LOTS 14, 15 & 299 KEROSENE LANE, BALDIVIS

LOCAL WATER MANAGEMENT STRATEGY

Prepared for:

Galati Nominees

Job No: 08.406

Report No: RP001

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions. Also it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

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The report has been prepared for the benefit of the Client and no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

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ENV will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

This report has been prepared to support the submission of a Local Structure Plan for the land located in Lots 14, 15 and 299, Kerosene Lane, Baldivis.

Under *Better Urban Water Management (BUWM)* (WAPC 2008a), a Local Water Management Strategy (LWMS) is required to support a Local Structure Plan prior to subdivision and development of land zoned Urban. The BUWM sets out the requirements for a LWMS, which must be approved by the Western Australian Planning Commission on advice of the Department of Water as part of the Local structure Plan Approval.

The objective of the LWMS is to ensure that sustainable management of the total water cycle at the Kerosene Lane development occurs through Water Sensitive Urban Design. This includes water conservation, stormwater management and groundwater management. Galati nominees aim to manage these issues at Lots 14, 15 and 299, Kerosene Lane, through the following initiatives:

Water Conservation

- Providing front yard Waterwise landscaping packages for residential lots that include waterwise plants, soil amendments to improve water and nutrient retention, minimal turf areas and water efficient irrigation; and
- Providing information packages to educate landowners on ex-house and in-house waterwise measures.

Stormwater Management

- Implementing a drainage design that ensures no flow off the site in the 1 in 100 year event from the development to pre-development levels through storage and infiltration on site; and
- Maximising infiltration on the subject site by constructing infiltration basins in POS where possible, planted with vegetation or grasses to encourage nutrient and suspended solids uptake and removal prior to infiltration. Side entry pits and associated manholes will also be open based to maximise infiltration.

Groundwater Management

- Ensuring infiltration basins are planted with vegetation or grass in frequently inundated areas to strip nutrients prior to infiltration;
- Limiting the use of fertilisers in POS; and
- Providing information packages to educate landowners on fertilise wise gardening through provision of information at settlement.

This LWMS demonstrates that Lots 14, 15 and 299, Kerosene Lane, Baldivis can be developed in a way that manages hydrological constraints. The outstanding issues can be resolved at the Urban Water Management Plan stage to create a development that meets the goals and ideals of *Better Urban Water Management*.

1 INTRODUCTION

This Local Water Management Strategy (LWMS) has been prepared to support the submission of a Local Structure Plan for Lots 14, 15 and 299, Kerosene Lane, Baldivis (the site). The total area of the site is approximately 39 Ha. The site is located approximately 38 km south west of the Perth Central Business District and is bounded to the north by Kerosene Lane, to the south by market gardens, to the west by markets gardens and uncleared bushland and to the east by market gardens, existing residential and proposed residential areas. The site is adjacent to areas supporting native vegetation and sand extraction activities to the north-east (Figure 1). Lake Cooloongup is approximately 750 m to the east and Kerosene Lane Swamp more than 50 m to the north. The site is currently used for market gardens and related processing activities and thus contains little remnant vegetation.

The site lies within the Baldivis (North) District Structure Plan (DSP) area and within the City of Rockingham. Under *Better Urban Water Management* (BUWM) (WAPC, 2008a) and *Planning Bulletin 92* (WAPC 2008b) a Local Water Management Strategy (LWMS) is required to support a Local Structure Plan. The LWMS provides strategic information regarding the management of water in the development while outlining and demonstrating the feasibility of the proposed design. This work is then refined and details confirmed at the Subdivision Stage, through Urban Water Management Plans. *BUWM* sets out the requirements for a LWMS, which must be reviewed and approved by the City of Rockingham and Department of Water prior to development proceeding.

1.1 TOTAL WATER CYCLE MANAGEMENT – PRINCIPLES AND OBJECTIVES

The process of managing the total water cycle in an urban scenario is referred to as Water Sensitive Urban Design (WSUD). A Local Water Management Strategy seeks to support WSUD by assisting to design, develop and maintain urban water systems that are sensitive to the total water cycle. The principles of WSUD as outlined in the *Better Urban Water Management* (BUWM) (WAPC 2008a) have been used here. These principles are to:

- Protect natural systems – protect and enhance natural water systems and their hydrological regimes in urban developments;
- Integrate stormwater treatment into the landscape – use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments;

- Protect water quality – protect the water quality draining from urban development and minimise outputs of phosphorus and nitrogen and other pollutants;

- Manage run-off and peak flows – reduce peak flows from urban developments by using local detention measures and minimising impervious areas; and

- Add value while minimising development costs – minimise the drainage infrastructure cost of development.

1.2 PLANNING BACKGROUND

1.2.1 Metropolitan Region Scheme

Under the provisions of the Metropolitan Region Scheme (MRS), the subject site is zoned 'Urban'. Land located immediately to the north of the subject site is currently zoned 'Rural'. An 'other regional road' reservation (extension of Eighty Road) is located to the east of this LSP area.

1.2.2 City of Rockingham Town Planning Scheme No. 2

The City of Rockingham Town Planning Scheme No. 2 (TPS2) was gazetted on 19 November 2004.

Under the provisions of TPS2 the subject site is currently zoned 'Development' with an applicable residential density of 'R20/40'. Lot 299 also has an additional use which allows for the retail sale of fruit and vegetables and associated incidental items from the site.

1.2.3 Baldivis (North) District Structure Plan

The Baldivis (North) District Structure Plan (DSP) was approved by the City of Rockingham in 2000 to support the urbanisation of the land.

The City of Rockingham commissioned the preparation of the DSP for the proposed urban areas of Baldivis located north of Safety Bay Road. The Structure Plan area includes all the 'Urban' and 'Urban Deferred' zoned land located within Kerosene Lane, Baldivis Road, Safety Bay Road and Mandurah Road.

A District Water Management Strategy was not developed as part of the DSP, as there was no requirement for such reports when the DSP was written.

1.3 PREVIOUS STUDIES

Previous studies into land and water management in the area are:

- Baldivis (North) District Structure Plan (Taylor Burrell et al. 2000)
- Lot 14, 15 and 299, Kerosene Lane, Baldivis Local Structure Plan: Environmental Report (ENV Australia 2008a)
- Lot 14, 15 and 299, Kerosene Lane, Baldivis Environmental Preliminary Site Investigation (ENV Australia 2008b)

2 PROPOSED DEVELOPMENT

2.1 KEY POINTS OF STRUCTURE PLAN

The Local Structure Plan represents a mixed use residential development including low (R20) and medium (R30 to R60) densities, a commercial precinct and a school (Figure 2).

The area of Public Open Space (POS) meets the normal 10% gross land area requirement.

2.2 ENVIRONMENTAL REPORT AND MANAGEMENT PLAN

An Environmental Assessment of Lots 14, 15 and 299, Kerosene Lane was undertaken by ENV Australia and included in the Local Structure Plan. The report is based on the work done for a Preliminary Site Investigation (PSI), Acid Sulphate Soil (ASS) Investigation and Hydrology Investigation carried out by ENV Australia on Lots 14, 15 and 299. The report includes recommendations for environmental management of the site related to the proposed development such as provision of sufficient buffers for a neighbouring gas pipeline, sand quarries, poultry farms and neighbouring market gardens. The lack of native vegetation is not a constraint to the proposed development.

3 PRE-DEVELOPMENT ENVIRONMENT

3.1 TOPOGRAPHY

The topographic height of the site ranges from 6-18 m Australian Height Datum (AHD). The landscape is gently undulating (Figure 3). The highest point occurs in the north-east corner of the site and the lowest point occurs in the north-west of the site (Figure 3).

3.2 SOILS AND GEOLOGY

The sites soils are identified by Gozzard (1983) as consisting of mostly Sand derived from Tamala Limestone (S7) with a pocket of Limestone and Safety Bay sand (LS) in the south west corner (Figure 4). These soils are described as:

- *Sand derived from Tamala Limestone* (S_7) – Sand, pale and olive yellow, medium to coarse-grained, sub-angular quartz with a trace of feldspar, moderately sorted, of residual origin; and

- *Limestone* (L_S) – Pale yellowish brown, fine to coarse grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin. This land unit may have limestone rock present at the surface.

Geology mapping matches the observations of the soil profile taken when drilling the monitoring bores (Appendix A). The soil types on the site are generally highly permeable apart from some of the limestone rock outcrops. The sands in the site are expected to have a hydraulic conductivity of 8-50 m/day (Davidson 1995).

3.2.1 Acid Sulfate Soils

Acid Sulfate Soil (ASS) risk mapping (shown in Figure 5) indicates that the site is located in an area of “no known risk of ASS occurring within three metres of the natural soil surface” (WAPC 2003). A small area located approximately 200 m to the north of the site is present which has a “high to moderate risk of ASS occurring within three metres of the natural soil surface” (WAPC 2003). Based on this risk ASS is not considered to be a constraint on this site.

3.2.2 Contaminated Sites Assessment

An assessment of contamination is required for the site under the Contaminated Sites Act (2003) because it has been used as a market garden. A Preliminary Site Investigation (PSI) following Department of Environment and Conservation (DEC) guidelines was completed for Lots 14, 15 and 299, Kerosene Lane in July 2008 (ENV Australia 2008b), as required by the DEC *Contaminated Sites*

Management Series – Reporting on Site Assessments (DEP 2001). Based on this PSI, areas of potential contamination were identified at the subject site.

Because the site has historically been a market garden, a contaminated sites condition may be imposed for the subdivision of the site. If required, this work will be undertaken to the satisfaction of the Department of Environment and Conservation (DEC).

3.2.3 Phosphorus Retention Index

The Phosphorus Retention Index (PRI) is an index to classify the phosphorus adsorption capacity of soils. Soil samples were collected at each bore from a depth of 0.05m and sent to a laboratory for PRI analysis. Mean results are presented in Table 1 and full results are shown in Appendix B. According to Allen and Jeffery (1990) the soil at all bores may be classed as 'very weakly adsorbing or desorbing' when the PRI is less than 2. These results suggest that site soils do not retain phosphorus. This has implications for the use of fertilisers on the site, particularly with regards to leaching into groundwater and potentially increasing nutrient levels.

Table 1: Mean Phosphorus Retention Index Results (PRI)

Bore	Mean PRI
MW1	0.95
MW2	0.9
MW3	1.05
MW4	1.6
MW5	1.1

3.3 SURFACE WATER QUANTITY AND QUALITY

There are no ephemeral or permanent surface water bodies within the site. The nearest wetlands are Kerosene Lane Swamp (more than 50 m north of the site) and Lake Cooloongup (approximately 750 m west of the site) (Figure 1). Both Lake Cooloongup and Kerosene Lane Swamp are Conservation Category Wetlands which are also identified by the Environmental Protection (Swan Coastal Lakes) Policy 1992 (as EPP Lakes).

The site is currently cleared and used as market gardens with a soil profile consisting of medium grained sand at the surface. Thus the site soils maintain a high hydraulic conductivity. Hydraulic processes are dominated by infiltration

with little to no surface run-off following rainfall except during extreme events. As a result there are no dedicated drainage lines in the site due to the high infiltration capacity and topography of the site (ENV Australia 2008a).

3.4 GROUNDWATER QUANTITY AND QUALITY

The site is located within the area defined in the Perth Groundwater Atlas (PGWA) (WRC 1997 and DoE 2004a). The PGWA shows groundwater flow to be in a westerly direction (DoE 2004a). Minimum groundwater levels are presented in the PGWA as approximately 1 mAHD across the site (DoW 2004a), while maximum groundwater levels are shown to be between 3 and 4 mAHD (WRC 1997). The hydraulic gradient shown across the site is approximately 1 in 1000 or 1 m in 1 km which is very low. This is typical of limestone formations found in the Baldivis area.

Groundwater monitoring was undertaken in 2008. One Department of Water (DoW) groundwater monitoring well is located adjacent to the site and five monitoring wells were installed by ENV Australia within the site (Figure 6). The wells were monitored for water level and quality. The groundwater levels measured in the DoW bore since installation in 1975 (full records shown in Appendix C) were also reviewed to provide maximum and minimum groundwater levels (Figure 6). The calculated maximum groundwater levels on the site varied from 2.98 mAHD at MW4 in the southeast to 2.87 mAHD at MW1 in the centre of the site. The minimum groundwater levels measured onsite varied from 1.84 mAHD at MW4 in the southeast to 1.47 mAHD at MW1 in the centre of the site (Appendix D). The bore records are shown in Table 2. Full monitoring records may be found in Appendix D.

The groundwater levels measured by ENV did not indicate a clear flow direction. Geology mapping also reveals that the site is situated mostly on sand derived from limestone with pockets of limestone rock situated throughout the site (Gozzard 1983). Such geology typically has very high hydraulic conductivity. Under such conditions groundwater flow direction can be difficult to determine, particularly on small sites such as Lots 14, 15 and 299, Kerosene Lane. The Kerosene Lane area also has many market gardens with bores extracting groundwater. The impact of drawdown from these bores can change and reverse local flow directions, leading to complex groundwater patterns of the type seen at Kerosene Lane. Regardless of this it is considered that the regional flow direction is towards the west (Figure 3).

The shortest distance between the calculated maximum groundwater level and the natural surface is 3.51 m (bore MW3). The largest distance between the calculated maximum groundwater level and the natural surface is 16.63 m (DoW 3035) (Table 2).

Table 2: Maximum Groundwater Levels at Site Bores

Bore	Calculated Maximum Groundwater Level (mAHD)	Depth to Calculated Maximum Groundwater Level (m)
MW1	2.87	8.02
MW2	2.94	15.07
MW3	2.92	3.51
MW4	2.98	9.65
MW5	2.90	10.03
DoW 3035	2.93	16.63

Salinity levels measured in groundwater are in the 'fresh water' range (0-500 mg/L TDS) (DoE 2004a) and pH is generally stable and neutral (Table 3). Full physical parameter results may be found in Appendix D.

Table 3: Mean Physical Parameters

Bore	EC (mS/cm)	TDS (mg/L)	pH
MW1	4.08	135	6.75
MW2	0.63	95	7.29
MW3	3.53	154	6.94
MW4	1.32	115	7.23
MW5	2.63	129	7.15

Groundwater on the site is generally low in phosphorus with average total phosphorus (TP) varying between 0.06 and 0.91 mg/L (Table 4 and Figure 7). The TP concentrations exceeded the Short Term Swan-Canning Cleanup Program (SCCP) target of 0.2 mg/L (SRT 1999) at two bores (MW3 and MW5) (Table 4). The total nitrogen (TN) concentrations exceeded the Short Term SCCP target of 2 mg/L at all bores (Table 4 and Figure 7). High TN and nitrate concentrations may be due to impacts from upgradient market gardens. An investigation into laboratory analysis was conducted to confirm these levels. Duplicate and triplicate samples were taken at MW2 to determine the intra and inter-laboratory accuracy, respectively. Relative Percentage Differences (RPDs) were calculated for both the duplicate and triplicate samples. RPDs for all duplicate nutrient analyses were less than 50% and the majority of the RPDs for the triplicate nutrient analyses were less than 50%, which is considered within

acceptable error range (Standards Australia 1998). Full nutrient results and RPD calculations may be found in Appendix D.

Table 4: Mean Nutrient Results

Bore	Total P	PO_4	Total N	NO_3-N	NH_3-N	TKN
MW1	0.06	0.02	177	177	0.06	<0.2
MW2	0.19	0.01	6.25	5.6	0.05	0.7
MW3	0.91	0.01	117	113	0.06	4.4
MW4	0.17	<0.01	13.4	12.3	0.05	1.1
MW5	0.60	<0.01	145	141	0.07	4.1
SCCP[1] Long Term Target	0.1		1			
SCCP[1] Short Term Target	0.2		2			
DoE 2003[2]				11.3[3]		

[1]Swan River Trust (2003)

[2]DoE (2003)

[3]The NO3-N assessment level has been calculated from the total NO3 assessment level for water (50 mg/L) in DoE (2003).

3.5 ENVIRONMENTAL ASSETS

This section represents a brief summary of the environmental assets and water dependent ecosystems on the site.

3.5.1 Bush Forever

There is no native vegetation on the site; however, an area of bushland approximately 100 m north east of the site is identified as Bush Forever site No 356. This site is part of Lake Cooloongup, Lake Walyungup and adjacent Bushland, Hillman to Port Kennedy (Figure 8). No buffers to development apply to Bush Forever sites.

3.5.2 Water Dependant Ecosystems

The site is approximately 750 m to the east of Lake Cooloongup and more than 50 m south of Kerosene Lane Swamp, a small wetland to the north of Kerosene Lane (Figure 1). Both Lake Cooloongup and Kerosene Lane Swamp are Conservation Category wetlands which are also identified by the Environmental Protection (Swan Coastal Lakes) Policy 1992 giving them protection under the Environmental Protection Act (1986).

The Environmental Protection Authority (EPA) requires that buffer separation distances of 50–100 m from development apply to conservation category wetlands (EPA 2008). The separation distances, including the presence of Kerosene Lane swamp, are such that buffer requirements do not affect the site.

4 DESIGN CRITERIA

The principles, design objectives and criteria shown here are from *Better Urban Water Management (BUWM)* (WAPC 2008a) which is the appropriate guidance document for the Kerosene Lane area. Quotes from BUWM are shown in italics.

4.1 WATER CONSERVATION - AND EFFICIENCY

Principle

No potable water should be used outside of homes and buildings with the use of water to be as efficient as possible (WAPC 2008a).

Design Objectives

Consumption target for potable water of 100 kL/person/year (State Water Plan Target), including not more than 40-60 kL/person/year scheme water (WAPC 2008a).

Site Response

The 40-60 kL/person/year scheme water target is well below the State Water Plan target of 100 kL/person/year scheme water use. At the time of preparation of the State Water Plan, the average Perth Water Use was 153 kL/person/year (Government of Western Australia 2007). As approximately half of domestic water use is for ex-house purposes (Coghlan and Loh 2003), meeting this target requires that no potable water is used outside the home. The development will achieve the 100 kL/person/year State Water Plan target.

4.2 WATER QUANTITY MANAGEMENT

Principle

Post-development annual discharge volume and peak flows will be maintained relative to pre-development conditions, unless otherwise established through determination of Ecological Water Requirements for sensitive environments (WAPC 2008a).

Criteria

<u>Ecological Protection</u> - For the critical one year average recurrence interval (ARI) event, the post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore

desirable environmental flows and/or hydrological cycles as specified by the DoW.

Flood Management - Manage the catchment run-off for up to the 1 in 100 year ARI event in the development area to pre-development peak flows, unless otherwise indicated in an approved strategy or as negotiated with the relevant drainage service provider (WAPC 2008a).

Site Response

In the pre-development case, there is not considered to be any flow off the site because of the high hydraulic conductivity of the site soils.

The post-development drainage strategy is based on infiltration of all stormwater on-site in events up to the 1 in 100 year event, which maintains the pre-development condition.

4.3 WATER QUALITY MANAGEMENT

These are intended to apply to run-off from impervious areas and should be met in addition to the groundwater design objectives.

Principle

Maintain surface and groundwater quality at pre-development levels (winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub-catchment in which the development is located (WAPC 2008a).

Criteria

Contaminated Sites – To be managed in accordance with the Contaminated Sites Act 2003.

All other Land – If the pollutant outputs from the development (measured or modelled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements in the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. If these conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the National Water Quality Management Strategy (ARMCANZ & ANZECC 2000) (WAPC 2008a).

Site Response

The development proposes to use Best Management Practices in line with the Stormwater Management Manual (DoW 2004-2007) to manage water quality on

the site. Any groundwater contamination found on the site will be managed in accordance with the Contaminated Sites Act (2003).

4.4 STORMWATER MODELLING CRITERIA

Principle

If it is proposed to use a stormwater modelling tool to demonstrate compliance with design objectives, the following design modelling parameters are recommended.

As compared to a development that does not actively manage stormwater quality:

- *At least 80% reduction in the average annual load of total suspended solids;*
- *At least 60% reduction in the average annual load of total phosphorus;*
- *At least 45% reduction in the average annual load of total nitrogen; and*
- *At least 70% reduction in the average annual load of gross pollutants* (WAPC 2008a).

Site Response

Stormwater modelling is not proposed for the site at this stage because currently there is no commercially available tool approved by the DoW to undertake such modelling for this area. Should such a tool become available, modelling will be undertaken at an Urban Water Management Plan stage.

Biofiltration areas with an equivalent area of 2% of the directly connected constructed impervious area will be installed.

4.5 DISEASE VECTOR AND NUISANCE INSECT MANAGEMENT

Principle:

To reduce health risks from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated in a time period not exceeding 96 hours.

*Permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of the Departments of Water and Health (*WAPC 2008a).

Site Response

The system has been designed to ensure that detained immobile stormwater is fully infiltrated in a time period not exceeding 96 hours.

Permanent water bodies are not proposed for this site.

5 WATER CONSERVATION STRATEGY

5.1 INTRODUCTION

This section provides a summary of water conservation measures that will be undertaken in the Kerosene Lane development. Water conservation criteria for Water Sensitive Urban Design (WSUD) in *Better Urban Water Management* (BUWM) (WAPC 2008a) provide a consumption target of 100 kL/person/year, including not more than 40-60 kL/person/year of scheme water. At- a minimum, the Kerosene Lane will meet the State Water Strategy target of 100 kL/person/year for the LWMS to be approved.

This section also addresses the provision of water for the irrigation of areas of Public Open Space (POS) within the development and the servicing of potable water and wastewater supplies and sources. Water conservation issues are summarised and relevant matters to be addressed at the subdivision stage are presented.

5.2 WATER CONSERVATION MEASURES

Approximately half of all household water use is for maintaining gardens; therefore minimising water demand for landscaping is an essential water conservation measure for residential areas. Ex-house irrigation controls can be easily implemented through developer provided landscaping packages and are therefore easy to enforce.

It is intended that waterwise landscaping packages will be provided by Galati nominees and will include the verge and front yards. These packages will include the use of soil amendments (such as mulch or clayey/loamy soils to improve water and nutrient retention), waterwise plants (with native options), paving or mulched surfaces and minimal turf areas.

Support will also be provided to residents to educate them on how to minimise their water use. Packages of information will be provided to individual homeowners at the sale of lots and will include information on reducing fertiliser use and other water conservation and environmental management measures, including but not limited to:

- Using Water Efficiency Labelling and Standards (WELS) to choose fixtures with greater than four stars for tap fittings and three stars for shower heads, as well as advice about choosing flow regulators, washing machines and relevant rebates available from DoW;

- Water efficiency measures for ex-house use including how to operate waterwise irrigation systems, frequency and timing of irrigation, landscaping packages and timing and the use of pool covers;

- Rainwater tanks, requirements, regulatory approvals and information about installation of tanks, switching systems and plumbing to toilets and/or laundry and relevant rebates; and

- Greywater systems including requirements, approved products, regulatory approvals, installation of infrastructure for irrigation and relevant rebates available.

5.3 PROJECTED POTABLE WATER CONSUMPTION

The 100 kL/person/year target can be achieved as shown in Table 5, according to current water yields calculated from given lot yields, Water Corporation Waterwise Calculator assumptions and dwelling statistics. It is estimated that a resident living in the Kerosene Lane development will potentially use 84 kL/year on average of scheme water. This is 260 kL/year for the average house of 2.44 people. This number was calculated assuming that front yard waterwise landscaping was adopted and irrigation not over applied. These assumptions were based upon likely take up of in-house and ex-house waterwise measures from methods described in distributed information packages. Full potable demand calculations may be found in Appendix E.

Table 5: Average Predicted Scheme Water Usage

SCENARIO: FRONT YARD WATERWISE LANDSCAPING PACKAGE

		Volume Per Resident (L)	Annual Usage (kL/resident/yr)	Total Usage (kL/year)
Low	In-house	160	58	61,848
	Ex-house	78	28	29,961
	Total	238	87	91,809
Medium	In-house	167	61	23,339
	Ex-house	43	16	6,049
	Total	211	77	29,388
			In-house	85,187
			Ex-house	36,009
			Total	121,196

Average scheme water usage (kL/yr/resident) **84.20**
= Total Usage/ Total Residents

Average scheme water usage (kL/yr/dwelling) **205.42**
= Total Usage/ Total Residents

5.4 PUBLIC OPEN SPACE (POS)

Galati nominees submitted a successful licence application to the Department of Water (DoW) for an allocation of 250 ML/year to irrigate Lot 299, Kerosene Lane and 206.15 ML/year to irrigate Lots 14 and 15, Kerosene Lane. The groundwater allocation provided by the DoW is sufficient to ensure the irrigation of the proposed POS within the Kerosene Lane development at conventional irrigation rates.

The current groundwater licence held by Galati nominees will be amended in the Urban Water Management Plan at the subdivision stage accordingly, to meet an allocation which will reflect new water requirements at the proposed development. This includes an estimated irrigation rate for POS and the proposed school of 7,500 kL/ha/yr. Given that the total POS area is 4.59 ha and the school area is 3.5 ha (Figure 1) the site requires approximately 60.7 ML/year. It should also be noted that a separate licence will be required for any de-watering or construction works.

5.5 WATER BALANCE

An increase in recharge volume of approximately 590% is estimated post-development as shown in Appendix F. The pre-development recharge is estimated at 29 ML/year. Water balance calculations indicate that approximately 173 ML/yr additional recharge will occur on site once developed (Appendix F).

5.6 POTABLE WATER SERVICING

Lot 299, Kerosene Lane, Baldivis is within the Perth south west coastal area and is covered by the Water Corporation (WC) Tamworth reservoir gravity water supply zone (Cossil and Webley 2009). Tamworth is an existing reservoir in north Baldivis. There is also a proposed reservoir in southern Baldivis known as the Karnup reservoir site. The WC is currently undertaking scheme reviews for this area which may result in a cancellation of Karnup reservoir construction due to bush forever conservation issues. This will influence scheme planning and distribution network requirements between Tamworth and Karnup. The Tamworth reservoir is fed by water from Stirling Dam through the 1400 mm diameter Stirling Trunk Main (dam transfer main).

The subject site is north of the Tamworth reservoir site and is largely unaffected by the future use of the Karnup reservoir site (Cossil and Webley 2009). The WC has undertaken extensive planning in this area for a network of distribution and reticulation size water mains. However, the uncertainty around Karnup is preventing the WC from finalising the broader area distribution network planning.

The WC has indicated that it is unlikely that sufficient capacity will be available in the existing reticulation mains in the adjoining roads and developments to service the proposed development area (Cossil and Webley 2009). In particular, the capacity of the 250mm diameter main in Eighty Road from Tamworth reservoir north to Fifty Road is at capacity. The WC are considering a route for a 500 mm diameter or larger main (size yet to be determined) that may need to be installed in Eighty Road and north along the future Nairn Drive extension through to Kerosene Lane to service the broader area. This 500 mm or larger water main would represent additional headworks to be funded by the WC. Depending on the timing of this project and the timing of other developments in the area, the water main may need to be prefunded by developers if required in advance of WC requirements and their ability to fund the works.

Local water reticulation will be designed and installed to service every property in the development (Cossil and Webley 2009). The reticulation design includes fire hydrant provisions in accordance with agreed standards between the WC and Fire and Emergency Services Authority.

5.7 WASTEWATER SERVICING

Water Corporation (WC) planning for the future waste water collection and treatment for Lot 299, Kerosene Lane, and adjacent areas in Baldivis is dependent on approval and development of the East Rockingham Waste Water Treatment Plant (WWTP) (Cossil and Webley 2009). The WC is currently seeking preliminary approvals for a treatment plant site to be located near Chesterfield Road west of Mandurah Road and north of Day Road in the East Rockingham industrial area. Problems have been experienced in the past with other sites that have not been approved on environmental grounds. As a result, the WC has been recently reluctant to support rezoning proposals (to urban) under the Metropolitan Region Scheme within the East Rockingham WWTP catchment until there is certainty with the treatment plant site.

Notwithstanding the lack of certainty with the ultimate treatment facility location the WC have prepared a scheme plan for the north Baldivis area (Cossil and Webley 2009). The land associated with this structure plan and the surrounding land is proposed to be served by conventional gravity sewer, gravitating to a permanent 'type 180' waste water pumping station denoted by the WC as Baldivis Pumping Station B. The pumping station site is proposed on the north side of Kerosene Lane opposite the north eastern boundary of Lot 299. The outlet for the pressure main from the pump station is proposed to traverse north along the eastern boundary of lot 287 and ultimately to the proposed waste water treatment plant. The waste water pumping station will need a site of between 1600 m^2 and 2500 m^2 (depending on storage requirements) and a buffer of 50 m. If situated as proposed by the Water Corporation on Lot 287, buffer requirements

by way of set backs and the Kerosene Lane road reserve will satisfy the buffer requirement.

If the ultimate site for pumping station site B is not available at the time of development of Lot 299, a temporary pumping station may need to be provided on Lot 299 or the permanent site may need to be moved to Lot 299 (Cossil and Webley 2009). Either of these options could be accommodated from an engineering perspective with minor modification to the LSP.

The WC have made provision for a 375 mm diameter gravity main receiving both gravity and future pumped flow from south of this site running in a generally south to north direction. (Cossil and Webley 2009) An alignment for the 375 mm main can be provided within the proposed subdivisional road network.

There is a second proposed 375mm diameter gravity main receiving both gravity and future pumped flow from east of the site to be constructed within the Kerosene Lane road reserve (Cossil and Webley 2009).

Based on the assumption of the provision of the East Rockingham Waste Water Treatment Plant and the construction of the WC waste water pumping station 'B' or an alternative temporary pumping station the site can be served with conventional gravity sewer reticulation with all flows treated to Water Corporation standards (Cossil and Webley 2009).

The recycling of treated waste water is possible, and the WC has implemented nearby an effluent treatment and reuse plant for the Kwinana industrial area (Cossil and Webley 2009). Further recycling strategies including some directly at the proposed East Rockingham plant are likely. However, these sustainability measures are beyond the scope and control of this development.

5.8 MATTERS TO BE ADDRESSED AT THE SUBDIVISION STAGE

Matters to be addressed at the subdivision stage in the Urban Water Management Plan(s) (UWMPs) are:

- Provide further details on waterwise landscaping packages to be implemented at the site;
- Finalise details to be included in the information packages;

6 STORMWATER MANAGEMENT STRATEGY

The stormwater management strategy for the Kerosene Lane site is based on infiltration of stormwater on site and maintaining water quality. As the local soils are generally highly permeable, it is considered that there would not be any surface water flow off the site in a 1 in 100 year event prior to development. To maintain this no flow condition, stormwater will be infiltrated on site in events up to the 1 in 100 year event. Both structural and non-structural Best Management Practices (BMPs) are proposed to achieve this, including infiltration basins incorporated in Public Open Space (POS) and bottomless manholes.

A Drainage Concept Plan for the site summarising the drainage concept is included in Figure 11. The text below explains the concepts behind this plan.

6.1 SURFACE WATER QUANTITY AND MANAGEMENT

6.1.1 Stormwater Management in Road Reserves

Stormwater within road reserves will be collected through side entry pits and swales (where appropriate). Pits and associated manholes will have open bases to increase infiltration locally from the system.

Major flow paths will be provided along road reserves for the 1 in 100 year flow. A minimum freeboard of 0.3 m will be provided between the 1 in 100 year water level and building floor levels.

6.1.2 Flood Management in Public Open Space

The site has been divided into two catchments for flood management purposes (Figure 11 and Table 6) based on approximate topographic catchments.

The site will utilise pits with open bases and drainage swales in POS to increase infiltration of stormwater throughout the drainage network. The use of open bottomed pits will increase infiltration at source. Vegetated infiltration basins in POS will be utilised. Conceptual designs of the infiltration basins for each of the catchments are presented in Figures 9 and 10.

Drainage area and swales within POS is restricted at the subject site due to the presence of a gas easement for the Parmelia Gas Pipeline, running along the western edge of the site (Figure 2). Planning Bulletin 87 states that stormwater compensating basins are not permitted in the gas pipeline corridor/easements (WAPC 2007). Therefore this section of POS cannot be used for drainage.

The areas and volumes of storage required in the 1 in 100 year event are shown in Table 6 below for each catchment. These areas represent the storage for the

whole 1 in 100 year event, without allowances for losses through drainage pits. This is seen as a maximum area for inundation. Efforts will be made to reduce this area by maximising infiltration within the road reserve and other areas prior to water entering the basins.

Table 6: Catchment Parameters at Lots 14, 15 and 299 Kerosene Lane, Baldivis

Catchment Parameter	Catchment 1	Catchment 2
Equivalent Impervious Area (Ha)	6.85	2.55
Storm Volume 1 yr (m^3)	1,120	420
Storm Volume 5 yr (m^3)	1,720	640
Storage Volume 10 yr (m^3)	4,110	1,536
Storage Volume 100 yr (m^3)	9,110	3,405
Base level of Basin (mAHD)	5.5	8.5
TWL 10 yr (mAHD)	6.4	9.4
TWL 100 yr (mAHD)	6.7	9.7
Area of water at TWL 10 yr (m^2)	7,776	2,907
Area of water at TWL 100 yr (m^2)	9,296	3,890

The total impervious area subject to inundation in a 1 in 10 year ARI event is estimated at 1.22 Ha. The area of inundation is shaded in each catchment in Figure 10. The vegetated infiltration basins themselves will be shaped and located to maximise the useability of the Public Open Space (POS) while maintaining acceptable depths of inundation. Basins will be designed so that the base will be at least 0.5 m above maximum groundwater levels (Figure 9). A maximum depth of water of 1.2 m has been adopted in the swale design for calculating the effect of a 1 in 100 year flood event.

The basins will be designed at the subdivision stage to be gentle-sloped, rounded structures (Figure 11) with small vegetated areas in the base to incorporate bioretention processes within useable POS. The basins will be designed so that they are integrated into the landscape design to maintain larger useable POS areas during smaller events and ensure at-source infiltration is maximised. This is demonstrated in cross-sections of the basins (Figures 9 and 10) which present these drainage concepts and show that adequate

clearance to groundwater will be achieved at the site. The vegetated basins will form part of a treatment train of Gross Pollutant Traps, bubble-up pits and infiltration structures to maximise nutrient stripping and suspended solids uptake prior to infiltration to the groundwater table, in line with the concepts of the Stormwater Management Manual (DoW, 2004-2007) and BUWM (WAPC, 2008).

Basins will be vegetated with either grass or native plants to be decided upon at later stages in the development. Discussions with the City of Rockingham confirmed that the council has no preference in this matter (Darren Dropulich, City of Rockingham, 03/02/09).

Swales will be used in the proposed development in wider road reserves, where the location of driveways do not form a constraint, such as areas adjacent to POS or where road widths are adequate for the use of swales. Swale locations are shown conceptually in Figure 12 (previously Figure 11). The final locations of the swales will be determined on consultation with the City of Rockingham and included in Urban Water Management Plans during subdivision.

6.1.3 Household Drainage

The drainage from households will be managed on the lots through the use of soakwells or other onsite infiltration structures. Lots will not be provided with a direction connection to the road drainage system. This is considered appropriate as the hydraulic conductivity of the local soils is high.

6.2 SURFACE WATER QUALITY

Stormwater quality on the site will be maintained through the use of infiltration basins to remove nutrients and sediments and by maximising infiltration through open bottom side entry pits and manholes. The drainage basins will be planted with vegetation to encourage nutrient and suspended solids uptake and removal prior to infiltration. Gross Pollutant Traps (GPTs) will also be used prior to discharge to basins or Public Open Space. This forms a treatment train of open bottomed manholes, GPTs and infiltration structures, in line with the concepts of the Stormwater Management Manual (DoW 2004-2007) and BUWM (WAPC 2008a).

The package of information provided to landowners at settlement of their property will include information on reducing fertiliser use and other water conservation and environmental management measures. Fertiliser use within the POS will be minimised as part of the development.

6.3 IMPACT ON WATER DEPENDANT ECOSYSTEMS

There are no water dependant ecosystems (WDEs) within or adjacent to the site. The closest WDE is Kerosene Lane swamp, approximately 100 m north of the site. As all stormwater is infiltrated on site, no surface water will leave the site. Surface water from the site will therefore not impact on surrounding areas.

6.4 MATTERS TO BE ADDRESSED AT THE SUBDIVISION STAGE

Matters to be addressed at the subdivision stage in the Urban Water Management Plan(s) (UWMPs) are:

- Provision of a detailed drainage design and planning for the subdivision area and confirmation of sizing and location of structures; and
- Details of landscaping, including vegetation using grasses/native plants, for basins and POS.

7 GROUNDWATER MANAGEMENT STRATEGY

7.1 GROUNDWATER LEVELS

Because of the significant depth to groundwater over the site (greater than 4.5 m below ground level), depth to groundwater is not considered to be a constraint on this site. At least 1.2 m of clearance to groundwater is available throughout the site and therefore, subsoil drainage and fill are not required to ensure adequate clearance from finished lot levels to groundwater levels.

7.2 IMPACT ON WATER DEPENDANT ECOSYSTEMS

There are no water dependent ecosystems (WDEs) in the area as outlined in Section 3.5.2. The groundwater flow direction on the site is generally westerly, away from the nearest wetland to the site, Kerosene Lane Swamp. It is therefore considered that there will be no impact to WDEs from groundwater flowing from the development.

7.3 IMPLICATIONS FOR FILL

Fill is not required for ensuring adequate depth to groundwater on the site. Cut to fill will be undertaken on the site for aesthetic purposes and to ensure that lots are suitably graded for house construction.

7.4 GROUNDWATER QUALITY MANAGEMENT

7.4.1 Nutrient Management

Nutrient concentrations entering groundwater will be reduced through the use of a mixture of structural and non-structural Best Management Practices including:

- Basins with vegetation or grass in frequently inundated areas to strip nutrients prior to infiltration;
- Limiting the use of fertilisers in POS; and
- Provision of education to householders on fertilise wise gardening through provision of information at settlement.

A Detailed Site Investigation (DSI), including water quality testing, will be undertaken in line with the Contaminated Sites Act (2003) to further investigate groundwater contamination issues on the site will be undertaken if required by the Department of Environment and Conservation (DEC) as a condition of subdivision.

It is noted that the phosphorus retention index (PRI) of the existing soils is less than two. This is likely to be due to the current use of the land as a market garden. The soils on the site are derived from limestone, which would be generally expected to have a PRI of 5 -20 (Allen and Jeffrey, 1990). A PRI of 15 is generally considered to be the target for binding phosphorus in soils. The use of soil amendments for POS and residential gardens should be considered at the subdivision stage.

7.5 MATTERS TO BE ADDRESSED AT THE SUBDIVISION STAGE

Matters to be addressed at the subdivision stage in the Urban Water Management Plan(s) (UWMPs) are:

- Confirmation of finished lot levels;
- Details of landscaping and education packages to be provided to householders;
- Details of landscaping, swale and basin design, including vegetation and soils amendments for POS,
- Undertake contaminated sites investigations and management the satisfaction of the DEC, if required as a condition of subdivision; and
- Consideration of the need for soil amendments for POS and residential gardens on the site.

8 MATTERS TO BE ADDRESSED AT THE SUBDIVISION STAGE

The following section summarises all matters presented in this report that have to be addressed at the subdivision stage in the Urban Water Management Plan(s) (UWMPs).

These are:

- Provide further details on waterwise landscaping packages to be implemented at the site;
- Finalise details to be included in the information packages;
- Provision of a detailed drainage design and planning for the subdivision area and confirmation of sizing and location of structures;
- Details of landscaping, including vegetation using grasses/native plants, for basins and POS;
- Confirmation of finished lot levels;
- Details of landscaping and education packages to be provided to householders;
- Details of landscaping, swale and basin design, including vegetation and soils amendments for POS;
- Undertake contaminated sites investigations and management the satisfaction of the DEC, if required as a condition of subdivision; and
- Consideration of the need for soil amendments for POS and residential gardens on the site.

9 MONITORING

9.1 PROGRAM FOR URBAN WATER MANAGEMENT PLAN PREPARATION (UWMP)

Four months of groundwater monitoring has been undertaken at the Kerosene Lane site, including a peak winter event in September 2008. A baseline for post-development groundwater quality and levels will be provided as part of the first UWMP.

9.2 POST-DEVELOPMENT MONITORING

It is expected that this program will run for two years until handover of the drainage assets to the council and will include sampling of groundwater and surface water for pH, electrical conductivity and nutrients.

The post-development monitoring program will be determined as part of the UWMP process. It is considered too early at this stage to determine the final post-development monitoring program.

10 IMPLEMENTATION

10.1 ROLES AND RESPONSIBILITIES

Item	Scheme Development	Interim Maintenance (Minimum of two years) –	Long-term Maintenance
Waterwise Landscaping Packages	Developer	Residents and strata companies.	Residents and strata companies.
Householder education packages	Developer	Developer	Council, as part of any existing or possible future City-wide schemes.
Drainage system, including GPTs and basins	Developer	Developer for at least 2 years as per Council requirements	Council
Public Open Space	Developer	Developer for at least 2 years as per Council requirements	Council
Monitoring of the development	Developer	Developer for two years until handover of asset to council	Developer for monitoring in compliance with groundwater licensing conditions. Council for other items.

10.2 FUNDING

No external funding is being sought for this project.

10.3 REVIEW

It is expected that the UWMP for this site will comply with the LWMS. However, if changes are made to the subdivision design, or alternative methods of water management are considered more appropriate, changes may be made at the UWMP stage. Any changes will be approved by the City of Rockingham and Department of Water as part of the planning process.

11 CONCLUSIONS

The objective of the Local Water Management Strategy (LWMS) is to ensure that sustainable management of the total water cycle at Lots 14, 15 and 299 Kerosene Lane, occurs through Water Sensitive Urban Design. This includes water conservation, stormwater management and groundwater management. Galati nominees aim to manage these issues at the Kerosene Lane site through the following initiatives:

Water Conservation

- Providing front yard Waterwise landscaping packages for residential lots that include waterwise plants, soil amendments to improve water and nutrient retention, minimal turf areas and water efficient irrigation; and
- Providing information packages to educate landowners on ex-house and in-house waterwise measures.

Stormwater Management

- Implementing a drainage design that ensures no flow off the site in the 1 in 100 year event from the development to pre-development levels through storage and infiltration on site; and
- Maximising infiltration on the subject site by constructing infiltration basins in POS where possible, planted with vegetation or grasses to encourage nutrient and suspended solids uptake and removal prior to infiltration. Side entry pits and associated manholes will also be open based to maximise infiltration.

Groundwater Management

- Ensuring infiltration basins are planted with vegetation or grass in frequently inundated areas to strip nutrients prior to infiltration;
- Limiting the use of fertilisers in POS; and
- Providing information packages to educate landowners on fertilise wise gardening through provision of information at settlement.

This LWMS demonstrates that Lots 14, 15 and 299 Kerosene Lane can be developed in a way that manages hydrological constraints. The outstanding issues can be resolved at the Urban Water Management Plan stage to create a development that meets the goals and ideals of *Better Urban Water Management*.

12 REFERENCES

Allen, DG and Jeffery, RC 1990, *Methods for Analysis of Phosphorus in Western Australian Soils, Report on Investigation No. 37*, Chemistry Centre, Perth, Western Australia.

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) 2000, *National Water Quality Management Strategy - Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Coghlan, P and Loh, M 2003, *Domestic Water Use Study in Perth, Western Australia*, Water Corporation, Perth.

Cossil and Webley 2009, Lot 299 Kerosene Lane Baldivis Engineering Servicing Report, Cossil and Webley, Perth.

Davidson, WA 1995, *Hydrogeology and Groundwater Resources of the Perth Region, Western Australia*, Western Australia Geological Survey, Bulletin 142, Perth.

Department of Environmental Protection (DEP) 2001, *Contaminated Sites Management Series - Reporting on Site Assessments*, Department of Environmental Protection, Perth.

Department of Environment (DoE) 2003, *Assessment Levels for Soil, Sediment and Water, Contaminated Sites Management Series*, Department of Environment, Perth, Western Australia.

Department of Environment (DoE) 2004a, *Perth Groundwater Atlas Second Edition,* Department of Environment, Perth.

Department of Environment (DoE) 2004b. *Contaminated Sites Management Series - Potentially Contaminating Activities, Industries and Land Uses*, Department of Environment, Perth.

Department of Water (DoW) 2004-2007, *Stormwater Management Manual for Western Australia,* Department of Water, Perth.

Environmental Protection Authority (EPA) 2008, *Environmental Guidance for Planning and Development. Guidance Statement No 33.* Environmental Protection Authority, Perth, Western Australia.

ENV Australia 2008a, *Lot 14, 15 and 299, Kerosene Lane, Baldivis Local Structure Plan: Environmental Report*.

ENV Australia 2008b, *Lot 14, 15 and 299, Kerosene Lane, Baldivis Environmental Preliminary Site Investigation.*

Government of Western Australia 2007, *State Water Plan*, Department of Premier and Cabinet.

Gozzard, JR. 1983, *Rockingham part Sheets 2033 II and 2033 III.* Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.

Standards Australia/Standards New Zealand (1998), *Water Quality: Sampling, Part I: Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples*, AS 5667.1:1998, Standards Australia / Standards New Zealand, NSW.

Swan River Trust 2003, *Developing targets for the Swan-Canning Cleanup Program (SCCP), River Science Issue 7*, Government of Western Australia, Perth, Western Australia.

Taylor Burrell, Bowman Bishaw Gorham and Wood and Grieve 2000, *Baldivis (North) Structure Plan*.

Water Corporation 2008, *Water Supply Consumption Tool*, Water Corporation. Available from: <http://www.watercorporation.com.au/P/publications_alternative_water_supply.cfm> [25 February 2009].

Western Australian Planning Commission (WAPC) 2003, *Acid Sulfate Soils, Planning Bulletin 64*, Western Australian Planning Commission, Perth, Western Australia.

Western Australian Planning Commission (WAPC) 2007, *High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region, Planning Bulletin 87*, Western Australian Planning Commission, Perth, Western Australia.

Western Australian Planning Commission (WAPC) 2008a, *Better Urban Water Management,* Western Australian Planning Commission, Perth, Western Australia.

Western Australian Planning Commission (WAPC) 2008b, *Planning Bulletin 92 Urban Water Management,* Western Australian Planning Commission, Perth, Western Australia.

FIGURES

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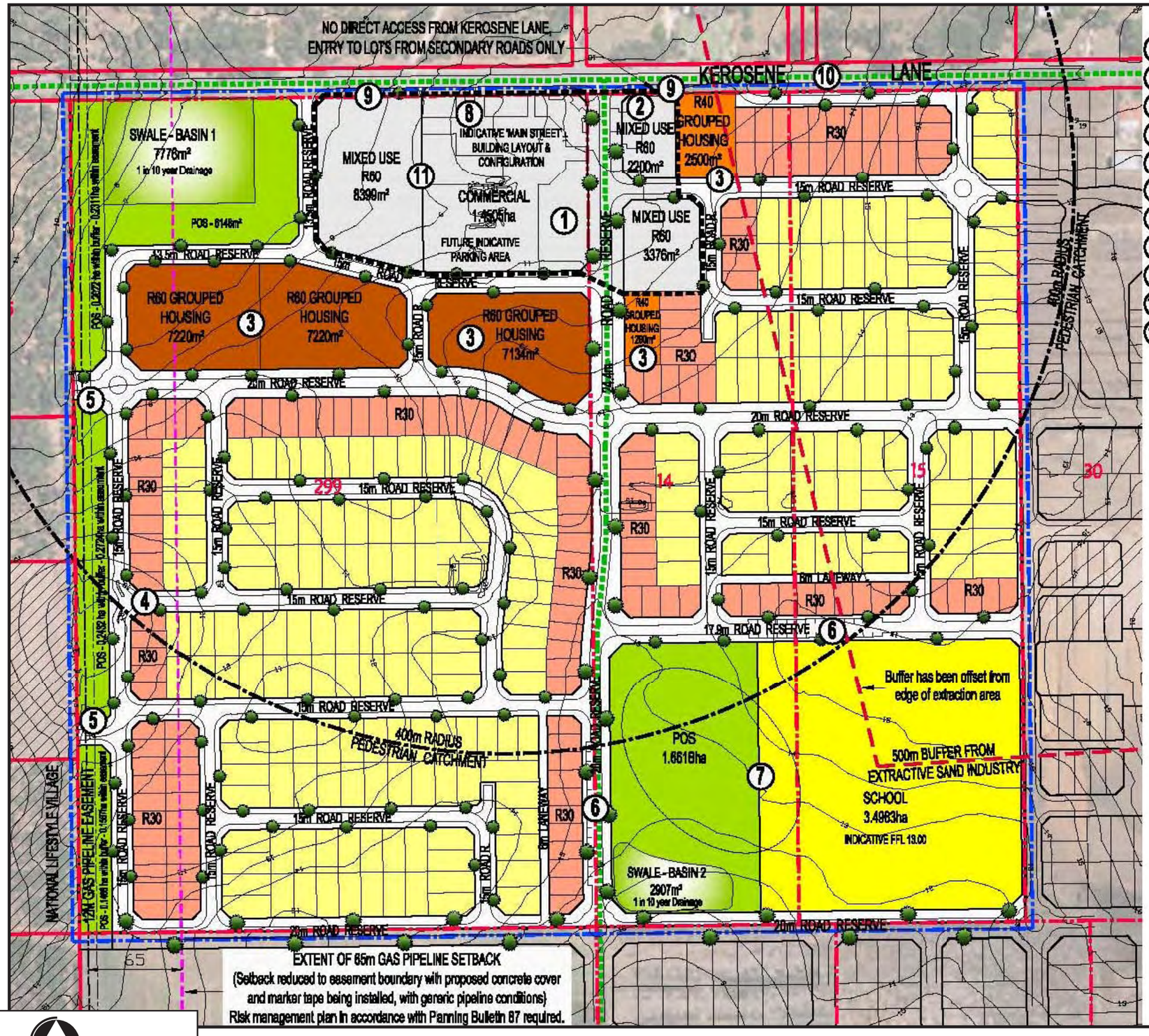

STRUCTURE PLAN NOTES

1. Spud Shed Commercial Premises - (2500m² retail NLA max)
2. Existing House (to be demolished).
3. Grouped housing, Mixed use and Commercial sites subject to DAP to ensure high quality main street built form and streetscape is achieved.
4. Traffic calming treatment at intersection.
5. Potential future east-west road linkages across gas pipelire.
6. On-street carparking surrounding school site.
7. POS (active playing field) and school site. Site to be flat as per City of Rockingham and Department of Education and Training requirements.
8. Single access for Commercial premises shown on plan.
9. No direct access from Kerosene Lane, entry to lots from secondary roads only.
10. Future upgrading of Kerosene Lane as per Baldivis Road, needs Study. Slip lane servicing Residential Lots fronting Kerosene Lane as shown.
11. Accoustic and visual buffer between mixed use development and commercial premises.

Total Structure Plan Area		**38.7847 ha**
Deductions for Calculating Net Site Area		
Primary School	3.4983 ha	
Commercial Site 1	1.4505 ha	
Restricted POS (1.7285 ha provided restricted open space - 0.6767 ha maximum permitted)	1.0518 ha	
Total	**6.0006 ha**	
Net Area		**32.7841 ha**
10 % POS	**3.2784 ha**	
8% unrestricted	*2.6227 ha*	
Joint School POS	1.6618 ha	
Pipeline Buffer	0.5920 ha	
NW Pocket Park	0.6148 ha	
Total	**2.8686 ha**	
2% restricted	*0.6767 ha*	
Pipeline Easement	0.6602 ha	
Basin 1	0.7776 ha	
Basin 2	0.2907 ha	
Total	**1.7285 ha**	
8% unrestricted	2.8686 ha	
2% restricted	0.6557 ha	
Total	**3.5243 ha (10.75%)**	

LEGEND

- Residential - R20
- Residential - R30
- Residential - R40
- Residential - R60
- School
- Public Open Space
- Drainage Swale incorporated into POS
- Existing Lot Boundary
- Structure Plar Boundary
- Future Bus Routes
- Gas pipeline setback
- 500m Buffer from Extractive Sand Industry
- All Commercial and mixed use sites are excluded and are to be progressed through separate Amendment to Town Planning Scheme No. 2.

CITY OF Rockingham
TOWN PLANNING SCHEME NO. 2

COUNCIL APPROVED
DATE ___/___/____

APPROVED ENDORSED BY
WAPC ON ___/___/____

N

metres

0 30 60 90 120 150

APPROX. SCALE 1 : 3 000 @ A3
DATUM: GDA49 MGA50
Source: Planning Solutions, RevH, 8th June 2010

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Planning Solutions Pty Ltd
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY
LOCAL STRUCTURE PLAN
FIGURE 1

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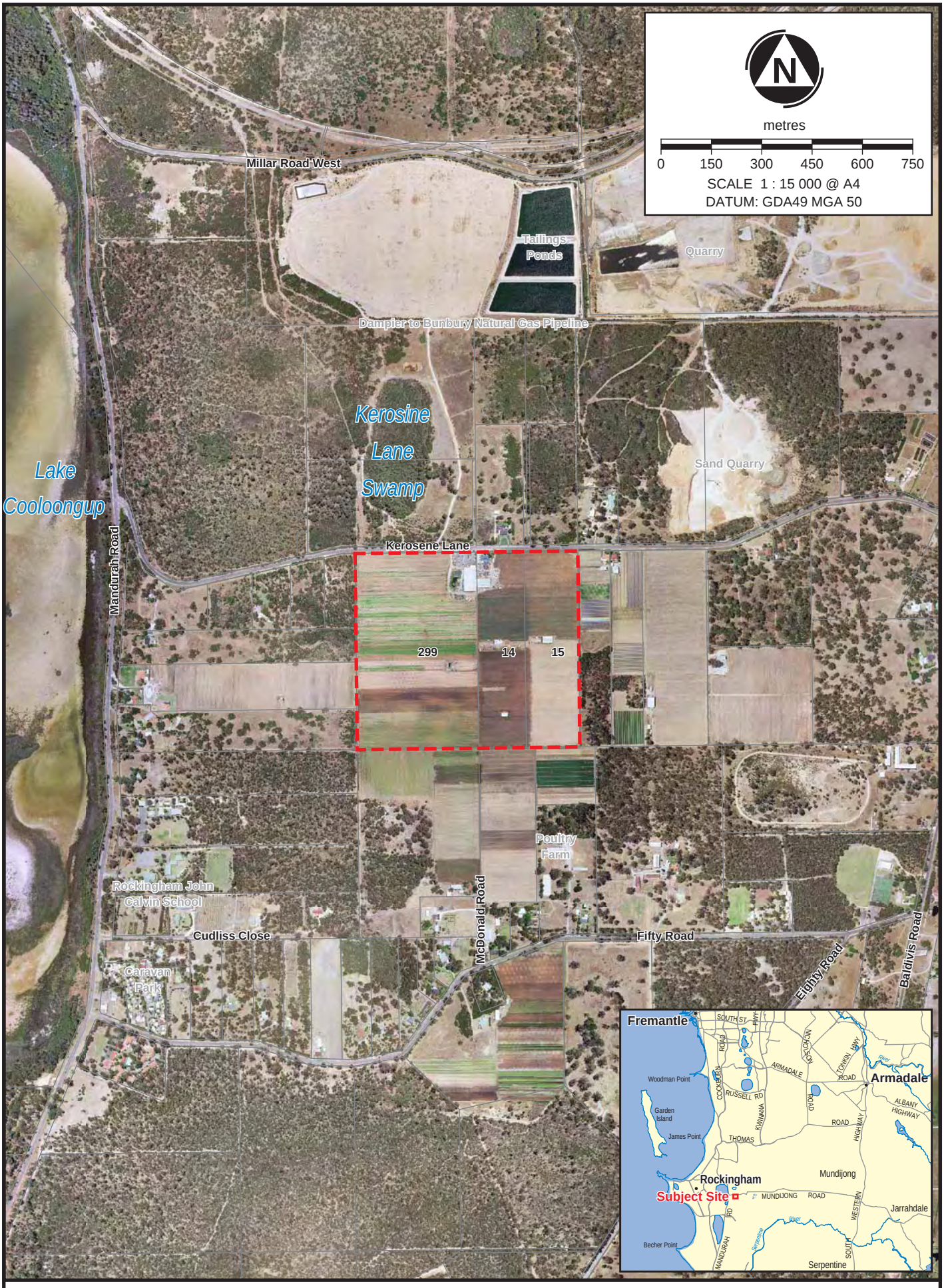

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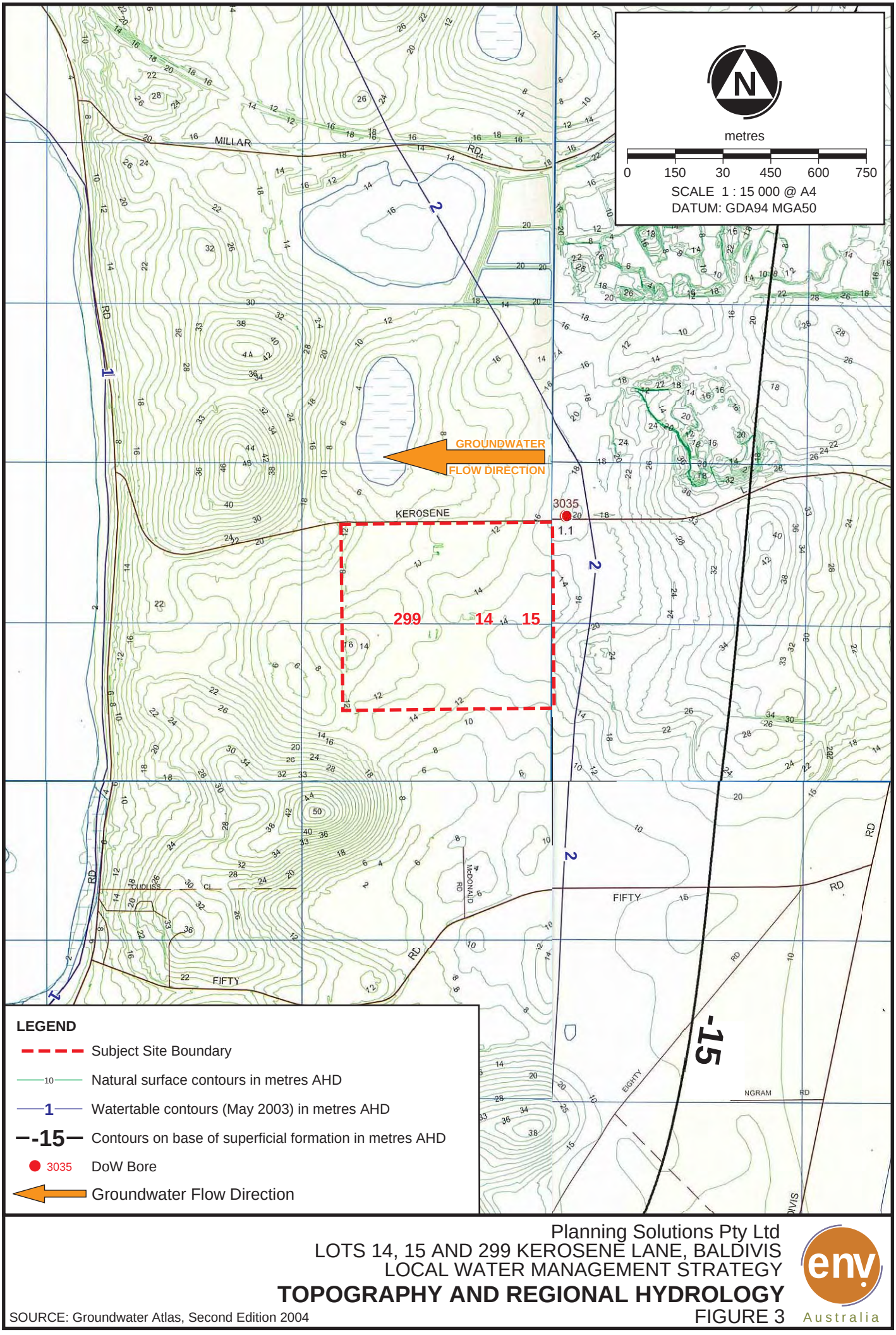
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY

SITE LOCATION

FIGURE 2

Aerial Photograhy supplied by Landgate

env Australia



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LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS

LOCAL WATER MANAGEMENT STRATEGY

TOPOGRAPHY AND REGIONAL HYDROLOGY

FIGURE 3

SOURCE: Groundwater Atlas, Second Edition 2004

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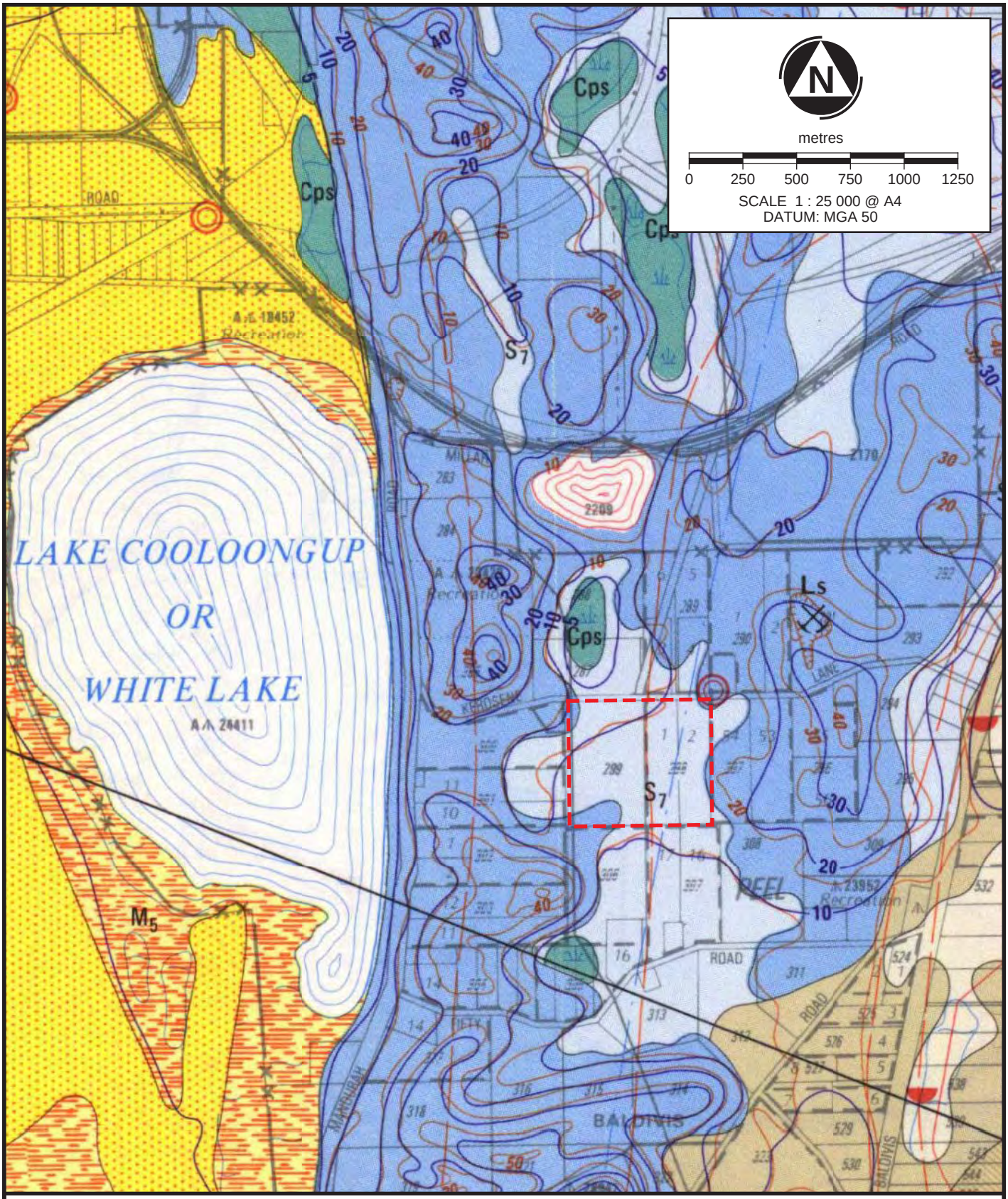

LEGEND

Subject Site Boundary

S 7 SAND - pale yellowish brown, medium to coarse-grained, sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.

L S LIMESTONE - pale yelowish brown, fine to coarse grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.

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LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY

SOILS AND GEOLOGY

GEOLOGY SOURCE: Geological Survey of WA, 1:50 000 Environmental Geology Series

FIGURE 4

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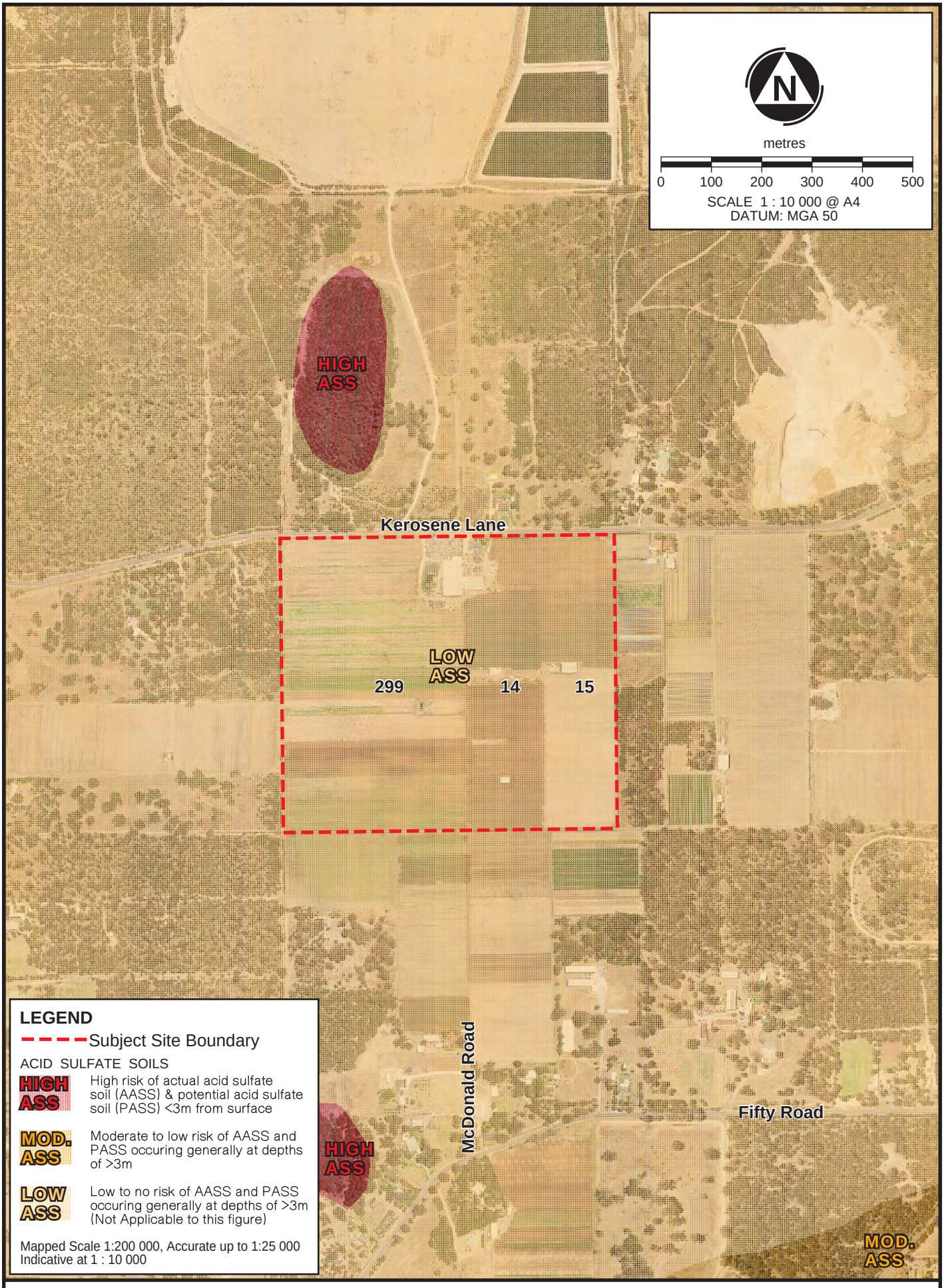

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LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS

LOCAL WATER MANAGEMENT STRATEGY

ACID SULFATE SOIL RISK

FIGURE 5

ACID SULFATE SOIL SOURCE: DPI, 10-02-05

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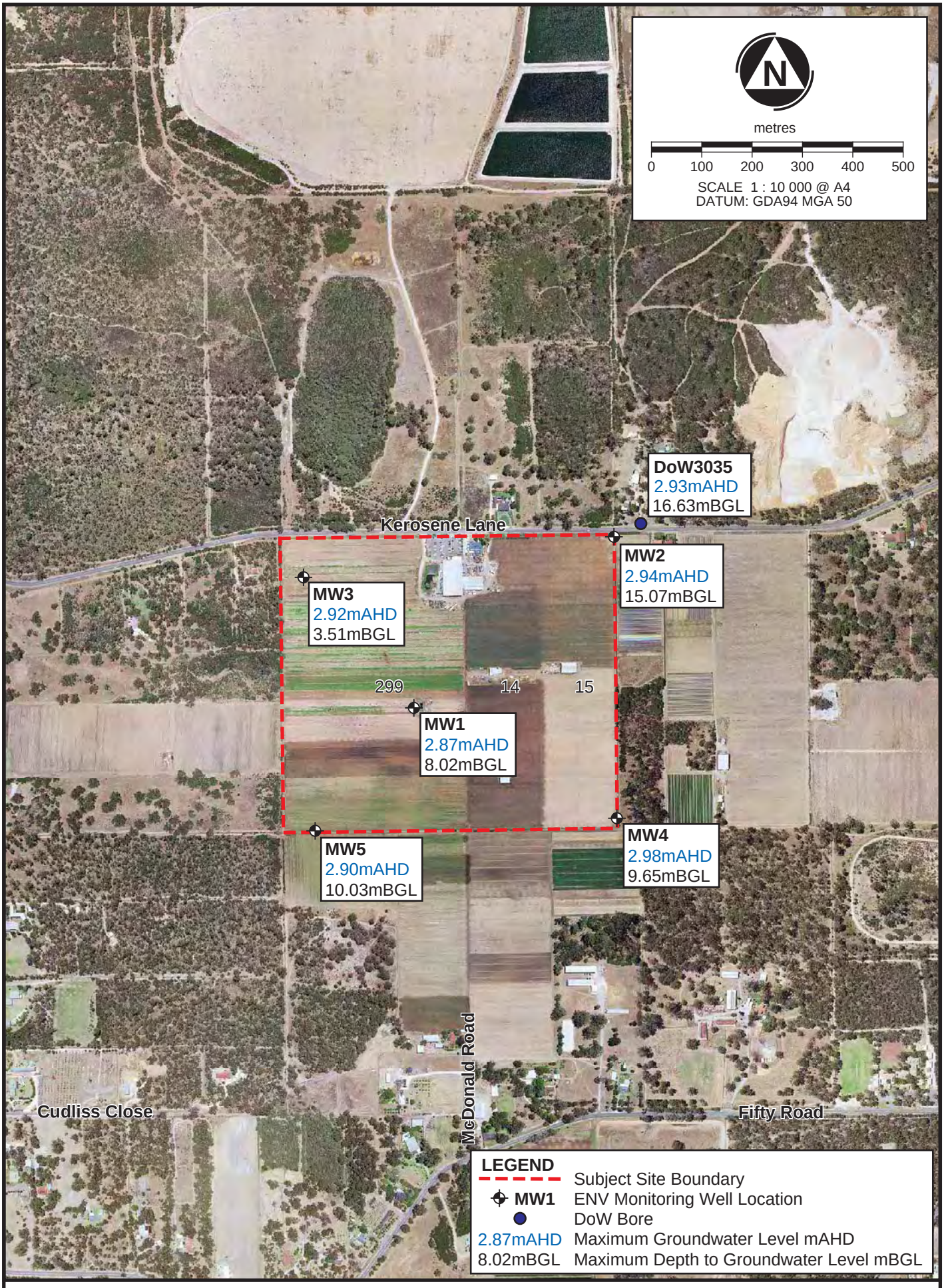

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LOCAL WATER MANAGEMENT STRATEGY

MAXIMUM GROUNDWATER LEVELS

FIGURE 6

Aerial Photography supplied by Landgate

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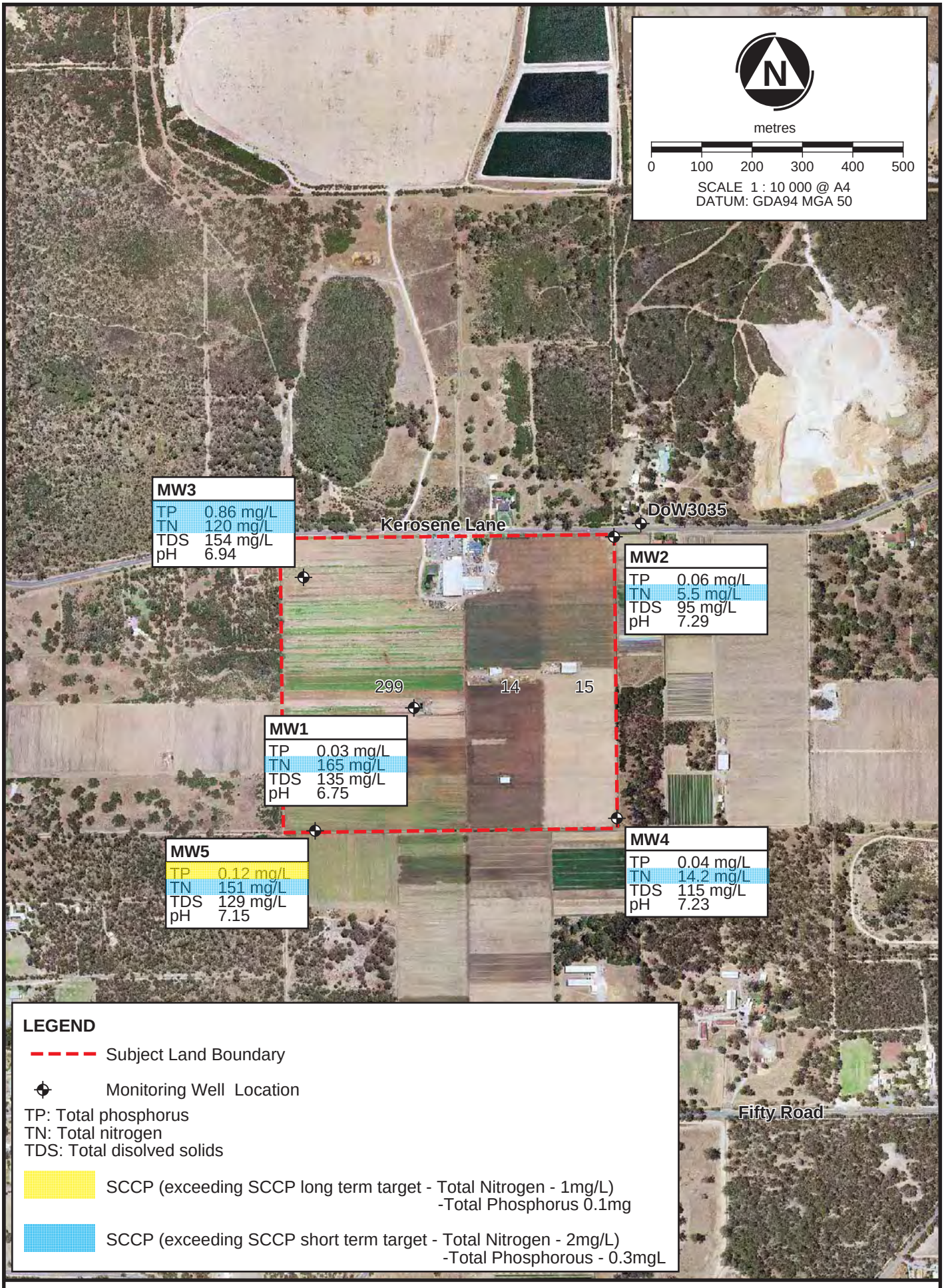

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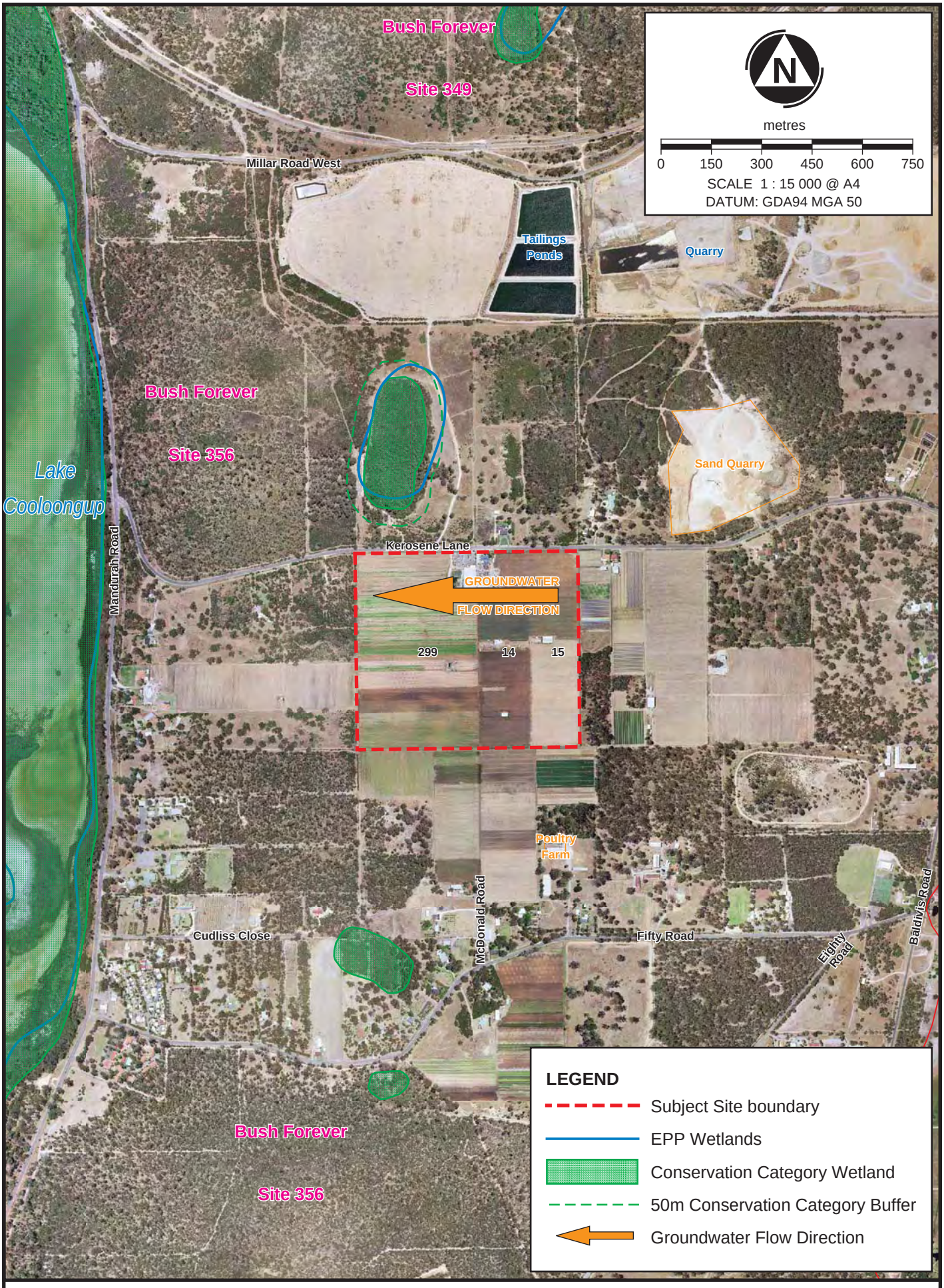
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY
GROUNDWATER QUALITY
FIGURE 7

Aerial Photography supplied by Landgate

env Australia



PRINTED: Thu 26 Feb 09

AUTHOR: GR 3-02-09

DRAWN: TE 3-02-09

08-406-1_F8.dgn

Aerial Photo supplied by Landgate

Planning Solutions Pty Ltd

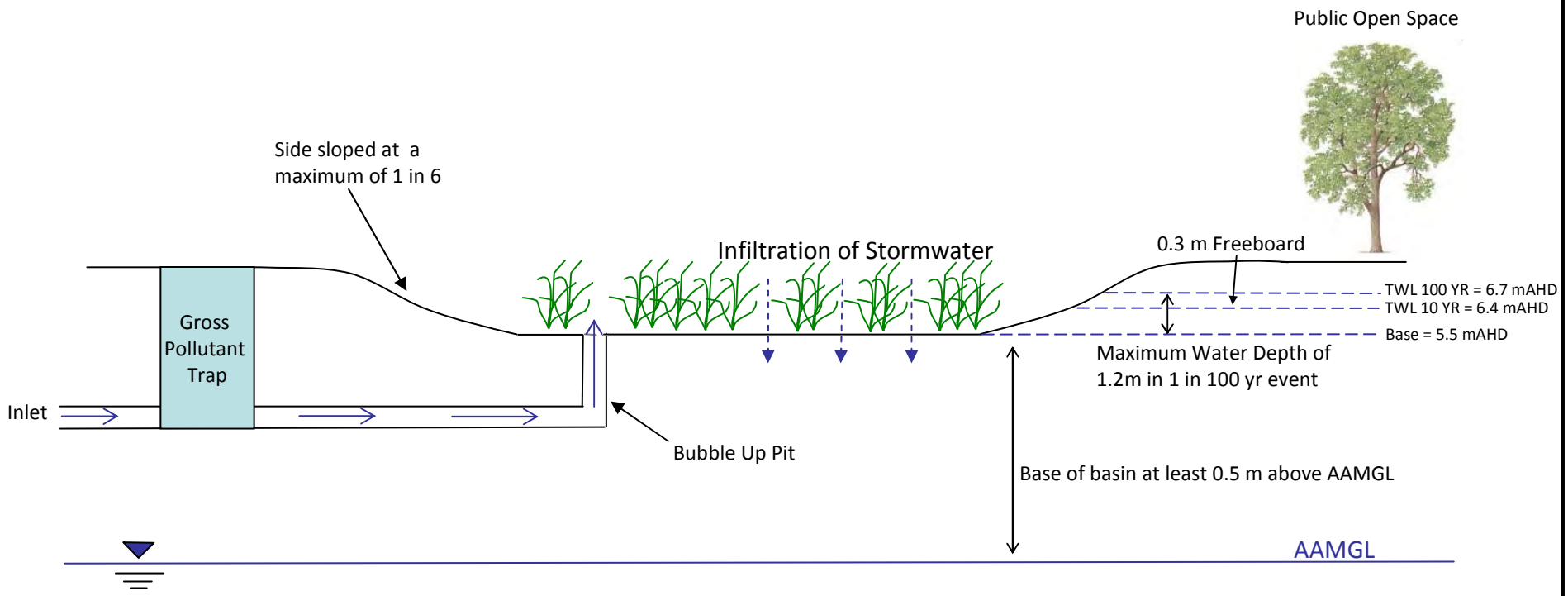
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS

LOCAL WATER MANAGEMENT STRATEGY

ENVIRONMENTAL CONSTRAINTS MAPPING

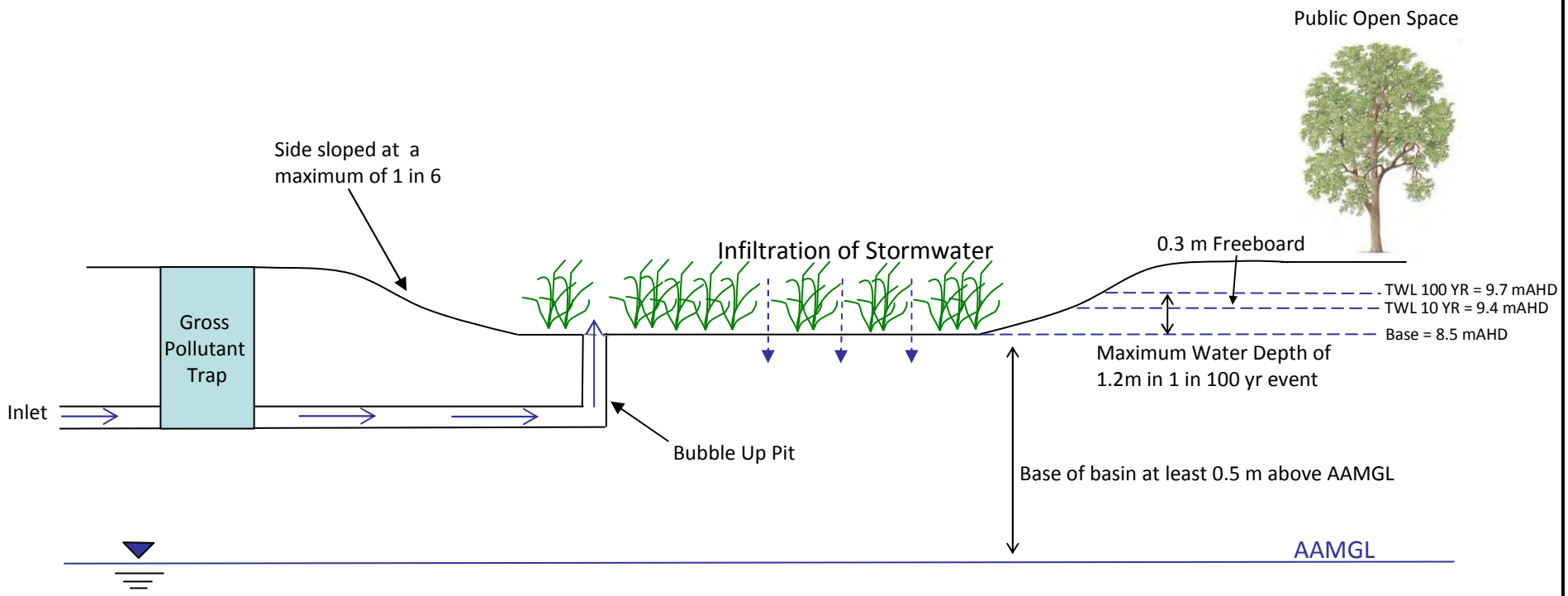
FIGURE 8

env Australia



Base of basin to be vegetated.
Landscaping details to be confirmed in Urban Water Management Plan.

FIGURE 9: Conceptual Vegetated Infiltration Basin Design Basin 1	**Job No: 08.406**
	Drawn By: PA/HL
Client: Planning Solutions Pty Ltd	Checked By: HL
Project: Lots 14, 15 and 299 Kerosene Lane Baldivis LWMS	Scale: NTS Date: 5.11.2010



Base of basin to be vegetated.
Landscaping details to be confirmed in Urban Water Management Plan.

FIGURE 10: Conceptual Vegetated Infiltration Basin Design Basin 2	**Job No: 08.406**
	Drawn By: PA/HL
Client: Planning Solutions Pty Ltd	Checked By: HL
Project: Lots 14, 15 and 299 Kerosene Lane Baldivis LWMS	Scale: NTS Date: 5.11.2010

PRINTED: Mon 08 Nov 10

BASIN 1

1YR = 1900m²
10YR = 7800m²
100YR = 9300m²

PERTH-KWINANA GAS PIPELINE EASEMENT

BASIN 2

1YR = 700m²
10YR = 2950m²
100YR = 3900m²

BASIN 1 - SWALE

EIA	6.85ha
S1	1150m³
S5	1750m³
S10	4150m³
S100	9150m³
TWL 1YR	1900m²
TWL 5YR	2900m²
TWL 10YR	7800m²
TWL 100YR	9300m²
SITE AREA	12000m²
BASE LEVEL	5.5m AHD
TWL 10 YR	6.4m AHD
TWL 100 YR	6.7m AHD

BASIN 2 - SWALE

EIA	2.55ha
S1	450m³
S5	650m³
S10	1550m³
S100	3400m³
TWL 1YR	700m²
TWL 5YR	1100m²
TWL 10YR	2950m²
TWL 100YR	3900m²
SITE AREA	5600m²
BASE LEVEL	8.5m AHD
TWL 10 YR	9.4m AHD
TWO 100YR	9.7m AHD

EXISTING TOPOGRAPHIC CATCHMENTS

PRE DEVELOPMENT CATCHMENT FLOW DIRECTION

LEGEND

- SUBJECT SITE BOUNDARY
- TWL — TOP WATER LEVEL
- S — STORAGE VOLUME
- GROSS POLLUTANT TRAP TO BE INSTALLED UPSTREAM OF BASIN
- AREA OF INUNDATION FOR A 1 IN 10 YEAR EVENT
- TOPOGRAPHIC CONTOURS (1m interval)

NOTES

1. SWALE SIDE SLOPES - 1:8
2. MAX. DEPTH, TWL 100 IN SWALE AREAS - 1.2m
3. SIDE ENTRY PITS AND MANHOLES TO HAVE PERMEABLE BASES.
4. P.O.S. IN THE PARMELIA GAS PIPELINE EASEMENT NOT TO BE USED FOR DRAINAGE IN ACCORDANCE WITH PLANNING BULLETIN 87 (WAPC, 2007 HIGH PRESSURE GAS TRANMISSION PIPELINES IN THE PERTH METROPOLITAN REGION)
5. IT IS ASSUMED THAT RUNOFF FROM EXTERNAL LOTS WILL BE INFILTRATED ONSITE AND THEREFORE WILL NOT INCREASE SUBJECT SITE DRAINAGE.
6. DETAILS OF LANDSCAPING DESIGN TO BE PROVIDED AT SUBDIVISION STAGE.

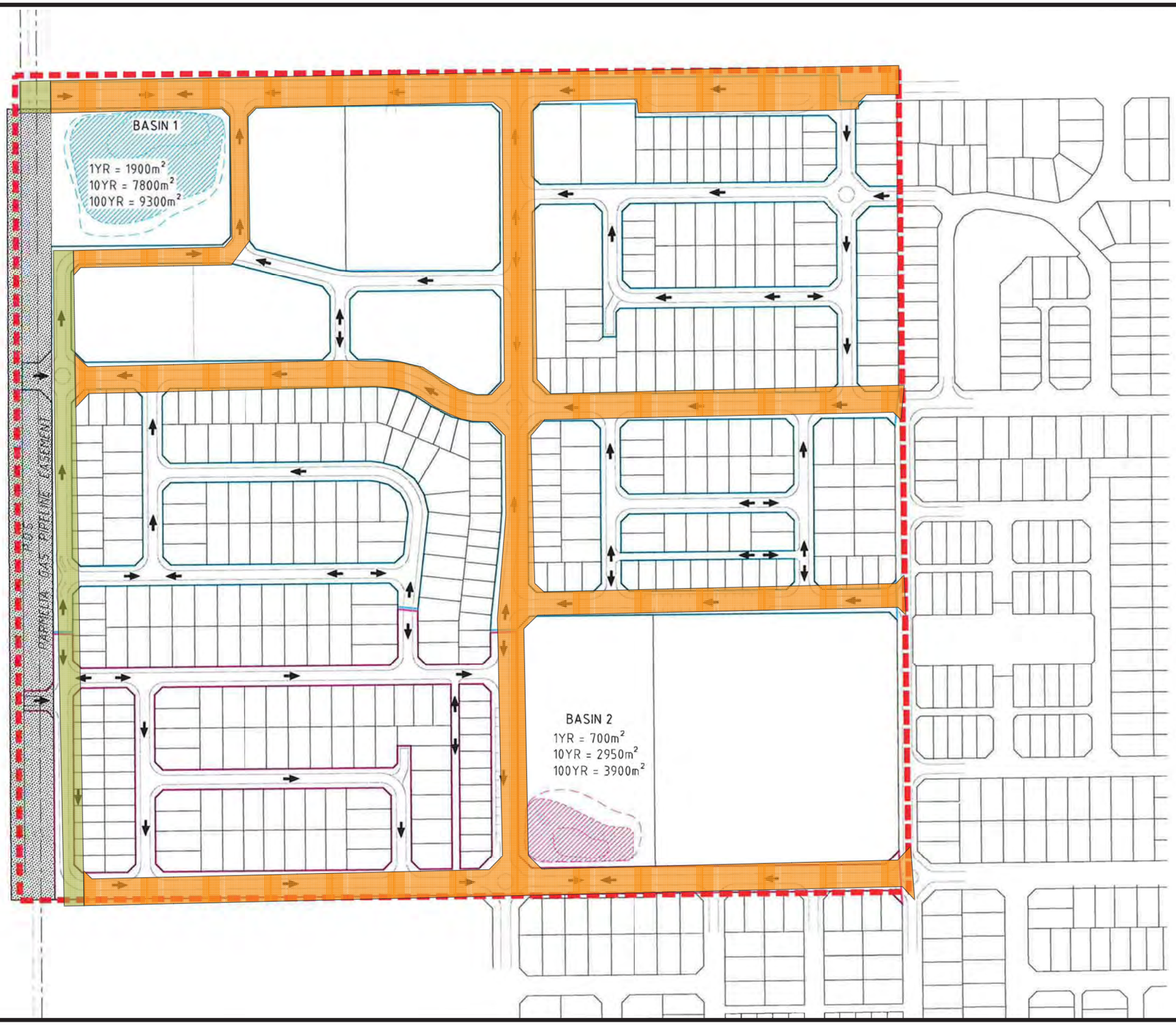
DRAWN: TE 23-06-10 AUTHOR: MD 23-06-10

08-406-1f11.dgn

SOURCE: Cossill and Webley 5955-00-302 Rev B

Planning Solutions Pty Ltd
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY
DRAINAGE CONCEPT PLAN
FIGURE 11

env Australia



BASIN 1 - SWALE

EIA	6.85ha
S1	1150m³
S5	1750m³
S10	4150m³
S100	9150m³
TWL 1YR	1900m²
TWL 5YR	2900m²
TWL 10YR	7800m²
TWL 100YR	9300m²
SITE AREA	12000m²
BASE LEVEL	5.5m AHD
TWL 10 YR	6.4m AHD
TWL 100 YR	6.7m AHD

BASIN 2 - SWALE

EIA	2.55ha
S1	450m³
S5	650m³
S10	1550m³
S100	3400m³
TWL 1YR	700m²
TWL 5YR	1100m²
TWL 10YR	2950m²
TWL 100YR	3900m²
SITE AREA	5600m²
BASE LEVEL	8.5m AHD
TWL 10 YR	9.4m AHD
TWO 100YR	9.7m AHD

Use of swales/rain gardens constrained by gas easement

Potential roads with swales/rain gardens

LEGEND

- SUBJECT SITE BOUNDARY
- TWL — TOP WATER LEVEL
- S — STORAGE VOLUME
- GROSS POLLUTANT TRAP TO BE INSTALLED UPSTREAM OF BASIN
- AREA OF INUNDATION FOR A 1 IN 10 YEAR EVENT

NOTES

1. SWALE SIDE SLOPES - 1:8
2. MAX. DEPTH, TWL 100 IN SWALE AREAS - 1.2m
3. SIDE ENTRY PITS AND MANHOLES TO HAVE PERMEABLE BASES.
4. P.O.S. IN THE PARMELIA GAS PIPELINE EASEMENT NOT TO BE USED FOR DRAINAGE IN ACCORDANCE WITH PLANNING BULLETIN 87 (WAPC, 2007 HIGH PRESSURE GAS TRANMISSION PIPELINES IN THE PERTH METROPOLITAN REGION)
5. IT IS ASSUMED THAT RUNOFF FROM EXTERNAL LOTS WILL BE INFILTRATED ONSITE AND THEREFORE WILL NOT INCREASE SUBJECT SITE DRAINAGE.
6. DETAILS OF LANDSCAPING DESIGN TO BE PROVIDED AT SUBDIVISION STAGE.

SOURCE: Cossill and Webley 5955-00-302 Rev B

Planning Solutions Pty Ltd
LOTS 14, 15 AND 299 KEROSENE LANE, BALDIVIS
LOCAL WATER MANAGEMENT STRATEGY

POTENTIAL SWALE LOCATION PLAN

FIGURE 12

env Australia

APPENDIX A
MONITORING BORE LOGS

Client: Galati Nominees
Performed by: Strataprobe+I.S+B.W
Borehole: MW1

Project: Kerosene Lane Baldivis
Date Logged: 3/9/08 - 4/9/08
Job No: 08.272

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations
	0.05		0 - 2.2	Brown/ reddish SAND, loamy, medium grained, moderately sorted, moist		Had to put 100mm diameter collar around top of bore to stop hole collapsing in, couldn't finish off with riser
	PRI					
1.0				gravelly limestone fill		
2.0			2.2 - 12.5	Limestone, pale cream/reddish coloured		
3.0						Hard fractured cemented 'rock' layers composed of large quartz grains and calcareous material. Took over 4 hours to drill through.
4.0						
5.0						
6.0						
7.0						
8.0						
9.0		▽				SWL @ ~9m bgl thin sand lenses below water table
10.0						
11.0						
12.0						
				End of hole 12.4m		
13.0						

NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Galati Nominees
Performed by: Strataprobe+I.S+B.W
Borehole: MW2

Project: Kerosene Lane Baldivis
Date Logged: 11/8/08, 12/8/2008, 2/9/08
Job No: 08.272

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations
	0.05		0 - 0.5	SAND, brown, fine to medium grained,		Sonic rig, 0-3m (11/8/08)
	PRI			moderately sorted, quartz, subangular, moisture		Redrilled with auger rig (12/8/08)
			0.5 - 1.6	SAND, orange, fine to course grained,		
				moderately sorted, quartz, subangular, moisture		Redrilled with rotary airblast (2/9/08)
2.0			1.6	LIMESTONE, pale cream/white, cemented dry		
						Sonic rig refusal at 3m -limestone
						too hard
4.0						
6.0						
8.0			8.1-15.2	Limestone, white, hard concrete, dry		Auger rig refusal at 8m, limestone was
						too hard, it was damaging augers
10.0						
12.0						
14.0						
			15.2 -18	SAND, yellow/cream, medium to course grained		
				moderately sorted, damp		
16.0		▽				SWL @ ~16m bgl
18.0						
				End of hole 18m		
20.0						
22.0						
24.0						

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Galati Nominees
Performed by: Strataprobe+I.S+B.W
Borehole: MW3

Project: Kerosene Lane Baldivis
Date Logged: 3/9/08
Job No: 08.272

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations
	0.05m		0 -0.5	SAND, loamy, medium to course grained,		Drilled with rotary air blast
	PRI			moderately sorted, reddish brown, moist.		3/9/08
			0.5 - 4.2m	SAND, reddish orange, medium grained		
				moderately sorted, moist		
1.0						
				layer of limestone 1.5 -2m		
2.0						
3.0						
4.0						
			4.2 - 7.3	Limestone, pale green coloured, cemented		
5.0						SWL @ ~5m bgl
6.0						
7.0						
				End of hole 7.3m		
8.0						
9.0						
10.0						
11.0						
12.0						

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Galati Nominees
Performed by: Strataprobe + B.W
Borehole: MW4

Project: Kerosene Lane Baldivis
Date Logged: 11/9/08, 2/9/08
Job No: 08.272

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations
	0.05		0 - 1.1	SAND, brown, fine to medium grained, moderately sorted, quartz, subangular, some moisture		Sonic rig, 0-6m (11/8/08)
	PRI					
						Redrilled with rotary air blast 2/9/08
1.0						
			1.1 - 4	SAND, orange, fine to course grained, moderately sorted, quartz, subangular, some moisture.		
2.0						
3.0						
4.0			4 - 4.2	band of LIMESTONE, pale cream		
			4.2 - 5	SAND, orange, fine to medium grained moderatly sorted, quartz, sub angular - rounded some moisture		
5.0			5-5.2	clayey SAND, pale cream, some limestone gravel (~3 mm diameter), damp		
			5.2 - 7	SAND, orange, fine to medium grained moderatly sorted, quartz, sub angular-rounded some moisture		
6.0						Sonic rig refusal @ 6m - hit hard
						limestone
			7-13	Limestone, pale cream/white, cemented, dry.		
7.0						
8.0						
9.0						
10.0						
11.0						SWL @ ~11m bgl
12.0						
13.0				End of hole 13.0m		

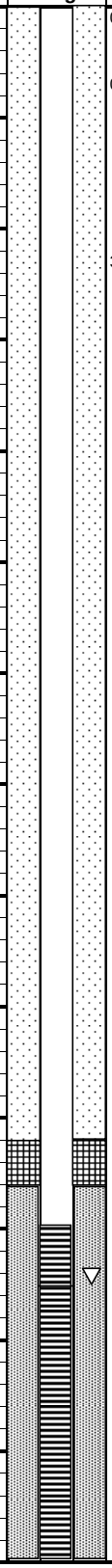
NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Galati Nominees
Performed by: Strataprobe+I.S+B.W
Borehole: MW5

Project: Kerosene Lane Baldivis
Date Logged: 3/9/08
Job No: 08.272

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations
	0.05		0 - 0.7	SAND, loamy, brown, medium to course grained		
	PRI			moderately sorted, quartz		
			0.7 - 3.1	Red/orange SAND, medium grained,		
1.0				moderately sorted, moist		
2.0						
			3.1 - 14	Limestone, hard, centred, pale, cream.		
3.0						
4.0						
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
						SWL @ ~11m bgl
12.0						
13.0						
14.0						

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

APPENDIX B

PHOSPHORUS RETENTION INDEX RESULTS

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
PHOSPHORUS RETENTION INDEX RESULTS

ANALYSIS REPORT

CSBP LIMITED ABN: 81 008 668 371

UNITS CUSTNO	PADDOCK	SAMPLE_ID	SERIAL_NO	LAB_NUMBER	Index PHOS_RETEN
67405	SIDEBOTTOM IAN	MW1	MW1	6B S08171	1.1
67405	SIDEBOTTOM IAN	MW2	MW2	6B S08172	1.3
67405	SIDEBOTTOM IAN	MW3	MW3	6B S08173	0.7
67405	SIDEBOTTOM IAN	MW4	MW4	6B S08174	0.7
67405	SIDEBOTTOM IAN	MW5	MW5	6B S08175	1.4
67405	SEIGERSCHMIDT BARBARA	MW1	MW1	6B S08176	0.8
67405	SEIGERSCHMIDT BARBARA	MW2	MW2	6B S08177	0.5
67405	SEIGERSCHMIDT BARBARA	MW3	MW3	6B S08178	1.4
67405	SEIGERSCHMIDT BARBARA	MW4	MW4	6B S08179	2.5
67405	SEIGERSCHMIDT BARBARA	MW5	MW5	6B S08180	0.8

Bore	Average PRI
MW1	0.95
MW2	0.9
MW3	1.05
MW4	1.6
MW5	1.1

APPENDIX C
DEPARTMENT OF WATER GROUNDWATER BORE RECORDS

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
DEPARTMENT OF WATER GROUNDWATER BORE RECORDS

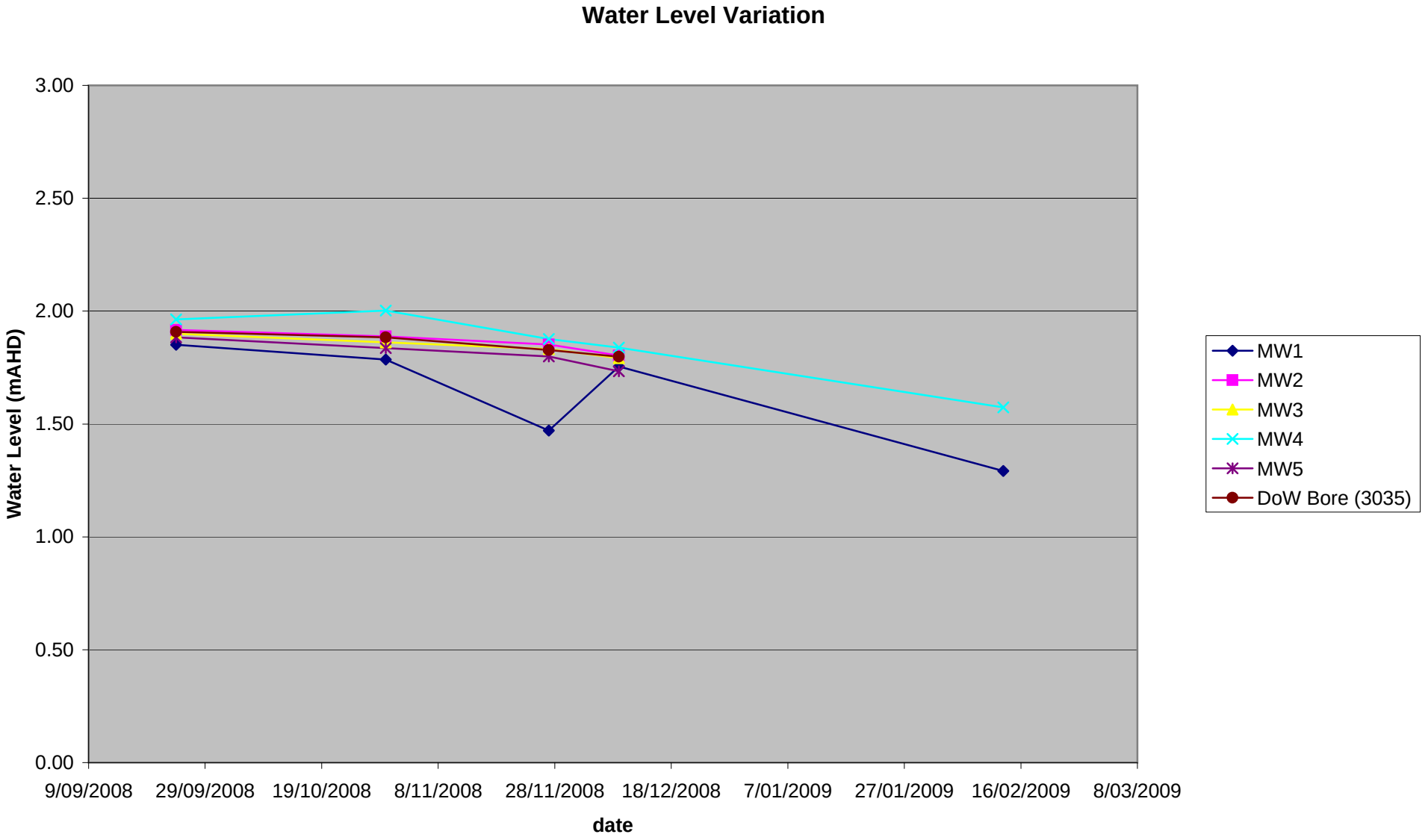
BORE ID (WIN SITE)	COLLECTED DATE	GROUNDWATER LEVEL (mAHD)
3035	12:00:00 16/05/1975	2.348
3035	00:00:00 01/06/1975	2.348
3035	12:00:00 12/06/1975	2.348
3035	12:00:00 11/07/1975	2.478
3035	12:00:00 13/08/1975	2.648
3035	12:00:00 15/09/1975	2.928
3035	12:00:00 15/10/1975	2.748
3035	12:00:00 26/11/1975	2.668
3035	12:00:00 05/03/1976	2.258
3035	12:00:00 15/04/1976	2.128
3035	12:00:00 03/05/1976	2.108
3035	00:00:00 02/06/1976	2.288
3035	12:00:00 03/06/1976	2.108
3035	12:00:00 02/07/1976	2.178
3035	12:00:00 10/09/1976	2.378
3035	12:00:00 14/10/1976	2.418
3035	12:00:00 05/11/1976	2.348
3035	12:00:00 12/04/1977	1.858
3035	12:00:00 09/05/1977	1.948
3035	12:00:00 20/06/1977	1.858
3035	12:00:00 06/07/1977	1.888
3035	12:00:00 07/09/1977	2.078
3035	12:00:00 13/10/1977	2.088
3035	12:00:00 14/11/1977	2.028
3035	12:00:00 30/03/1978	1.768
3035	12:00:00 19/04/1978	1.598
3035	12:00:00 17/09/1980	2.298
3035	12:00:00 23/10/1980	2.338
3035	12:00:00 12/11/1980	2.288
3035	12:00:00 11/12/1980	2.168
3035	12:00:00 21/01/1981	2.018
3035	12:00:00 23/02/1981	1.988
3035	12:00:00 24/03/1981	1.798
3035	12:00:00 24/04/1981	1.658
3035	12:00:00 15/05/1981	1.738
3035	12:00:00 23/06/1981	1.908
3035	12:00:00 17/07/1981	2.028
3035	12:00:00 13/08/1981	2.218
3035	12:00:00 23/09/1981	2.448
3035	12:00:00 22/10/1981	2.428
3035	12:00:00 19/11/1981	2.458
3035	12:00:00 17/12/1981	2.238
3035	12:00:00 25/01/1982	2.328
3035	12:00:00 18/02/1982	2.168
3035	12:00:00 21/04/1982	2.038
3035	12:00:00 18/05/1982	2.008
3035	12:00:00 22/06/1982	2.128
3035	12:00:00 22/07/1982	2.238

BORE ID (WIN SITE)	COLLECTED DATE	GROUNDWATER LEVEL (mAHD)
3035	12:00:00 19/08/1982	2.448
3035	12:00:00 20/09/1982	2.558
3035	12:00:00 18/10/1982	2.498
3035	12:00:00 18/11/1982	2.438
3035	12:00:00 16/12/1982	2.348
3035	12:00:00 17/01/1983	2.128
3035	12:00:00 16/02/1983	1.918
3035	12:00:00 17/03/1983	2.018
3035	12:00:00 20/04/1983	2.028
3035	12:00:00 23/05/1983	1.858
3035	12:00:00 21/06/1983	1.928
3035	12:00:00 20/07/1983	2.128
3035	12:00:00 23/08/1983	2.258
3035	12:00:00 21/09/1983	2.348
3035	12:00:00 19/10/1983	2.338
3035	12:00:00 18/11/1983	2.358
3035	12:00:00 21/02/1984	1.918
3035	12:00:00 23/03/1984	1.858
3035	12:00:00 16/04/1984	1.758
3035	12:00:00 18/05/1984	1.938
3035	12:00:00 18/06/1984	2.058
3035	12:00:00 16/07/1984	2.118
3035	12:00:00 20/08/1984	2.288
3035	12:00:00 19/09/1984	2.368
3035	12:00:00 30/10/1984	2.258
3035	12:00:00 20/11/1984	2.478
3035	12:00:00 17/12/1984	2.448
3035	12:00:00 25/01/1985	2.408
3035	12:00:00 20/03/1985	1.988
3035	12:00:00 15/04/1985	1.958
3035	12:00:00 14/05/1985	1.928
3035	12:00:00 13/06/1985	1.998
3035	12:00:00 17/07/1985	2.178
3035	12:00:00 13/08/1985	2.388
3035	12:00:00 10/09/1985	2.458
3035	12:00:00 15/10/1985	2.498
3035	14:12:00 12/12/1985	2.278
3035	13:30:00 03/02/1986	2.008
3035	14:28:00 20/02/1986	1.928
3035	12:43:00 19/03/1986	1.968
3035	13:21:00 13/05/1986	1.888
3035	14:23:00 17/06/1986	1.978
3035	14:47:00 15/07/1986	2.108
3035	14:56:00 14/08/1986	2.298
3035	13:55:00 17/09/1986	2.558
3035	14:20:00 21/10/1986	2.558
3035	12:55:00 11/11/1986	2.518
3035	09:28:00 04/12/1986	2.448

BORE ID (WIN SITE)	COLLECTED DATE	GROUNDWATER LEVEL (mAHD)
3035	12:00:00 28/01/1987	2.158
3035	10:20:00 16/02/1987	2.058
3035	15:40:00 05/03/1987	1.998
3035	13:14:00 03/04/1987	1.938
3035	13:26:00 06/05/1987	1.948
3035	13:57:00 03/06/1987	1.938
3035	13:31:00 07/07/1987	2.058
3035	12:45:00 06/08/1987	2.188
3035	14:49:00 09/09/1987	2.328
3035	13:41:00 12/10/1987	2.308
3035	13:43:00 04/11/1987	2.238
3035	13:23:00 02/12/1987	2.148
3035	13:37:00 09/02/1988	1.888
3035	14:37:00 04/03/1988	1.878
3035	14:46:00 28/04/1988	1.698
3035	14:25:00 10/05/1988	1.688
3035	13:33:00 02/06/1988	1.808
3035	13:53:00 26/07/1988	2.048
3035	13:26:00 16/08/1988	2.228
3035	11:37:00 07/09/1988	2.298
3035	13:22:00 18/10/1988	2.358
3035	13:20:00 09/11/1988	2.298
3035	12:14:00 23/01/1989	1.998
3035	12:22:00 03/05/1989	1.708
3035	11:59:00 25/07/1989	1.948
3035	12:48:00 23/10/1989	2.218
3035	15:02:00 01/02/1990	1.898
3035	13:50:00 03/04/1990	1.808
3035	13:17:00 17/07/1990	1.948
3035	13:10:00 10/10/1990	2.158
3035	14:37:00 10/01/1991	1.838
3035	09:16:00 11/04/1991	1.548
3035	13:11:00 11/07/1991	1.888
3035	13:22:00 02/10/1991	2.328
3035	13:38:00 29/01/1992	2.038
3035	11:54:00 10/04/1992	2.088
3035	15:09:00 30/04/1992	2.058
3035	11:21:00 10/07/1992	2.238
3035	10:27:00 13/10/1992	2.518
3035	14:05:00 13/01/1993	2.168
3035	14:10:00 19/04/1993	1.838
3035	09:43:00 16/07/1993	1.968
3035	12:50:00 07/10/1993	2.198
3035	12:19:00 24/01/1994	1.798
3035	13:07:00 22/04/1994	1.478
3035	11:42:00 14/07/1994	1.788
3035	11:50:00 13/10/1994	2.058
3035	12:30:00 18/01/1995	1.648
3035	11:35:00 07/04/1995	1.318
3035	13:45:00 13/07/1995	1.548
3035	12:45:00 16/10/1995	1.908
3035	09:55:00 12/01/1996	1.678
3035	12:35:00 29/04/1996	1.358
3035	15:50:00 10/07/1996	1.548

BORE ID (WIN SITE)	COLLECTED DATE	GROUNDWATER LEVEL (mAHD)
3035	11:45:00 11/10/1996	1.998
3035	15:15:00 16/01/1997	1.658
3035	12:45:00 16/04/1997	1.388
3035	09:35:00 10/07/1997	1.648
3035	11:10:00 09/10/1997	1.888
3035	11:30:00 14/01/1998	1.488
3035	11:35:00 25/03/1998	1.308
3035	11:40:00 13/07/1998	1.468
3035	12:10:00 06/10/1998	1.808
3035	11:23:00 13/01/1999	1.488
3035	11:29:00 30/04/1999	1.188
3035	12:04:00 20/09/1999	1.978
3035	10:38:00 30/05/2000	1.488
3035	11:46:00 10/10/2000	2.028
3035	12:16:00 08/05/2001	1.348
3035	11:58:00 15/10/2001	1.638
3035	11:46:00 10/05/2002	1.168
3035	11:28:00 10/10/2002	1.518
3035	11:27:00 09/05/2003	1.108
3035	14:10:00 14/10/2003	1.648
3035	12:41:00 30/04/2004	1.058
3035	11:45:00 20/10/2004	1.488
3035	12:50:00 12/05/2005	1.048
3035	11:25:00 05/10/2005	1.868
3035	11:38:00 05/05/2006	1.288
3035	11:51:00 05/10/2006	1.448
3035	13:08:00 30/04/2007	0.918
3035	12:47:00 12/10/2007	1.528
3035	13:19:00 08/05/2008	1.428

APPENDIX D
GROUNDWATER MONITORING RECORDS


Water Level Variation
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Water Level (mAHD)
9/09/2008
29/09/2008
19/10/2008
8/11/2008
28/11/2008
18/12/2008
7/01/2009
27/01/2009
16/02/2009
8/03/2009
date
MW1
MW2
MW3
MW4
MW5
DoW Bore (3035)

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
GROUNDWATER MONITORING RECORDS - WATER LEVEL RECORDS

Bore	Ground Level (mAHD)	Top of Casing (mAHD)	Depth of Casing (m)	Depth to Water (m)				
				24/09/2008	30/10/2008	27/11/2008	9/12/2008	13/02/2009
MW1	10.895	11.48	13.10	9.62	9.69	10.00	9.72	10.18
MW2	18.003	18.68	19.63	16.77	16.80	16.83	16.88	-
MW3	6.432	6.93	7.49	5.03	5.07	5.10	5.14	-
MW4	12.633	13.13	13.80	11.17	11.13	11.26	11.30	11.56
MW5	12.934	13.32	15.30	11.44	11.49	11.53	11.59	-
DoW Bore (3035)	19.558	20.06	39.44	18.15	18.17	18.23	18.26	-

Groundwater Level (GWL) (AHD)						MAX	MIN	Calculated Max GWL (mAHD)
Bore	24/09/2008	30/10/2008	27/11/2008	9/12/2008	13/02/2009			
MW1	1.85	1.79	1.47	1.76	1.29	1.85	1.47	2.87
MW2	1.92	1.89	1.85	1.80	-	1.92	1.80	2.94
MW3	1.90	1.86	1.83	1.79	-	1.90	1.79	2.92
MW4	1.96	2.00	1.88	1.84	1.57	2.00	1.84	2.98
MW5	1.88	1.84	1.80	1.73	-	1.88	1.73	2.90
DoW Bore (3035)	1.91	1.88	1.83	1.80	-	1.91	1.80	2.93

Depth Below Ground Level (BGL) (m)						MAX	MIN	Calculated Max GWL (m BGL)
Bore	24/09/2008	30/10/2008	27/11/2008	9/12/2008	13/02/2009			
MW1	9.04	9.11	9.42	9.14	9.60	9.42	9.04	8.02
MW2	16.09	16.12	16.15	16.20	-	16.20	16.09	15.07
MW3	4.53	4.57	4.60	4.64	-	4.64	4.53	3.51
MW4	10.67	10.63	10.76	10.80	11.06	10.80	10.63	9.65
MW5	11.05	11.10	11.14	11.20	-	11.20	11.05	10.03
DoW OBS T290 (O)	17.65	17.67	17.73	17.76	17.76	17.65	17.65	16.63

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
GROUNDWATER MONITORING RECORDS - PHYSICAL PARAMETERS

pH					MEAN
	24/09/2008	30/10/2008	9/12/2008	13/02/2009	
MW1	6.84	6.70	6.70		6.75
MW2	7.49	6.95	7.43		7.29
MW3	6.95	6.96	6.92		6.94
MW4	7.37	7.03	7.29		7.23
MW5	7.23	7.12	7.10		7.15

EC (uS)					MEAN
	24/09/2008	30/10/2008	9/12/2008	13/02/2009	
MW1	4.04	4.13	4.08		4.08
MW2	0.60	0.67	0.62		0.63
MW3	3.66	3.64	3.29		3.53
MW4	1.11	1.23	1.61		1.32
MW5	2.28	2.78	2.83		2.63

Redox (mV)					MEAN
	24/09/2008	30/10/2008	9/12/2008	13/02/2009	
MW1	194	123	87		135
MW2	127	86	71		95
MW3	202	158	102		154
MW4	181	100	63		115
MW5	196	140	52		129

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
GROUNDWATER MONITORING RECORDS - NUTRIENT LEVELS

Date		Total P mg/L	PO4 mg/L	Total N mg/L	NO3-N mg/L	NH3-N mg/L	TKN mg/L	Metals	Arsenic mg/L	Cadmium mg/L	Chromium mg/L	Copper mg/L	Lead mg/L	Nickel mg/L	Zinc mg/L	Mercury mg/L
24/09/2008	**MW1**	0.05	<0.01	91.7	91.7	<0.1	<0.1		<0.001	<0.0001	<0.001	0.002	<0.001	<0.001	<0.005	<0.0001
30/10/2008		0.02	0.02	219	219	0.02	<0.5		0.006	0.0002	0.008	0.002	<0.001	0.002	0.006	<0.0001
9/12/2008		0.02	0.01	184	184	0.08	<0.1		0.003	<0.0001	<0.001	0.002	<0.001	0.001	<0.005	<0.0001
13/02/2009		0.13	0.03	214	214	0.05	<0.1		-	-	-	-	-	-	-	-
MEAN		0.06	0.02	177	177	0.06	<0.2		0.003	0.0001	0.003	0.002	<0.001	0.001	0.005	<0.0001
24/09/2008	**MW2**	0.06	<0.01	6.7	5.5	0.03	1.2		<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
30/10/2008		0.02	0.01	5	4.6	0.02	0.5		0.005	0.0002	0.01	<0.001	0.001	0.001	<0.005	<0.0001
9/12/2008		0.09	<0.01	4.8	4.1	0.12	0.7		0.006	0.0002	0.012	<0.001	0.001	0.001	<0.005	<0.0001
13/02/2009		0.58	<0.01	8.5	8.14	0.02	0.4		-	-	-	-	-	-	-	-
13/02/2009	***Duplicate***	*0.73*	*<0.01*	*9.4*	*8.83*	*0.02*	*0.6*		-	-	-	-	-	-	-	-
13/02/2009	***Triplicate***	*0.28*	*0.009*	*10*	*8.8*	*<0.1*	*1.3*		-	-	-	-	-	-	-	-
MEAN		0.19	0.01	6.25	5.6	0.05	0.7		0.004	0.00017	0.008	<0.001	<0.001	0.001	<0.005	<0.0001
24/09/2008	**MW3**	1.81	<0.01	19.5	17.4	<0.1	2.0		0.046	0.0001	0.326	0.008	0.031	0.016	0.015	<0.0001
30/10/2008		0.28	0.02	227	211	0.03	15.4		0.034	<0.0001	0.182	0.005	0.014	0.014	0.012	<0.0001
9/12/2008		0.48	<0.01	114	114	0.09	<0.1		0.029	<0.0001	0.149	0.005	0.014	0.008	0.008	<0.0001
13/02/2009		1.07	<0.01	108	108	0.03	0.1		-	-	-	-	-	-	-	-
MEAN		0.91	0.01	117	113	0.06	4.4		0.036	<0.0001	0.219	0.006	0.020	0.013	0.012	<0.0001
24/09/2008	**MW4**	0.06	<0.01	16.9	15.1	0.11	1.8		<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
30/10/2008		0.03	<0.01	16.1	15.7	0.02	0.4		0.003	<0.0001	0.003	<0.001	<0.001	0.002	0.006	<0.0001
9/12/2008		0.03	<0.01	9.7	8.48	0.05	1.2		0.002	0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
13/02/2009		0.54	<0.01	11	10	0.03	1		-	-	-	-	-	-	-	-
MEAN		0.17	<0.01	13.4	12.3	0.05	1.1		0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	0.005	<0.0001
24/09/2008	**MW5**	0.02	<0.01	231	231	<0.1	<0.1		<0.001	<0.0001	<0.001	0.001	<0.001	<0.001	<0.005	<0.0001
30/10/2008		0.3	<0.01	123	110	0.02	12.8		0.019	0.0004	0.046	0.004	0.004	0.005	0.021	<0.0001
9/12/2008		0.03	<0.01	99.6	99.6	0.11	<0.1		0.002	0.0002	0.002	0.002	<0.001	<0.001	<0.005	<0.0001
13/02/2009		2.04	<0.01	125	122	0.04	3.2		-	-	-	-	-	-	-	-
MEAN		0.60	<0.01	145	141	0.07	4.1		0.007	0.0002	0.016	0.002	0.002	<0.001	0.01	<0.0001
13/02/2009	**Container Blank**	<0.01	<0.01	<0.1	<0.01	<0.01	<0.1		-	-	-	-	-	-	-	-
	SCCP[1] Long Term Target	0.1		1				DoE FWG (mg/L)	0.024	0.0002	0.01	0.0014	0.0034	0.011	0.008	0.00006
	SCCP[1] Short Term Target	0.2		2				DoE DWG (mg/L)	0.007	0.002		2	0.01	0.02	3	0.001
	DoE 2003[2]				11.3 [3]											

RELATIVE PERCENTAGE DIFFERENCE CALCULATIONS

13/02/2009	**Duplicate RPD - MW2 (%)**	22.9	-	10.1	8.1	0	40
13/02/2009	**Triplicate RPD - MW2 (%)**	69.8	-	16.2	7.8	-	106

NOTE: Means were calculated assuming the most conservative scenario for LOR. E.g. It was assumed that <0.01 = 0.01

[1]Swan Rivert Trust 2003, *Developing targets for the Swan-Canning Cleanup Program (SCCP), River Science Issue 7* , Government of Western Australia, Perth, Western Australia

[2]Department of Environment (DoE) 2003, *Assessment Levels for Soil, Sediment and Water, Contaminated Sites Management Series* , Department of Environment, Perth, Western Australia

[3]The NO3-N assessment level has been calculated from the total NO3 assessment level for water (50 mg/L) in DoE (2003).

APPENDIX E
POTABLE DEMAND CALCULATIONS

LOTS 14, 15 & 299, KEROSENE LANE, BALDIVIS LWMS
POTABLE WATER DEMAND

RESIDENTIAL SCHEME WATER USAGE SUMMARY

SCENARIO: NO CHANGE

		Volume Per Resident (L)	Annual Usage (kL/resident/yr)	Total Usage (kL/year)
Low	In-house	160	58	61,848
	Ex-house	146	53	56,396
	Total	306	112	118,244
Medium	In-house	167	61	23,339
	Ex-house	82	30	11,386
	Total	249	91	34,725
			In-house	85,187
			Ex-house	67,782
			Total	152,969

Average scheme water usage (kL/yr/resident) **106.28**
= Total Usage/ Total Residents

Average scheme water usage (kL/yr/dwelling) **259.27**
= Total Usage/ Total Residents

SCENARIO: FRONT YARD WATERWISE LANDSCAPING PACKAGE

		Volume Per Resident (L)	Annual Usage (kL/resident/yr)	Total Usage (kL/year)
Low	In-house	160	58	61,848
	Ex-house	78	28	29,961
	Total	238	87	91,809
Medium	In-house	167	61	23,339
	Ex-house	43	16	6,049
	Total	211	77	29,388
			In-house	85,187
			Ex-house	36,009
			Total	121,196

Average scheme water usage (kL/yr/resident) **84.20**
= Total Usage/ Total Residents

Average scheme water usage (kL/yr/dwelling) **205.42**
= Total Usage/ Total Residents

DEVELOPMENT STATISTICS

	Avg House area	Avg Hardstand area	Avg Garden area (excludes verge)	Number of Dwellings	Persons per house
Low	220	99.50	184.78	379	2.79
Medium	192	105.46	86.29	211	1.81

Total Residents **1439**

Average number of residents per dwelling **2.44**

R20 Households Potable and Non-potable water usage

Average number of residents per household: 2.79 *Assumed traditional households (Water Corp from ABS Census 2001)*

It is assumed that the lawn to garden ratio per household is:

	Yard (m^2)	Verge (m^2)	Total (m^2)
Lawn / Garden	142	40	182

Assumptions based upon Water Corporation standards

Washing Machine	0.042	kL/person/day
Shower	0.050	kL/person/day
Toilet	0.033	kL/person/day
Kitchen Sink	0.008	kL/person/day
Bathroom Basin	0.006	kL/person/day
Bath	0.001	kL/person/day
Laundry Trough	0.004	kL/person/day
Dishwasher	0.003	kL/person/day
Air Con	0.006	kL/house/day
Leaks	0.029	kL/house/day
Spa	0.002	kL/house/day
Garden/Lawn	0.003	kL/m^2/day
Irrigation Loss	0.0002	kL/m^2/day

Total per household

	kL/day	kL/yr
Washing Machine	0.117	42.77
Shower	0.140	50.92
Toilet	0.092	33.61
Kitchen Sink	0.022	8.15
Bathroom Basin	0.017	6.11
Bath	0.003	1.02
Laundry Trough	0.011	4.07
Dishwasher	0.008	3.04
Air Con	0.006	2.19
Leaks	0.029	10.59
Spa	0.002	0.73
Garden/Lawn	0.55	199.29
Irrigation Loss	0.04	13.29
Total in house	0.447	163.19
Total ex house	0.408	148.80
Rainwater tank augmentation	0	0
Total per household	0.85	311.99

	kL/person/day	kL/person/yr
Total per person	0.306	112

R20 Households Potable and Non-potable water usage + FRONT LANDSCAPING PACKAGES

Average number of residents per household: 2.79 *Assumed traditional households (Water Corp from ABS Census 2001)*

It is assumed that the lawn to garden ratio per household is:

	Yard (m^2)	Verge (m^2)	Total (m^2)
Lawn / Garden	142	40	182

Assumptions based upon Water Corporation standards

Washing Machine	0.042	kL/person/day
Shower	0.050	kL/person/day
Toilet	0.033	kL/person/day
Kitchen Sink	0.008	kL/person/day
Bathroom Basin	0.006	kL/person/day
Bath	0.001	kL/person/day
Laundry Trough	0.004	kL/person/day
Dishwasher	0.003	kL/person/day
Air Con	0.006	kL/house/day
Leaks	0.029	kL/house/day
Spa	0.002	kL/house/day
Garden/Lawn	0.0015	kL/m^2/day
Irrigation Loss	0.0002	kL/m^2/day

Total per household

	kL/day	kL/yr
Washing Machine	0.117	42.77
Shower	0.140	50.92
Toilet	0.092	33.61
Kitchen Sink	0.022	8.15
Bathroom Basin	0.017	6.11
Bath	0.003	1.02
Laundry Trough	0.011	4.07
Dishwasher	0.008	3.04
Air Con	0.006	2.19
Leaks	0.029	10.59
Spa	0.002	0.73
Garden/Lawn	0.27	99.65
Irrigation Loss	0.04	13.29
Total in house	0.447	163.19
Total ex house	0.217	79.05
Rainwater tank augmentation	0	0
Total per household	0.66	242.24

	kL/person/day	kL/person/yr
Total per person	0.238	87

R30 Households Potable and Non-potable water usage

Average number of residents per household: 1.81 *Assumed cottage households (Water Corp from ABS Census 2001)*

It is assumed that the lawn to garden ratio per household is:

	Yard (m^2)	Verge (m^2)	Total (m^2)
Lawn / Garden	42	24	66

With Water Efficiency Measures, as per Waterwise Calculator with European Garden

Washing Machine	0.042	kL/person/day
Shower	0.050	kL/person/day
Toilet	0.033	kL/person/day
Kitchen Sink	0.008	kL/person/day
Bathroom Basin	0.006	kL/person/day
Bath	0.001	kL/person/day
Laundry Trough	0.004	kL/person/day
Dishwasher	0.003	kL/person/day
Air Con	0.006	kL/house/day
Leaks	0.029	kL/house/day
Spa	0.002	kL/house/day
Garden/Lawn	0.003	kL/m^2/day
Irrigation Loss	0.0002	kL/m^2/day

Total per household

	kL/day	kL/yr
Washing Machine	0.076	27.75
Shower	0.091	33.03
Toilet	0.060	21.80
Kitchen Sink	0.014	5.29
Bathroom Basin	0.011	3.96
Bath	0.002	0.66
Laundry Trough	0.007	2.64
Dishwasher	0.005	1.97
Air Con	0.006	2.19
Leaks	0.029	10.59
Spa	0.002	0.73
Garden/Lawn	0.20	72.27
Irrigation Loss	0.01	4.82
Total in house	0.30	110.61
Total ex house	0.15	53.96
Rainwater tank augmentation	0	0
Total per household	0.45	164.57

	kL/person/day	kL/person/yr
Total per person	0.249	91

R30 Households Potable and Non-potable water usage + FRONT LANDSCAPING PACKAGES

Average number of residents per household: 1.81 *Assumed cottage households (Water Corp from ABS Census 2001)*

It is assumed that the lawn to garden ratio per household is:

	Yard (m^2)	Verge (m^2)	Total (m^2)
Lawn / Garden	42	24	66

With Water Efficiency Measures, as per Waterwise Calculator with European Garden

Washing Machine	0.042	kL/person/day
Shower	0.050	kL/person/day
Toilet	0.033	kL/person/day
Kitchen Sink	0.008	kL/person/day
Bathroom Basin	0.006	kL/person/day
Bath	0.001	kL/person/day
Laundry Trough	0.004	kL/person/day
Dishwasher	0.003	kL/person/day
Air Con	0.006	kL/house/day
Leaks	0.029	kL/house/day
Spa	0.002	kL/house/day
Garden/Lawn	0.0015	kL/m^2/day
Irrigation Loss	0.0002	kL/m^2/day

Total per household

	kL/day	kL/yr
Washing Machine	0.076	27.75
Shower	0.091	33.03
Toilet	0.060	21.80
Kitchen Sink	0.014	5.29
Bathroom Basin	0.011	3.96
Bath	0.002	0.66
Laundry Trough	0.007	2.64
Dishwasher	0.005	1.97
Air Con	0.006	2.19
Leaks	0.029	10.59
Spa	0.002	0.73
Garden/Lawn	0.10	36.14
Irrigation Loss	0.01	4.82
Total in house	0.30	110.61
Total ex house	0.08	28.67
Rainwater tank augmentation	0	0
Total per household	0.38	139.28

	kL/person/day	kL/person/yr
Total per person	0.211	77

APPENDIX F
WATER BALANCE CALCULATIONS

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Post-development Water Balance
Summary Sheet

	Drainage and Infiltration (ML)	Bore Water Use (ML)
Houses (ML/yr)	123.49	0.00
Commericial (ML/yr)	40.1143	1.39
School (ML/yr)	32.7995	13.43
POS areas (ML/yr)	3.2752	23.90
Drainage areas and roads (ML/yr)	48.86	0
Total per use (ML/yr)	248.54	38.73

Assume that one third of household irrigation comes from bore water.

Pre-Development	Drainage and Infiltration (ML/yr)
Pre Development	**29.4**

Total recharge to groundwater and drains (ML/yr)	**209.81**
% Increase Recharge	**712**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Pre-development Water Balance

No lot drainage and no sub-surface drainage
Assuming 10% of rainfall as total recharge as per Davi 29
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)

Total rainfall for site	294492	kL/yr for site
Total flow to groundwater/streams	29449	kL/yr for site
	29	**ML/yr for site**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS

Assumptions

Rainfall data and Evap data from Kwinana (1955-2008) & Perth airport (1981-2008) accessed 13 Jan 2009
Waterwise garden water use is based on 155 kL/house/yr or 424.7 L/house/day as given by E. Sahouryeh of Water Corporation
References to GHD (2005) are to *Non-potable Water Use: Guidelines for developers and their consultants* (draft) (GHD, 2005 b in the references)
No lot drainage and no sub-surface drainage
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)
Rain and irrigation has a 17.5% surface loss
Epot=0.7*Pan Evaporation

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
Monthly Rainfall	11.3	15.5	16.6	44.3	104.1	158.9	155.0	106.5	67.4	41.2	23.6	8.1	759.3
Monthly Evaporation	313.1	268.8	241.8	150	93	66	65.1	80.6	108	164.3	222	279	2051.7
Potential Evaporation	219	188	169	105	65	46	46	56	76	115	155	195	1436

Input parameters

A	Total Residential Lots	590	From LSP
	Total Commercial Lots	4	From LSP
B	Residential (Ha)	19.796	From LSP - as shown on the figure
C	Commercial (Ha)	1.4505	Sum of all lot areas from the sub-division plan
	Commerical Hardstand (Ha)	0.652725	From LSP
	School (Ha)	3.4983	Assume 45% paved commercial areas as per Perth Urban Water Balance Study (1987)
D	POS Total (Ha)	4.5971	From LSP
	POS Irrigated (residential + sporting) (Ha)	3.5288	From LSP - includes all parks, POS/drainage and dedicated drainage reserve (from conversation with Cossil & Webley (03/02/09), that all drainage basins will in fac be open, not fenced sumps and therefore was assumed that it would be treated as POS)
	POS Not Irrigated (Ha)	1.0683	35.286
	POS Reserve (Ha)	0	From LSP - assume dedicated drainage reserve will not be irrigated
G	Road Reserve (Ha)	9.443	Not required for this site.
H	Total Area (Ha)	38.785	Total Area - Residential - POS - Commercial
I	Road Reserve as road (Ha)	6.80	From LSP - Total Lots Area
K	Road Reserve as verge (Ha)	2.64	The rest of the road reserve minus verge area
L	Verge per house (m^2/house)	44.8	Remainder of verge
M	Verge driveway per house (m^2/house)	24	Road reserve as verge / no of houses
N	Verge lawn per house (m^2/house)	21	4m driveway width multiplied by 6m (2 car driveway) The remainder of verge that is not driveway and is assumed to be irrigated infiltration area
	From Dwelling Statistic Assumptions		
O	Lot Area (m^2)	336.0	Average lot area calculated in Dwelling Statistics spreadsheet (weighted average)
P	Average house size (m^2)	162	Average house size calculated in Dwelling Statistics spreadsheet (weighted average)
Q	Non verge lawn/garden (m^2)	107	Average garden arera calculated in Dwelling Statistics spreadsheet (weighted average)
R	External paving/hardstand (m^2)	67	Average hardstand area calculated in Dwelling Statistics spreadsheet (weighted average)
	From Above, commercial specification		
S	Lot Area (m^2)	14505	From LSP
T	Commercial Irrigation (m^2)	1450.5	Assumed 10% area requires irrigation
U	External paving/hardstand (m^2)	7325.025	Assumed that the remainder of the lot is hardstand
V	Commercial Verge (m^2)	0	
W	Commercial Buildings (m^2)	5729.475	Assumed that 39.5% of Commercial (small shops) will be roofed as per Perth Urban Water Balance Study (1987)
	Commercial Buildings and Hardstand (m^2)	13054.5	
	From Above, school specification		
	Lot Area (m^2)	34983	From LSP
	School Irrigation (m^2)	13993.2	Assumed 40% area requires irrigation (higher than commercial due to school ovals)
	External paving/hardstand (m^2)	6996.6	Assumed that the remainder of the lot is hardstand
	School Verge (m^2)	0	Assumed that 40% of School will be roofed and remainder will be sporting hardstand
	School Buildings (m^2)	13993.2	
	School Buildings and Hardstand (m^2)	20989.8	

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to Groundwater from Household Irrigation and Household Runoff (excluding swales)

Assumes that household irrigation includes non-swale verges, calculated as per assumptions sheet
From GHD (2005), *Non-potable Water Use, Guidelines for developers and their consultants.*
Irrigation in the subdivision is based on post-water restriction potable water from personal communication with J. Brennan & E. Sahouryeh, Water Corp
Epot=0.7*Pan Evaporation
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)
Rain and irrigation has a 17.5% surface loss

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	11.3	15.5	16.6	44.3	104.1	158.9	155.0	106.5	67.4	41.2	23.6	8.1	759.3
Monthly Evaporation	313.1	268.8	241.8	150.0	93.0	66.0	65.1	80.6	108.0	164.3	222.0	279.0	2051.7
Evap-Trans	219.2	188.2	169.3	105.0	65.1	46.2	45.6	56.4	75.6	115.0	155.4	195.3	1436.2
GHD (2005)- gives ratios over an annual basis (Single) (L/house/day)	911	911	841	561	280	140	35	35	70	351	771	911	484.75
Irrigation in subdivision (L/house/day)	798	798	737	492	245	123	31	31	61	308	675	798	425
Irrigation (kL/house/month)	24.74	22.35	22.84	14.75	7.60	3.68	0.95	0.95	1.84	9.53	20.26	24.74	154.243
Garden Rainfall (kL/house/month)	1.44	1.98	2.12	5.66	13.31	20.31	19.81	13.61	8.61	5.27	3.02	1.04	96.1795
Roof splash (10% of rain falling on rooves)	0.18	0.25	0.27	0.72	1.69	2.57	2.51	1.73	1.09	0.67	0.38	0.13	12.1905
Paving runoff	0.98	1.35	1.44	3.85	9.05	13.81	13.47	9.26	5.86	3.58	2.05	0.70	65.39601
Total input to gardens (kL/house/month)	27.35	25.93	26.67	24.97	31.64	40.37	36.74	25.54	17.40	19.05	25.71	26.61	328.01
Surface evaporation and interception losses	4.79	4.54	4.67	4.37	5.54	7.07	6.43	4.47	3.05	3.33	4.50	4.66	57.40
Total input - surface evap	22.57	21.39	22.01	20.60	26.11	33.31	30.31	21.07	14.36	15.71	21.21	21.96	270.61
Potential Evap for area	28.01	24.05	21.63	13.42	8.32	5.90	5.82	7.21	9.66	14.70	19.86	24.96	183.56
Total input - potential evap	-5.45	-2.66	0.37	7.18	17.79	27.40	24.49	13.86	4.70	1.01	1.35	-3.01	87.04
Therefore infiltration to groundwater from gardens(kL/house)	0.00	0.00	0.37	7.18	17.79	27.40	24.49	13.86	4.70	1.01	1.35	0.00	98.16
TOTAL GARDEN INFILTRATION FOR RESIDENTIAL AREA	0	0	220	4238	10493	16167	14448	8179	2770	598	798	0	**57912**
Water to soakwells or drains from roof (kL/house/month)	0.0	2.3	2.5	6.6	15.6	23.8	23.2	16.0	10.1	6.2	3.5	1.2	111.1
TOTAL SOAKWELL OR DRAIN INFILTRATION FOR ESTATE (kL)	27	1371	1468	3918	9206	14053	13708	9419	5961	3644	2087	716	**65578**
Total Irrigation Water Use for Residential areas (kL)	14598	13185	13476	8700	4487	2171	561	561	1086	5625	11956	14598	**91003**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to groundwater from irrigated Commerical areas

Irrigated commercial areas (ie green space around the office building) assumed to be irrigated as per non-drainage POS
Irrigation for the commercial area is assumed to be 0.960 kL/m2/yr (Water Corporation model)
Assumes that driveway is 40% of verge and runs off onto the lawn
Assumes the same verge properties/characteristics as a residential property/house
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)
Epot=0.7*Pan Evaporation

	Total	
Rainfall	759.3	
Evaportation	2051.7	
Evap-Transporation	1436.2	
Commericial irrigation (kL/year)	1392.5	
Total Garden rainfall (kL/year)	1101.365	
Rainfall on Rooves	4350.39	
Paving runoff	5311.606	
Total input to gardens (kL/year)	12155.84	
Surface evaporation and interception losses	2127.272	
Total input-surface evap	10028.57	
Potential evap for area	0	
Total input - potential evap	10028.57	
Therefore infiltration to groundwater from gardens(kL)	10028.57	
TOTAL INFILTRATION FOR COMMERCIAL AREA ROOVES AND GARDENS	**40114.28**	
Water to soakwells or drains from roof (kL/month)	39403.8	
Total Irrigation Water Use for Commerical areas (kL)	1392.5	Assumed to be from bores

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to groundwater from irrigated School areas

Irrigated school areas (ie green space around the school building) assumed to be irrigated as per non-drainage POS
Irrigation for the commercial area is assumed to be 0.960 kL/m2/yr (Water Corporation model)
Assumes the same verge properties/characteristics as a residential property/house
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)
Epot=0.7*Pan Evaporation

	Total
Rainfall	759.3
Evaportation	2051.7
Evap-Transporation	1436.2
School irrigation (kL/year)	13433.5
Total Garden rainfall (kL/month)	10625.0
Rainfall on Rooves	10625.0
Paving runoff	5073.5
Total input to gardens (kL/month)	39757.0
Surface evaporation and interception losses	6957.5
Total input-surface evap	32799.5
Potential evap for area	0.0
Total input - potential evap	32799.5
Therefore infiltration to groundwater from gardens(kL)	32799.5
TOTAL INFILTRATION FOR SCHOOL AREA ROOVES AND GARDENS	**32799.5**
Water to soakwells or drains from roof (kL/month)	95864.4
Total Irrigation Water Use for School areas (kL)	13433.5

Assumed to be from bores

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to groundwater from Irrigated POS

Includes both irrigation and rainfall
From GHD (2005)
Epot=0.7*Pan Evaporation
Assume that 30% is shrubs, rest is irrigated lawn

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	11.3	15.5	16.6	44.3	104.1	158.9	155.0	106.5	67.4	41.2	23.6	8.1	759.3
Monthly Evaporation	313.1	268.8	241.8	150.0	93.0	66.0	65.1	80.6	108.0	164.3	222.0	279.0	2051.7
Evap-Trans	219.2	188.2	169.3	105.0	65.1	46.2	45.6	56.4	75.6	115.0	155.4	195.3	1436.2
Turf Irrig (kL/d/ha) from GHD (2005)	52	51	34	17	0	0	0	0	0	18	28	47	247
Shrub Irrig (kL/d/ha) from GHD (2005)	34	33	21	9	0	0	0	0	0	9	15	31	152
Average volume per ha assuming 30% shrubs (kl/d/ha)	46.6	45.6	30.1	14.6	0	0	0	0	0	15.3	24.1	42.2	218.5
Average volume per ha assuming 30% shrubs (kl/month/ha)	1444.6	1413.6	933.1	452.6	0	0	0	0	0	474.3	747.1	1308.2	6773.5
For Total Irrigated POS													
Monthly irrigation (kL/month)	5097.70	4988.31	3292.72	1597.13	0.00	0.00	0.00	0.00	0.00	1673.71	2636.37	4616.38	23902.3
Rainfall (kL/month)	398.75	546.96	585.78	1563.26	3673.48	5607.26	5469.64	3758.17	2378.41	1453.87	832.80	285.83	26554.2
Total input (kL/ha/month)	5496.46	5535.28	3878.50	3160.39	3673.48	5607.26	5469.64	3758.17	2378.41	3127.58	3469.16	4902.21	50456.5
Surface evaporation and interception losses	3394.28	3418.25	2395.13	1951.67	2268.52	3462.71	3377.72	2320.82	1468.76	1931.40	2142.35	3027.31	31158.9
Total input - surface evap	2102.18	2117.02	1483.37	1208.72	1404.96	2144.55	2091.92	1437.35	909.65	1196.17	1326.82	1874.90	19297.6
Evapotransipiration for area	7734.07	6639.79	5972.85	3705.24	2297.25	1630.31	1608.07	1990.95	2667.77	4058.47	5483.76	6891.75	50680.3
Total input - evapotranspiration	-5631.90	-4522.77	-4489.47	-2496.52	-892.29	514.25	483.84	-553.60	-1758.13	-2862.30	-4156.94	-5016.85	-31382.7
groundwater from irrigated POS (kL/month)	0	0	0	0	0	514.248	483.844	0	0	0	0	0	**998.1**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to groundwater from Non-Irrigated POS

Assumes no irrigation, rainfall only
From GHD (2005)
Epot=0.7*Pan Evaporation

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	11.3	15.5	16.6	44.3	104.1	158.9	155.0	106.5	67.4	41.2	23.6	8.1	759.3
Monthly Evaporation	313.1	268.8	241.8	150.0	93.0	66.0	65.1	80.6	108.0	164.3	222.0	279.0	2051.7
Evap-Trans	219.2	188.2	169.3	105.0	65.1	46.2	45.6	56.4	75.6	115.0	155.4	195.3	1436.2
Turf Irrig (kL/d/ha) from GHD (2005)	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrub Irrig (kL/d/ha) from GHD (2005)	0	0	0	0	0	0	0	0	0	0	0	0	0
Average volume per ha assuming 30% shrubs (kl/d/ha)	0	0	0	0	0	0	0	0	0	0	0	0	0
For Total Non-Irrigated and Reserve POS													
Monthly irrigation (kL/month)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall (kL/month)	120.72	165.59	177.34	473.26	1112.10	1697.53	1655.87	1137.74	720.03	440.14	252.12	86.53	8038.96
Total input (kL/ha/month)	120.72	165.59	177.34	473.26	1112.10	1697.53	1655.87	1137.74	720.03	440.14	252.12	86.53	8038.96
Surface evaporation and interception losses	22.57	30.96	33.15	88.48	207.91	317.36	309.57	212.70	134.61	82.29	47.13	16.18	1502.90
Total input - surface evap	98.15	134.63	144.18	384.78	904.19	1380.17	1346.30	925.04	585.42	357.85	204.98	70.35	6536.05
Evapotransipiration for area	2341.39	2010.11	1808.20	1121.72	695.46	493.55	486.82	602.73	807.63	1228.65	1660.14	2086.39	15342.82
Total input - evapotranspiration	-2243.24	-1875.48	-1664.02	-736.93	208.73	886.62	859.47	322.30	-222.21	-870.80	-1455.15	-2016.04	-8806.76
Therefore infiltration to groundwater from non-irrigation and reserve POS (kL/month)	0	0	0	0	208.727	886.617	859.473	322.301	0	0	0	0	**2277.12**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Recharge to groundwater from Roads

Assumes no irrigation of these areas
Verges are included in 'Household irrigation' spreadsheets
From GHD (2005)
Epot=0.7*Pan Evaporation
Rain on Hard Surfaces is 4.5% Evap, 95.5% stormwater (WAWA, 1987)
Assume that drainage structures are not irrigated

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	11.3	15.5	16.6	44.3	104.1	158.9	155.0	106.5	67.4	41.2	23.6	8.1	759.3
Monthly Evaporation	313.1	268.8	241.8	150.0	93.0	66.0	65.1	80.6	108.0	164.3	222.0	279.0	2051.7
Evap-Trans	219.2	188.2	169.3	105.0	65.1	46.2	45.6	56.4	75.6	115.0	155.4	195.3	1436.2
Roads (does not include verges)													
Rainfall falling on roads (kL)	768.3	1053.8	1128.6	3011.9	7077.6	10803.3	10538.2	7240.7	4582.4	2801.1	1604.5	550.7	51161.1
Interception losses (kL)	34.6	47.4	50.8	135.5	318.5	486.1	474.2	325.8	206.2	126.1	72.2	24.8	2302.2
Runoff from roads (kL)	733.7	1006.4	1077.8	2876.3	6759.1	10317.2	10063.9	6914.9	4376.2	2675.1	1532.3	525.9	**48858.8**

Lots 14, 15 & 299, Kerosene Lane, Baldivis LWMS
Total Commercial Potable and Non-potable water use

It is assumed that total commercial consumption is 0.800 kL/m^2GLA/year (Water Corportation model)
It is assumed that total commercial consumption equates to 5% for irrigation, 60% as drinking water and 35% non-drinking water
It is assumed that there will be no commerical use of bore water

Water Corporation annual consumption (kL/m^2 GLA/year)	1160.4
Commercial drinking water (kL/m^2 GLA/year)	696.24
Commercial non-drinking water (kL/m^2 GLA/year)	406.14
Commercial bore water use (kL/m^2 GLA/year)	0