbonate or silicates	0.27	Seawater or brine	-1.60	Undersaturated with respect to calcite

Appendix I — Superficial aquifer bores – AquaChem modelling results – saturation indices

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
1/01/1998	9/06/2005	137.46	38.00	1.76	4.89	-3.46	-3.03	-2.89	-0.40	-5.82	-3.91	-3.23	-7.51	-5.83	0.04	-2.88
144B	28/06/2005	1028.51	318.58	4.14	-4.24	-1.93	0.19	0.34	-0.52	0.26	-0.46	-1.70	-5.92	1.07	-0.08	-0.52
2025A	28/06/2005	489.11	98.40	5.70	-1.63	-2.41	-3.39	-3.24	-0.56	-6.33	-2.53	-2.18	-6.16	-3.07	-0.12	-2.69
2069	21/07/2005	120.97	44.81	1.10	2.86	-3.08	-3.14	-3.00	-0.76	-6.47	1.63	-2.84	-7.84	5.25	-0.32	-2.89
2288	28/06/2005	231.11	65.05	2.21	-2.75	-2.74	-2.03	-1.88	-0.61	-3.94	5.03	-2.51	-7.16	12.06	-0.17	-1.69
3578A	27/06/2005	861.89	250.47	5.50	2.03	-1.83	-0.96	-0.82	-1.14	-2.00	4.63	-1.60	-5.80	11.25	-0.70	-1.76
459	20/06/2005	1037.43	337.27	3.08	-0.27	-1.70	0.53	0.67	0.06	0.49	0.90	-1.46	-6.10	3.77	0.51	-0.28
649	22/06/2005	149.57	59.59	1.18	4.82	-3.32	-1.90	-1.75	-0.40	-3.53	5.10	-3.08	-7.70	12.17	0.05	-1.93
8259A	30/04/2007	131.81	34.22	1.56	-4.78	-3.73	-3.61	-3.46	-0.33	-6.71	3.42	-3.49	-7.67	8.83	0.11	-2.19
8281	20/06/2005	381.57	156.11	1.43	-2.13	-2.01	-0.73	-0.58	-0.33	-1.85	6.86	-1.77	-7.13	15.70	0.12	-1.52
8282	19/07/2005	490.30	252.16	0.58	4.91	-2.12	0.92	1.07	-0.08	1.23	7.50	-1.87	-7.90	16.98	0.38	-0.81
8283	21/07/2005	637.24	226.82	2.40	2.90	-2.51	0.89	1.04	0.05	1.16	7.61	-2.27	-6.61	17.20	0.50	-3.71
8386	12/09/2005	172.44	32.32	2.98	-4.56	-3.74	-5.01	-4.87	-0.38	-9.05	-4.93	-3.50	-7.07	-7.89	0.07	-4.29
B270	26/07/2005	452.61	177.71	2.45	4.46	-2.82	-0.28	-0.14	-0.39	-0.98	5.55	-2.58	-6.61	13.09	0.05	-1.04
Bibra Lake 425	17/05/2005	1128.27	354.21	5.55	1.44	-1.70	0.47	0.62	-1.13	1.25	7.80	-1.47	-5.65	17.59	-0.69	-0.97
CSG6	15/07/2005	1815.31	480.26	8.14	4.55	-1.65	0.56	0.70	-0.69	1.62	2.58	-1.42	-5.26	7.15	-0.25	-0.39
CSI-3/97	7/04/2004	873.28	326.45	3.54	-0.02	-1.91	-0.20	-0.06	-0.59	-0.54	7.54	-1.67	-5.99	17.08	-0.15	-0.75
CW1	23/06/2003	112.61	12.19	3.74	2.06	-5.34	-6.15	-6.00	-0.14	-11.12	-6.40	-5.09	-7.34	-10.82	0.31	-4.22
E 1-89	5/07/2005	309.19	142.30	0.98	1.37	-2.68	-1.04	-0.89	-0.52	-1.71	4.65	-2.45	-7.63	11.28	-0.08	-1.45
FL1	30/06/2005	306.13	65.84	4.07	1.64	-2.85	-2.06	-1.91	-0.79	-3.98	3.94	-2.61	-6.66	9.85	-0.33	-1.70
GA 10	15/07/2003	546.52	237.81	1.75	0.00	-1.90	-5.34	-5.19	0.38	-10.03	-1.92	-1.66	-6.79	-1.86	0.83	-3.69
GA 14	15/07/2003	182.68	36.52	3.09	0.56	-3.79	-4.20	-4.06	-0.18	-7.40	0.86	-3.55	-7.07	3.69	0.27	-2.57
GA 15	15/07/2003	139.92	40.64	1.36	0.98	-3.86	-4.98	-4.83	-0.03	-8.91	3.64	-3.62	-7.76	9.26	0.42	-3.99
GA 4	15/07/2003	171.19	37.46	2.84	0.90	-4.11	-4.05	-3.90	-0.15	-7.28	1.99	-3.87	-7.05	5.95	0.30	-3.53
GA 5	15/07/2003	174.66	35.40	2.92	-1.17	-3.65	-4.17	-4.02	-0.16	-7.56	4.31	-3.40	-7.09	10.60	0.29	-3.65

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
GA 8	15/07/2003	342.45	100.15	2.96	1.17	-3.01	-2.37	-2.22	-0.15	-4.48	1.85	-2.77	-6.68	5.67	0.30	-2.64
GA 9	15/07/2003	367.82	122.08	2.64	0.17	-2.52	-4.17	-4.03	0.03	-7.48	1.29	-2.28	-6.73	4.55	0.48	-3.20
GA1	17/07/2003	462.87	202.20	1.71	2.63	-2.81	0.13	0.28	-0.09	-0.13	7.52	-2.58	-6.82	17.03	0.35	-2.09
GA11	8/03/2004	500.34	218.49	1.66	0.67	-2.84	0.75	0.90	-0.46	0.94	7.69	-2.60	-6.83	17.36	-0.01	1.10
GA11	27/07/2005	496.55	239.27	1.46	3.76	-2.84	0.39	0.53	-0.26	0.20	6.94	-2.60	-6.85	15.88	0.18	-0.69
GA12	17/07/2003	361.37	126.96	1.85	-4.99	-2.95	-1.04	-0.89	-0.08	-2.29	6.07	-2.71	-6.88	14.12	0.36	-1.62
GA13	17/07/2003	259.95	83.75	1.76	-4.65	-3.15	-1.49	-1.35	-0.17	-3.03	3.88	-2.92	-7.13	9.75	0.28	-1.81
GA17	17/07/2003	311.07	104.23	2.09	-1.92	-2.86	-1.26	-1.11	-0.09	-2.95	6.11	-2.63	-6.87	14.20	0.36	-1.77
GA17	27/07/2005	314.58	116.16	1.98	0.51	-2.94	-1.21	-1.06	-0.30	-2.57	6.20	-2.70	-6.87	14.38	0.14	-1.74
GA18	17/07/2003	205.62	45.12	2.59	-5.66	-3.49	-3.67	-3.52	0.00	-6.81	3.29	-3.25	-7.00	8.56	0.45	-2.95
GA22	27/07/2005	244.50	81.17	1.54	-3.55	-2.54	-1.56	-1.41	-0.39	-2.94	6.24	-2.31	-7.51	14.47	0.04	-1.83
GA25	3/05/2004	555.10	231.13	2.25	2.70	-2.79	-0.47	-0.33	-0.59	-1.09	6.91	-2.55	-6.61	15.80	-0.14	-0.75
GA26	3/05/2004	322.18	77.14	3.90	0.02	-3.40	-2.53	-2.39	-0.53	-4.44	5.31	-3.17	-6.52	12.61	-0.08	-1.68
GA28	26/07/2005	525.27	194.97	2.02	-2.31	-2.80	0.20	0.34	-0.32	0.26	7.46	-2.57	-6.76	16.91	0.12	-1.70
GA33	8/03/2004	509.34	227.00	1.79	2.04	-2.82	0.76	0.90	-0.53	1.28	7.92	-2.58	-6.76	17.83	-0.09	-2.30
GA33	27/07/2005	518.55	203.33	1.83	-3.19	-2.85	0.29	0.44	-0.30	0.36	7.51	-2.62	-6.75	17.01	0.14	-1.80
GB15	17/07/2003	712.37	260.35	3.77	0.00	-2.56	-5.58	-5.43	0.17	-9.92	4.51	-2.32	-5.95	11.00	0.62	-3.75
GB21	16/03/2004	168.23	32.18	3.34	10.18	-4.13	-5.56	-5.42	-0.70	-10.10	-3.93	-3.89	-7.12	-5.88	-0.25	-3.50
GB21	6/07/2005	179.82	30.75	3.37	-1.53	-4.20	-3.89	-3.74	-0.36	-6.74	3.30	-3.95	-7.05	8.59	0.09	-3.11
GB23	27/07/2005	155.94	38.57	2.73	1.55	-3.66	-6.31	-6.16	-0.51	-11.45	1.99	-3.42	-7.14	5.97	-0.07	-5.52
GC 11	21/07/2003	145.66	27.30	2.66	-1.06	-3.64	-4.07	-3.92	-0.39	-7.20	3.89	-3.40	-7.36	9.77	0.06	-1.83
GC 19	15/07/2003	171.08	29.68	3.51	-1.09	-4.22	-4.45	-4.30	-0.26	-7.87	4.58	-3.97	-7.00	11.13	0.19	-3.66
GC17	16/03/2004	111.74	17.90	2.39	0.82	-4.66	-4.81	-4.67	-0.48	-8.28	3.10	-4.43	-7.55	8.19	-0.04	-2.18
GC17	6/08/2005	110.99	26.31	1.78	0.62	-3.75	-4.21	-4.06	-0.36	-7.47	3.57	-3.52	-7.70	9.14	0.08	-3.46
GC4	6/07/2005	481.35	110.61	4.96	-0.57	-2.81	-3.69	-3.55	-0.27	-6.65	4.20	-2.58	-6.11	10.38	0.18	-3.70
GD 11	20/06/2005	788.05	295.99	2.35	-4.87	-1.34	-3.03	-2.89	-0.36	-6.07	4.74	-1.10	-6.48	11.47	0.08	-2.02

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
GD 12	21/06/2005	727.54	150.27	6.74	-2.12	-2.46	-1.75	-1.60	-1.03	-2.79	5.72	-2.23	-5.83	13.42	-0.59	-1.96
GD 2	6/06/2003	493.56	187.48	2.03	-2.94	-1.89	-0.76	-0.61	0.03	-1.65	8.86	-1.65	-6.72	19.70	0.47	0.40
GD12	24/03/2004	784.01	251.90	4.93	2.61	-2.08	-1.74	-1.59	-0.05	-2.82	5.34	-1.85	-5.84	12.67	0.40	-0.64
GD23	6/09/2003	742.44	298.83	2.42	-0.91	-2.13	0.08	0.23	0.11	0.39	5.69	-1.89	-6.37	13.36	0.56	-0.76
GD23	27/06/2005	634.93	212.30	3.28	-2.40	-2.05	-0.43	-0.28	-0.28	-0.92	7.15	-1.81	-6.24	16.28	0.17	-1.47
GD5	27/06/2005	2321.30	678.20	8.52	-1.41	-1.30	-0.14	0.01	-0.24	0.13	7.89	-1.07	-5.01	17.78	0.20	-0.31
GD8	25/03/2004	500.85	119.03	4.90	4.57	-2.38	-1.08	-0.94	-0.19	-1.76	7.96	-2.15	-6.32	17.92	0.25	-0.91
GE 2	13/09/2005	907.73	311.97	3.69	-1.85	-1.99	0.49	0.64	-0.44	0.83	7.50	-1.76	-6.02	16.99	0.00	-1.74
GE3	27/06/2005	668.27	270.56	2.43	0.86	-1.98	0.03	0.18	-0.32	-0.16	7.20	-1.75	-6.51	16.40	0.12	-1.27
GG3 (O)	21/07/2003	113.61	20.80	2.58	-2.94	-3.85	-4.51	-4.36	-0.47	-8.29	2.85	-3.61	-7.46	7.67	-0.02	-3.49
GM 16	22/06/2005	575.06	222.41	2.10	-3.83	-1.97	-0.34	-0.19	-0.42	-0.89	7.04	-1.73	-6.64	16.08	0.02	-1.38
GM 2	6/06/2003	600.36	217.94	2.12	-4.21	-2.16	0.37	0.52	0.16	0.41	7.54	-1.92	-6.60	17.06	0.61	-2.00
GM 7	6/06/2003	494.53	183.37	1.96	-1.76	-2.23	-0.01	0.14	-0.03	-0.20	7.49	-2.00	-6.78	16.97	0.42	-1.71
GM 9	22/06/2005	549.70	208.19	2.23	-0.04	-1.91	-0.73	-0.58	-0.22	-1.55	6.24	-1.68	-6.71	14.47	0.22	-1.52
GM26	27/06/2005	557.77	165.90	3.04	-1.10	-2.43	-0.98	-0.83	-0.59	-2.04	5.43	-2.20	-6.54	12.86	-0.15	-1.66
GN 13	5/06/2003	83.01	7.55	3.96	2.61	-5.05	-3.75	-3.60	-2.15	-7.58	4.68	-4.81	-7.57	11.33	-1.71	-2.69
GN23	16/06/2003	215.28	32.64	3.88	-0.59	-5.14	-3.02	-2.87	-0.01	-5.01	8.10	-4.90	-6.84	18.17	0.44	-0.47
GNM11A	6/07/2005	375.20	138.80	2.10	-2.83	-2.14	-4.77	-4.62	-0.08	-8.98	2.70	-1.90	-6.88	7.37	0.37	-4.98
GNM5	16/06/2003	177.62	53.79	1.72	-1.16	-3.10	-4.02	-3.87	-0.12	-7.21	3.51	-2.87	-7.42	9.00	0.33	-2.69
IF16	20/04/2004	840.73	394.17	1.64	-0.06	-2.37	-0.04	0.11	-0.73	-0.58	6.49	-2.14	-6.72	14.98	-0.29	-0.65
JB 4	8/02/2005	645.83	149.39	5.34	-4.69	-2.72	-2.23	-2.08	-0.19	-3.67	4.71	-2.49	-5.93	11.40	0.25	-2.37
JB 9A	4/06/2003	265.20	90.28	1.69	-0.23	-4.20	-1.25	-1.10	-0.01	-2.34	8.31	-3.95	-7.12	18.61	0.44	0.11
JB 9C	4/06/2003	149.74	27.62	2.81	-2.26	-4.85	-4.22	-4.07	-0.15	-7.44	3.44	-4.61	-7.17	8.85	0.30	-3.12
JB5	9/06/2003	187.26	67.34	1.70	-1.34	-3.06	-3.66	-3.51	-0.26	-6.52	5.34	-2.83	-7.22	12.66	0.18	-1.88
JE10C	19/07/2005	230.73	107.69	0.88	0.58	-3.26	-1.36	-1.21	-0.20	-2.58	6.90	-3.02	-7.49	15.78	0.24	-0.98
JE12A	20/07/2005	397.19	186.43	1.34	3.36	-3.87	0.53	0.68	-0.49	0.65	8.03	-3.63	-7.09	18.05	-0.05	-1.92
JE12B	20/07/2005	815.81	56.95	14.99	3.25	-2.49	-0.19	-0.05	-0.55	-1.45	7.55	-2.26	-5.68	17.08	-0.10	-3.20

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
JE12C	7/04/2004	137.38	53.40	1.65	5.01	-3.01	-2.08	-1.94	-0.82	-3.92	8.46	-2.78	-7.38	18.90	-0.38	-9.71
JE12C	25/07/2005	143.34	50.19	1.66	4.34	-3.23	-3.39	-3.24	-0.54	-6.04	3.88	-3.00	-7.50	9.75	-0.10	-3.08
JE22C	14/04/2004	314.24	136.06	0.93	0.73	-3.39	-3.66	-3.52	-0.13	-6.06	2.16	-3.16	-7.37	6.32	0.30	-1.98
JE4A	30/06/2005	881.29	291.75	5.09	6.36	-3.03	0.46	0.61	-0.29	0.96	8.76	-2.80	-5.80	19.49	0.15	-0.80
JE4C	30/06/2005	257.42	81.30	2.65	1.54	-3.11	-3.34	-3.19	-0.38	-5.71	5.20	-2.87	-6.85	12.37	0.07	-1.62
JM12	5/04/2004	241.96	64.77	2.92	0.02	-3.09	-2.88	-2.73	-0.74	-5.04	5.19	-2.86	-6.91	12.35	-0.29	-1.70
JM16	5/04/2004	176.71	24.68	4.53	2.46	-4.76	-4.24	-4.09	-0.65	-7.22	4.06	-4.53	-6.94	10.11	-0.21	-2.29
JM19	5/04/2004	148.64	42.23	2.18	0.05	-5.69	-4.37	-4.22	-0.70	-6.61	4.96	-5.45	-7.22	11.90	-0.25	-2.11
JM22	30/06/2005	191.45	35.10	3.38	-0.54	-3.67	-4.54	-4.39	-0.35	-7.85	4.01	-3.43	-7.07	10.00	0.10	-2.66
JM5	29/06/2005	504.20	193.69	2.63	-2.33	-2.32	-1.61	-1.47	-0.76	-2.95	4.94	-2.09	-6.39	11.87	-0.32	-1.88
JM51	20/04/2004	156.42	30.18	3.15	-1.21	-4.14	-6.08	-5.93	-0.53	-10.92	2.87	-3.90	-7.12	7.73	-0.08	-4.52
JM66C	21/07/2005	80.02	21.00	1.42	0.00	-3.98	-3.64	-3.49	-0.73	-6.83	3.89	-3.74	-7.95	9.77	-0.29	-3.12
JM7	29/06/2005	153.35	34.44	2.74	-2.11	-4.01	-4.92	-4.77	-0.58	-8.60	3.60	-3.77	-7.12	9.17	-0.13	-3.17
JP 14	9/12/2005	473.80	201.79	1.78	-0.45	-2.86	0.14	0.29	-0.30	-0.10	8.14	-2.63	-6.73	18.27	0.15	-1.06
JP 18C	6/06/2003	450.78	102.51	4.73	-4.94	-4.36	-2.17	-2.03	-1.69	-3.87	7.02	-4.13	-6.14	16.03	-1.25	-0.27
JP13 (I)	9/03/2004	242.57	42.56	4.40	0.04	-5.09	-2.63	-2.48	-1.47	-4.89		-4.85	-6.68		-1.03	
JP15	28/07/2005	537.87	177.96	2.97	-0.68	-3.08	0.23	0.37	-0.20	0.29	7.54	-2.84	-6.41	17.06	0.25	-2.05
JP3	9/03/2004	491.20	177.22	2.78	3.70	-3.21	0.32	0.46	-1.11	0.47	8.72	-2.98	-6.54	19.42	-0.67	-0.99
L10A	5/01/2007	354.80	173.21	1.02	2.91	-2.91	-0.30	-0.15	0.07	-1.16	8.81	-2.68	-7.11	19.60	0.51	-0.12
L10C	11/06/2003	152.62	41.22	2.24	-1.51	-3.68	-6.25	-6.10	-0.23	-11.51	-1.08	-3.44	-7.18	-0.19	0.22	-4.72
L10C	5/01/2007	134.44	36.58	2.23	-0.03	-4.25	-4.08	-3.94	-0.33	-6.95	7.81	-4.01	-7.21	17.60	0.12	-2.86
L160C	18/03/2004	293.70	75.27	3.16	1.22	-3.35	-2.28	-2.14	-0.48	-3.97	5.83	-3.12	-6.77	13.66	-0.05	-1.16
L240C	18/03/2004	175.54	31.22	3.53	0.06	-4.46	-2.08	-1.94	-1.51	-4.54	7.48	-4.24	-7.00	16.96	-1.07	-0.96
L50C	21/07/2003	151.90	24.00	3.37	-0.16	-4.33	-3.78	-3.63	-0.22	-6.69	5.30	-4.09	-7.13	12.57	0.23	-2.07
LB5	16/04/2004	399.26	68.45	5.36	0.07	-3.40	-3.94	-3.79	-0.47	-6.63	2.01	-3.17	-6.49	6.01	-0.04	-2.42
LN 2/89	9/08/2005	227.86	52.19	2.71	-4.63	-2.94	-3.20	-3.05	-0.15	-6.28	4.19	-2.70	-6.94	10.35	0.30	-2.37

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
LWIS 6/90	10/08/2005	415.14	155.64	1.95	-1.23	-3.31	-0.03	0.11	-0.15	-0.33	7.47	-3.07	-6.77	16.93	0.29	-1.83
MM 31	22/06/2005	578.88	383.22	0.64	1.15	-1.54	-2.86	-2.71	-0.41	-5.08	4.61	-1.31	-7.55	11.20	0.03	-2.32
MM 45	22/06/2005	535.68	148.91	3.92	2.78	-2.70	-0.94	-0.79	-0.03	-1.50	6.54	-2.47	-6.35	15.08	0.41	-1.45
MM 52	21/06/2005	417.31	111.01	3.18	4.36	-2.79	-1.02	-0.87	-0.10	-1.89	7.35	-2.56	-6.78	16.69	0.34	-0.47
MM10	6/11/2003	184.52	43.57	2.31	-0.98	-3.28	-5.91	-5.76	0.05	-11.01	1.51	-3.04	-7.21	5.01	0.49	-3.50
MM12	6/11/2003	229.23	39.25	4.03	-1.62	-3.58	-3.86	-3.71	-0.15	-6.78	4.41	-3.34	-6.80	10.81	0.30	-2.56
MM14	6/06/2003	636.24	248.45	1.85	-1.76	-1.76	-1.45	-1.30	-0.21	-2.72	5.70	-1.52	-6.71	13.38	0.24	-2.14
MM16	6/12/2003	689.45	229.98	2.81	1.21	-1.99	-2.72	-2.57	0.04	-5.12	4.18	-1.75	-6.38	10.33	0.50	-2.33
MM18	6/11/2003	207.82	75.20	1.61	3.22	-2.70	-5.73	-5.58	-0.07	-10.93	-0.99	-2.46	-7.32	-0.01	0.38	-3.50
MM28	20/04/2004	200.34	35.08	4.41	3.69	-4.00	-5.00	-4.86	-0.66	-8.71	3.62	-3.77	-6.79	9.22	-0.21	-3.46
MM49B	21/07/2003	399.21	140.28	2.42	-0.31	-2.58	-5.95	-5.81	-0.01	-10.80	1.13	-2.34	-6.77	4.25	0.44	-3.21
MM52	24/03/2004	401.83	133.30	4.22	22.49	-2.81	-0.94	-0.80	-0.33	-1.74	6.16	-2.58	-6.50	14.32	0.11	0.13
MM53	12/06/2003	314.35	127.94	1.50	-0.85	-2.41	-5.68	-5.53	0.16	-10.63	1.73	-2.17	-7.09	5.44	0.61	-3.45
MM59B	6/11/2003	92.95	17.79	2.06	-3.29	-4.40	-5.64	-5.49	-0.28	-9.99	3.99	-4.15	-7.66	9.94	0.17	-4.08
MS 14	4/06/2003	665.77	280.01	2.47	-0.11	-2.26	0.13	0.28	-0.43	0.38	7.54	-2.02	-6.28	17.07	0.02	-1.82
MS10	5/07/2007	994.13	218.86	7.06	0.29	-1.94	-2.35	-2.20	0.00	-4.04	7.47	-1.70	-5.71	16.93	0.44	-0.14
MS7	9/06/2003	1309.86	346.80	7.01	0.64	-1.89	-0.67	-0.53	0.36	-0.70	8.19	-1.64	-5.46	18.36	0.81	-0.39
MT1D	5/07/2007	283.55	54.87	3.82	-4.54	-3.68	-3.22	-3.07	-0.08	-5.90	3.86	-3.44	-6.62	9.71	0.36	-2.43
MT1S	6/09/2005	196.77	60.23	2.30	0.93	-3.13	-3.93	-3.78	-0.50	-7.01	3.39	-2.90	-7.10	8.77	-0.06	-2.82
NL424	29/06/2005	553.23	138.06	4.81	0.49	-2.34	-2.03	-1.88	-0.36	-3.61	5.79	-2.10	-6.15	13.55	0.10	-1.48
North Lake 425	17/05/2005	450.94	140.29	3.31	-2.31	-2.41	-2.59	-2.45	-0.60	-4.36	5.96	-2.18	-6.42	13.92	-0.16	-2.07
NR 3A	5/06/2003	181.46	29.88	3.34	-3.52	-3.63	-4.18	-4.03	-0.11	-7.61	4.27	-3.39	-7.05	10.51	0.33	-2.49
NR 3B	5/06/2003	172.21	35.62	2.77	-4.57	-3.39	-5.52	-5.37	-0.20	-10.51	0.02	-3.15	-7.08	2.02	0.25	-4.09
NR 3C	5/06/2003	138.80	53.45	1.49	4.20	-2.91	-5.20	-5.05	-0.39	-10.34	-0.38	-2.67	-7.44	1.21	0.06	-4.24
NR10C	21/07/2003	125.13	23.59	2.87	0.49	-3.97	-6.17	-6.02	-0.60	-11.49	-0.52	-3.73	-7.29	0.93	-0.15	-3.65
NR1B	23/06/2003	108.97	19.96	2.34	-4.51	-4.84	-5.18	-5.03	-0.35	-9.51	1.97	-4.60	-7.48	5.93	0.10	-4.05
NR1C	23/06/2003	200.97	70.20	1.51	1.12	-3.62	-3.90	-3.75	0.10	-6.58	4.75	-3.38	-7.24	11.49	0.55	-1.70

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
NR2C	18/03/2004	249.13	61.10	3.36	0.05	-3.27	-5.10	-4.95	-0.64	-8.99	3.31	-3.03	-6.80	8.61	-0.20	-3.62
NR6C	5/01/2007	105.05	17.89	2.88	3.41	-4.28	-5.94	-5.79	-0.31	-10.91	1.86	-4.04	-7.42	5.71	0.14	-4.56
NR7A	9/06/2003	300.72	84.52	2.65	0.93	-4.20	-1.51	-1.37	0.03	-2.96	6.79	-3.96	-6.79	15.55	0.49	-1.03
NR7B	6/09/2003	308.32	86.11	2.95	2.34	-4.25	-1.49	-1.34	-0.03	-2.79	6.88	-4.01	-6.70	15.72	0.43	-1.16
NR7C	6/09/2003	190.06	37.86	3.18	-2.20	-3.60	-4.22	-4.07	-0.10	-7.54	4.76	-3.35	-6.97	11.50	0.35	-2.85
NTH_RW	29/07/2008	16.51	5.11	0.67	4.45	-5.30	-5.88	-5.73		-10.78	1.95	-5.07	-9.18	5.88		-5.12
PCM 21	8/09/2005	149.78	26.87	3.27	-4.22	-4.23	-4.20	-4.05	-0.61	-7.31	4.57	-3.99	-7.06	11.13	-0.16	-2.85
PCM21	24/06/2003	135.64	19.86	3.12	-0.09	-5.10	-6.27	-6.12	-0.75	-11.47	6.67	-4.86	-7.22	15.31	-0.30	-2.51
PE2A	17/03/2004	204.73	37.78	3.69	0.05	-3.75	-2.81	-2.66	-0.47	-5.12	5.37	-3.52	-6.91	12.73	-0.03	-1.92
PE2B	17/03/2004	159.67	36.03	3.09	4.94	-3.95	-2.52	-2.37	-0.62	-4.54	7.61	-3.72	-7.09	17.20	-0.17	-0.82
PM 26	15/07/2003	221.97	57.10	2.30	-1.85	-3.31	-2.86	-2.71	-0.07	-5.42	3.37	-3.07	-7.11	8.72	0.39	-2.85
PM 31	26/07/2003	437.66	160.91	2.26	1.85	-2.26	-0.57	-0.42	-0.05	-1.25	7.04	-2.02	-6.78	16.07	0.40	-1.41
PM 33	15/07/2003	549.06	230.00	1.61	-3.07	-2.25	-0.15	0.00	-0.16	-0.69	6.99	-2.01	-6.83	15.96	0.29	-1.21
PM 35	10/08/2005	259.76	43.64	4.35	-1.17	-3.43	-3.12	-2.97	-0.41	-5.39	4.36	-3.19	-6.74	10.71	0.04	-2.66
PM12	16/06/2003	183.47	32.90	3.19	2.98	-4.42	-3.26	-3.12	0.00	-6.05	5.25	-4.18	-7.05	12.48	0.45	-1.69
PM16	24/06/2003	236.96	37.74	4.46	-0.91	-3.93	-3.70	-3.55	-0.12	-6.25	5.27	-3.69	-6.70	12.53	0.32	-2.92
PM16	28/07/2005	203.99	29.94	4.29	-2.65	-3.93	-4.47	-4.32	-0.33	-8.01	2.63	-3.69	-6.82	7.25	0.11	-3.78
PM18	24/06/2003	166.73	23.49	3.86	-4.96	-4.33	-3.97	-3.82	-0.30	-6.87	4.90	-4.09	-7.01	11.77	0.15	-2.44
PM19	24/06/2003	150.33	23.33	3.42	0.00	-4.35	-3.29	-3.14	-0.17	-5.55	7.49	-4.10	-7.14	16.96	0.28	-1.29
PM3	24/06/2003	581.35	149.75	4.98	-2.26	-2.85	-3.49	-3.34	-0.35	-5.63	4.55	-2.61	-6.07	11.08	0.09	-2.29
PM5	8/06/2005	143.09	26.12	3.57	3.06	-4.20	-5.63	-5.48	-0.55	-10.10	3.48	-3.96	-7.06	8.93	-0.10	-4.67
PM6	23/06/2003	164.83	24.17	3.01	-4.73	-3.99	-4.10	-3.95	0.01	-7.30	3.78	-3.75	-7.23	9.53	0.46	-2.62
PM6	8/06/2005	153.22	28.53	2.77	-4.76	-3.82	-3.84	-3.69	-0.38	-6.71	4.48	-3.58	-7.22	10.94	0.07	-2.78
PM7	5/04/2007	203.35	53.31	2.26	-3.31	-3.05	-4.04	-3.89	-0.20	-7.29	2.56	-2.81	-7.24	7.10	0.25	-2.89
PM8	8/06/2005	118.80	19.53	3.05	-2.79	-4.48	-4.54	-4.40	-0.68	-7.86	3.66	-4.24	-7.33	9.31	-0.23	-2.92
PP4 Shallow	5/04/2007	283.57	66.56	3.52	-1.22	-2.62	-4.34	-4.19	-0.34	-8.20	1.92	-2.38	-6.77	5.84	0.10	-3.56

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
PP4 Shallow	5/04/2007	283.65	66.56	3.52	-1.28	-2.62	-4.33	-4.18	-0.34	-8.19	1.92	-2.38	-6.77	5.84	0.10	-3.55
SE5	7/07/2005	1621.65	271.34	12.41	-0.21	-2.55	-1.34	-1.19	0.02	-1.72	6.04	-2.32	-5.07	14.08	0.46	-1.67
SHIRLEY BALLA	21/07/2005	197.42	58.23	2.34	0.00	-3.95	-5.28	-5.13	-0.36	-9.71	-1.92	-3.71	-7.02	-1.88	0.09	-4.14
T 500	13/09/2005	470.58	126.46	4.25	0.32	-3.01	-2.00	-1.85	-0.33	-3.53	4.76	-2.77	-6.22	11.50	0.12	-2.25
T110 (O)	19/07/2005	254.97	46.33	4.79	2.11	-4.77	-4.39	-4.24	-0.49	-8.10	2.37	-4.54	-6.53	6.73	-0.05	-3.47
T120 (O)	14/04/2004	807.40	155.08	7.34	0.11	-4.59	-2.41	-2.27	-1.45	-3.76		-4.35	-5.66		-1.00	
T130 (I)	15/07/2005	605.91	249.86	2.26	1.71	-2.52	0.65	0.79	-0.63	1.02	7.53	-2.28	-6.58	17.06	-0.19	-2.11
T140 (O)	7/04/2004	374.75	121.00	2.97	2.94	-2.31	-3.99	-3.85	-0.73	-7.33	5.21	-2.08	-6.68	12.42	-0.29	-2.15
T150 (O)	14/04/2004	108.59	25.22	2.15	2.76	-4.10	-4.63	-4.48	-0.68	-8.39	3.23	-3.85	-7.53	8.44	-0.23	-3.28
T161 (I)	19/07/2005	413.18	66.21	6.95	4.82	-4.92	-2.67	-2.53	-0.32	-4.35	5.77	-4.69	-6.15	13.52	0.12	-1.82
T200 (O)	20/07/2005	330.22	74.32	4.54	2.82	-3.23	-2.96	-2.81	-0.42	-5.26	5.29	-2.99	-6.42	12.58	0.02	-1.66
T220	14/04/2004	227.48	33.30	4.52	-0.75	-3.83	-4.23	-4.08	-0.17	-7.43	5.78	-3.60	-6.76	13.54	0.28	-1.39
T260 (O)	19/07/2005	196.57	38.47	3.86	6.28	-3.78	-2.58	-2.43	-0.60	-4.44	5.89	-3.54	-6.93	13.77	-0.16	-2.18
T340 (O)	15/07/2005	878.55	381.70	2.67	2.60	-1.70	0.79	0.93	-0.52	1.37	7.56	-1.46	-6.28	17.11	-0.07	-1.98
T370	7/07/2005	492.79	145.54	3.97	6.08	-2.34	-0.99	-0.84	-0.35	-1.57	7.24	-2.10	-6.48	16.46	0.10	-0.99
T380(O)	7/07/2005	540.12	264.25	1.44	4.10	-2.96	0.50	0.65	-0.28	1.68	7.57	-2.72	-7.05	17.12	0.16	-2.38
T420	7/07/2005	577.94	113.11	6.14	0.18	-3.03	-1.97	-1.83	-0.04	-3.22	5.28	-2.80	-6.02	12.55	0.40	-2.05
T430I	7/06/2005	1242.69	601.89	2.30	0.00	-1.71	-2.38	-2.23	-1.76	-5.09		-1.48	-6.08		-1.31	
T450I	7/06/2005	627.40	144.67	5.79	1.70	-4.32	-1.66	-1.51	-0.29	-2.83	6.68	-4.08	-5.92	15.34	0.16	-0.52
T530	7/05/2005	1517.72	546.28	5.02	0.69	-2.52	0.37	0.51	-0.31	1.00	7.09	-2.28	-5.51	16.17	0.14	-0.99
T540	7/05/2005	130.90	31.62	1.78	-0.91	-3.65	-2.74	-2.59	-0.53	-4.78	6.29	-3.42	-7.68	14.57	-0.09	-1.98
T570	7/04/2005	133.42	27.22	2.42	0.13	-3.71	-3.33	-3.18	-0.46	-5.76	5.40	-3.48	-7.52	12.78	-0.02	-2.64
T580 not 560	7/06/2005	169.36	47.47	1.64	-3.28	-3.38	-2.62	-2.48	-0.48	-4.53	6.14	-3.15	-7.51	14.27	-0.04	-1.84
T600	7/04/2005	276.94	44.81	4.22	-4.29	-4.96	-3.88	-3.73	-0.23	-6.44	4.56	-4.73	-6.65	11.10	0.22	-1.38
T670	7/04/2005	691.37	125.68	8.54	5.31	-3.46	-2.25	-2.11	-0.31	-3.12	7.53	-3.22	-5.72	17.04	0.14	-1.22
T75	29/06/2005	962.52	227.22	7.79	2.62	-2.27	-2.36	-2.21	-0.41	-4.12	5.33	-2.04	-5.51	12.66	0.03	-1.53
T8S (T85)	25/07/2005	634.74	135.54	6.73	0.69	-3.20	-3.40	-3.25	-0.27	-5.56	4.19	-2.97	-5.82	10.38	0.17	-2.42

Station ID	Sampling date	Calc TDS mg/L	Total hardness mg/L $CaCO_4$	SAR meq/L	E.N.	SI Anhydrite	SI Aragonite	SI Calcite	SI Chalcedony	SI Dolomite	SI Goethite	SI Gypsum	SI Halite	SI Hematite	SI Quartz	SI Siderite
TDP1	25/07/2005	1544.32	300.88	9.28	-3.25	-2.01	-2.12	-1.97	-0.02	-3.17	5.56	-1.77	-5.36	13.11	0.42	-1.55
TM4C	6/04/2004	421.64	74.71	4.82	0.03	-2.52	-2.27	-2.12	-0.12	-4.25	-4.93	-2.29	-6.57	-7.87	0.32	-1.20
TM7A	25/07/2005	2014.21	447.27	10.08	-2.12	-2.15	0.48	0.63	-0.03	1.17	7.43	-1.92	-5.00	16.86	0.41	-1.61
TM7C	25/07/2005	1434.47	347.46	8.17	-0.74	-2.03	-0.35	-0.21	-0.30	-0.33	7.30	-1.80	-5.31	16.58	0.14	-0.83
WCM	3/08/2005	276.31	111.85	1.69	-2.32	-2.61	-4.81	-4.67	-0.55	-8.53	1.53	-2.37	-7.36	5.05	-0.11	-4.33
WF 12	10/08/2005	630.15	216.28	3.25	0.85	-2.66	-0.08	0.06	-0.20	-0.06	7.34	-2.43	-6.28	16.68	0.24	-1.45
WH 100	10/08/2005	880.31	226.26	4.92	-4.98	-3.65	0.06	0.20	-0.24	0.20	7.33	-3.42	-5.89	16.65	0.20	-1.35
WM1	16/06/2003	493.08	128.34	3.84	-0.17	-3.07	-1.75	-1.60	0.13	-3.27	5.99	-2.84	-6.31	13.97	0.57	-0.82
WM24	9/06/2003	108.28	36.56	1.08	2.71	-3.28	-4.48	-4.33	-0.16	-8.20	3.72	-3.04	-8.09	9.42	0.29	-3.14
WM29	11/06/2003	464.89	167.47	1.92	2.33	-2.96	-1.53	-1.38	-0.20	-2.23	6.11	-2.71	-6.85	14.20	0.26	-0.86
WM3	16/06/2003	194.22	21.85	4.47	-2.84	-4.81	-4.14	-3.99	0.00	-7.27	3.87	-4.57	-6.94	9.71	0.45	-2.45
WM32	21/07/2003	185.53	26.40	4.40	1.26	-4.17	-5.47	-5.32	-0.17	-10.08	1.14	-3.93	-6.86	4.26	0.28	-4.06
WM4	16/06/2003	174.56	27.41	2.91	-4.04	-3.43	-3.79	-3.64	0.00	-6.89	3.41	-3.18	-7.33	8.79	0.45	-3.22
WM5	16/06/2003	196.47	45.65	2.58	-0.80	-3.52	-4.23	-4.08	-0.07	-7.27	3.82	-3.27	-7.18	9.63	0.38	-2.45
YB 11	26/07/2003	413.02	160.25	1.65	-2.27	-2.89	-0.21	-0.07	-0.01	-0.80	7.65	-2.65	-6.91	17.29	0.43	-1.11
YN 2	26/07/2003	297.06	99.57	2.09	-0.13	-3.07	-1.62	-1.47	-0.10	-3.45	5.11	-2.82	-6.93	12.20	0.35	-2.05
YN 3	26/07/2003	239.56	80.32	1.99	0.66	-3.30	-1.94	-1.79	-0.19	-3.69	6.20	-3.06	-7.05	14.37	0.26	-2.20
YN 3	9/12/2005	243.89	78.42	2.21	-0.03	-3.29	-1.76	-1.61	-0.37	-3.75	5.55	-3.05	-6.95	13.09	0.07	-2.09
YN 5	26/07/2003	1016.77	319.46	4.62	-5.11	-2.29	0.56	0.71	-0.11	0.91	8.44	-2.04	-5.69	18.85	0.34	-1.20
YN 5	9/08/2005	750.83	201.58	4.90	-0.89	-2.89	-0.18	-0.03	-0.39	-0.49	7.18	-2.65	-5.98	16.33	0.06	-1.23
YN 6	26/07/2003	381.66	151.12	1.88	2.70	-3.06	-0.86	-0.71	0.03	-2.11	6.27	-2.81	-6.83	14.51	0.48	-1.56
YN 7	26/07/2003	421.76	158.03	2.39	0.95	-2.26	-1.49	-1.35	-0.04	-3.14	5.12	-2.02	-6.61	12.22	0.41	-2.10
YN 8	26/07/2003	797.36	335.92	2.33	0.20	-2.07	-0.62	-0.48	-0.10	-1.37	6.20	-1.82	-6.39	14.38	0.35	-1.60
YSI 1	9/08/2005	3600.65	885.51	13.45	-4.18	-1.61	0.16	0.31	-0.40	0.65	7.39	-1.38	-4.41	16.77	0.04	-1.73
YY3 (I)	8/03/2004	300.63	71.08	3.57	0.03	-4.72	-0.62	-0.47	-0.64	-0.80	7.25	-4.49	-6.67	16.49	-0.19	1.09
YY3(I)	28/07/2005	317.35	85.18	3.53	4.44	-4.05	-1.74	-1.60	-0.37	-3.06	6.18	-3.82	-6.60	14.36	0.07	-1.59

Note: E.N. – , SAR – sodium absorption ratio, SI – saturated index, blanks – not calulated

Appendix J – Wetland and groundwater chemistry comparison sample report

Main sample: Loch McNess 8754,18/05/2005

Sample	Corr coeff	Euclidean distance
Loch McNess 8754,18/05/2005	1.00	0.00
YN 5,9/08/2005	0.99	240.38
WH 100,10/08/2005	0.99	315.93
Pipidinny Swamp 2,18/05/2005	0.99	152.49
YN 3,9/12/2005	0.99	33.77
YN 7,26/07/2003	0.93	53.05
YN 6,26/07/2003	0.92	50.70
Lake Yonderup,18/05/2005	0.85	54.07
YB 11,26/07/2003	0.82	89.58
Lake Nowergup,19/05/2005	0.75	74.49
LN 2/89,9/08/2005	0.73	69.69
Sea water	0.63	21803.59
L Pinjar rain,1/09/2003	0.61	132.84

Main sample: Lake Yonderup,18/05/2005

Sample	Corr coeff	Euclidean distance
Lake Yonderup,18/05/2005	1.00	0.00
YN 7,26/07/2003	0.97	26.56
Pipidinny Swamp 2,18/05/2005	0.93	138.89
YN 3,9/12/2005	0.86	68.61
Loch McNess 8754,18/05/2005	0.85	54.07
LN 2/89,9/08/2005	0.84	78.32
YN 5,9/08/2005	0.81	241.36
Sea water	0.66	21787.94
L Pinjar rain,1/09/2003	0.66	152.39

Main sample: Lake Nowergup,19/05/2005

Sample	Corr coeff	Euclidean distance
Lake Nowergup,19/05/2005	1.00	0.00
PM 33,15/07/2003	0.99	121.17
YB 11,26/07/2003	0.99	51.25
PM 31,26/07/2003	0.93	65.86
JP 18C,6/06/2003	0.25	215.64
Sea water	-0.04	21852.69
L Pinjar rain,1/09/2003	-0.07	152.63

Main sample: Lake Joondalup 8281,19/05/2005

Main sample: Lake Mariginiup 1943,19/05/2005

Sample	Corr coeff	Euclidean distance
Lake Mariginiup 1943,19/05/2005	1.00	0.00
WM24,9/06/2003	0.98	1329.80
MS10,5/07/2007	0.70	985.81
JB5,9/06/2003	0.60	1304.61
MT1S,6/09/2005	0.55	1301.62
Jandabup Lake 1944,24/05/2005	0.41	1290.25
MS7,9/06/2003	0.38	1007.82
8386,12/09/2005	0.33	1316.70
Gnangara Lake 8386,24/05/2005	0.32	1007.53
8281,20/06/2005	0.26	1266.38
L Pinjar rain,1/09/2003	0.24	1362.82
Sea water	0.20	21177.02
JB 4,8/02/2005	0.14	1203.34
MT1D,5/07/2007	0.00	1306.04

Main sample: Pipidinny Swamp 1,18/05/2005

Sample	Corr coeff	Euclidean distance
Pipidinny Swamp 1,18/05/2005	1.00	0.00
L Pinjar rain,1/09/2003	0.99	7440.17
Sea water	0.99	14583.46
YN 7,26/07/2003	0.77	7297.57
Pipidinny Swamp 2,18/05/2005	0.61	7214.57
Loch McNess 8754,18/05/2005	0.60	7338.64
WH 100,10/08/2005	0.49	7115.60
YN 6,26/07/2003	0.27	7339.44
YB 11,26/07/2003	0.05	7346.25

Main sample: Pipidinny Swamp 2,18/05/2005

Sample	Corr coeff	Euclidean distance
Pipidinny Swamp 2,18/05/2005	1.00	0.00
Loch McNess 8754,18/05/2005	0.99	152.49
YN 7,26/07/2003	0.97	119.11
WH 100,10/08/2005	0.96	183.27
YN 6,26/07/2003	0.91	132.71
YB 11,26/07/2003	0.82	132.97
Sea water	0.62	21685.94
Pipidinny Swamp 1,18/05/2005	0.61	7214.57
L Pinjar rain,1/09/2003	0.60	283.15

Main sample: Jandabup Lake 1944,24/05/2005

Sample	Corr coeff	Euclidean distance
Lake Joondalup 8281,19/05/2005	1.00	0.00
Lake Goollelal 459,24/05/2005	0.96	100.02
Gnangara Lake 8386,24/05/2005	0.95	304.31
Jandabup Lake 1944,24/05/2005	0.93	253.61
MS7,9/06/2003	0.92	281.12
FL1,30/06/2005	0.88	233.18
GD 2,6/06/2003	0.87	172.40
MS10,5/07/2007	0.85	193.04
JB 4,8/02/2005	0.83	153.92
L Pinjar rain,1/09/2003	0.76	348.34
Sea water	0.75	21617.84
JP 18C,6/06/2003	0.74	197.81
8281,20/06/2005	0.62	229.99
WH 100,10/08/2005	0.62	240.62

Main sample: Lake Goollelal 459,24/05/2005

Sample	Corr coeff	Euclidean distance
Lake Goollelal 459,24/05/2005	1.00	0.00
Lake Joondalup 8281,19/05/2005	0.96	100.02
MT1S,6/09/2005	0.95	185.90
MM16,6/12/2003	0.94	63.01
MS10,5/07/2007	0.94	232.15
JB5,9/06/2003	0.93	192.24
Jandabup Lake 1944,24/05/2005	0.92	164.50
MS7,9/06/2003	0.91	361.22
Gnangara Lake 8386,24/05/2005	0.90	352.14
8386,12/09/2005	0.85	197.45
JB 4,8/02/2005	0.77	160.83
L Pinjar rain,1/09/2003	0.77	258.27
Sea water	0.75	21691.90
WM24,9/06/2003	0.75	234.28
MT1D,5/07/2007	0.69	166.81
Lake Mariginiup 1943,19/05/2005	0.68	1147.35
JB 9C,4/06/2003	0.67	215.48
8281,20/06/2005	0.51	153.49
Loch McNess 8754,18/05/2005	0.49	169.36
WH 100,10/08/2005	0.39	301.35

Main sample: North Lake 425,17/05/2005

Sample	Corr coeff	Euclidean distance
North Lake 425,17/05/2005	1.00	0.00

Sample	Corr coeff	Euclidean distance
Jandabup Lake 1944,24/05/2005	1.00	0.00
Gnangara Lake 8386,24/05/2005	1.00	479.52
MS7,9/06/2003	1.00	504.36
8386,12/09/2005	0.98	33.73
MT1S,6/09/2005	0.98	27.46
JB 4,8/02/2005	0.96	236.80
JB5,9/06/2003	0.96	34.99
L Pinjar rain,1/09/2003	0.95	97.90
Sea water	0.94	21812.36
Lake Joondalup 8281,19/05/2005	0.93	253.61
Lake Goollelal 459,24/05/2005	0.92	164.50
MS10,5/07/2007	0.92	376.28
MT1D,5/07/2007	0.91	55.02
JB 9C,4/06/2003	0.90	51.71

Main sample: Gnangara Lake 8386,24/05/2005

Sample	Corr coeff	Euclidean distance
Gnangara Lake 8386,24/05/2005	1.00	0.00
MS7,9/06/2003	1.00	142.06
Jandabup Lake 1944,24/05/2005	1.00	479.52
8386,12/09/2005	0.99	505.51
MT1S,6/09/2005	0.98	503.10
L Pinjar rain,1/09/2003	0.97	573.29
JB 4,8/02/2005	0.97	277.48
JB5,9/06/2003	0.97	508.21
Sea water	0.96	21349.57
WM29,11/06/2003	0.96	518.09
Lake Joondalup 8281,19/05/2005	0.95	304.31
MM16,6/12/2003	0.93	373.27
MT1D,5/07/2007	0.93	456.86
MS10,5/07/2007	0.93	160.81
JB 9C,4/06/2003	0.92	522.47
Herdsman Lake 619,24/05/2005	0.90	488.08
Lake Goollelal 459,24/05/2005	0.90	352.14
JB 9A,4/06/2003	0.82	522.63
WM24,9/06/2003	0.42	556.72
Lake Mariginiup 1943,19/05/2005	0.32	1007.53

Main sample: Lake Gwelup 465, 24/05/2005

Sample	Corr coeff	Euclidean distance
Lake Gwelup 465,24/05/2005	1.00	0.00

NL424,29/06/2005	0.91	75.88
Bibra Lake 425,17/05/2005	0.87	319.76
L Pinjar rain,1/09/2003	0.85	205.20
Sea water	0.83	21723.00
JM12,5/04/2004	0.80	124.73

Main sample: Bibra Lake 425,17/05/2005

Sample	Corr coeff	Euclidean distance
Bibra Lake 425,17/05/2005	1.00	0.00
Gnangara Lake 8386,24/05/2005	0.99	200.88
NL424,29/06/2005	0.99	263.72
JM12,5/04/2004	0.98	411.89
L Pinjar rain,1/09/2003	0.90	506.70
Sea water	0.90	21449.80
North Lake 425,17/05/2005	0.87	319.76

Main sample: Lake Forrestdale 602,30/05/2005

Sample	Corr coeff	Euclidean distance
Lake Forrestdale 602,30/05/2005	1.00	0.00
North Lake 425,17/05/2005	0.68	1808.78
NL424,29/06/2005	0.36	1810.58
Bibra Lake 425,17/05/2005	0.35	1641.53
L Pinjar rain,1/09/2003	0.23	1985.58
Sea water	0.19	20856.74
FL1,30/06/2005	0.11	1909.82
T110 (O),19/07/2005	0.05	1926.33

Main sample: Lake Walyungup 1470,17/05/2005

Sample	Corr coeff	Euclidean distance
Lake Walyungup 1470,17/05/2005	1.00	0.00
L Pinjar rain,1/09/2003	1.00	15541.03
Sea water	1.00	6601.04
T110 (O),19/07/2005	0.97	15403.42
FL1,30/06/2005	0.91	15428.29
Lake Forrestdale 602,30/05/2005	0.23	14424.96
T340 (O),15/07/2005	0.03	15319.41
T380(O),7/07/2005	-0.22	15458.98

Lake Forrestdale 602,30/05/2005	0.65	1894.15
Lake Mariginiup 1943,19/05/2005	0.59	1276.38
WM24,9/06/2003	0.55	91.90
GD 2,6/06/2003	0.54	124.76
GM 16,22/06/2005	0.27	175.46
Lake Goollelal 459,24/05/2005	0.20	206.98
Lake Joondalup 8281,19/05/2005	0.13	293.50
Lake Yonderup,18/05/2005	0.12	121.95
GM26,27/06/2005	0.02	224.92
MM16,6/12/2003	0.02	180.93

Main sample: Herdsman Lake 619,24/05/2005

Sample	Corr coeff	Euclidean distance
Herdsman Lake 619,24/05/2005	1.00	0.00
GM26,27/06/2005	1.00	16.91
GM 16,22/06/2005	0.93	74.31
Lake Monger, 24/05/2005	0.82	112.05
GD23,27/06/2005	0.74	120.30
Lake Joondalup 8281,19/05/2005	0.47	207.59
GD5,27/06/2005	0.28	940.21
Sea water	0.17	21763.91
L Pinjar rain,1/09/2003	0.15	263.58
Lake Gwelup 465,24/05/2005	-0.02	228.57

Main sample: Lake Monger, 24/05/2005

Sample	Corr coeff	Euclidean distance
Lake Monger, 24/05/2005	1.00	0.00
GD23,27/06/2005	0.97	53.92
Gnangara Lake 8386,24/05/2005	0.96	381.28
JB 9A,4/06/2003	0.90	194.23
Lake Yonderup,18/05/2005	0.89	155.84
Herdsman Lake 619,24/05/2005	0.82	112.05
GM26,27/06/2005	0.80	118.08
GM 16,22/06/2005	0.79	120.35
GD5,27/06/2005	0.75	850.89
Sea water	0.70	21664.86
L Pinjar rain,1/09/2003	0.68	293.83
Lake Gwelup 465,24/05/2005	-0.25	270.81

Shortened forms

CDFM	Cumulative deviation from mean
DO	Dissolved oxygen
EC	Electrical conductivity
Eh	Reduction potential
GIS	Geographic information system
m AHD	Elevation relative to Australian height datum
mbgl	Metres below ground level
Sic	Saturation indices for calcite
TDS	Total dissolved solids
WIN	Water information network

References and further reading

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