Satterley Property Group

Austin Cove Phase Two

Urban Water Management Strategy

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STUDY TEAM

Satterley Property Group	Project Direction
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RPS	Groundwater modelling, report sections
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Note: All land identified in this document or any plan submitted with it for use for public purposes, including public open space, conservation category wetland, vegetation buffers, school sites, drainage areas and the like, has been identified for these uses in accordance with standard practice, relevant policies or at the request of the relevant agencies. The identification of land for these purposes does not necessarily imply that any or all such land will be ceded free of cost or that any use is necessarily shown at its highest and best use.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. EXECUTIVE SUMMARY

1.1 Introduction

The proposed Austin Cove Phase 2 development is located on 271ha of low-lying land east of the Peel Inlet and about 11km east of Mandurah. The site is immediately south of the South Yunderup 100-year floodway of the Murray River and immediately west of the planned Perth-Bunbury Highway Peel Deviation.

Satterley Property Group (Satterley) proposes to develop about 2,350 residential lots in Phase 2. A feature of the development will be the creation of a 27ha central open space incorporating a 16.6ha lined lake to serve landscape, active and passive recreation, irrigation, flood management and amenity functions. Another feature is a large multiple-use corridor (MUC) running east-west through the estate, which will serve landscape, passive recreation, drainage, ecological and amenity functions.

Austin Cove is the first major land-based urban development to be undertaken in the inner eastern Peel-Harvey catchment since the early 1990s, when the Peel-Harvey Stage 2 ERMP, the Peel-Harvey EPP and Statement of Planning Policy 2.1 set limits on clearing, drainage and phosphorus exports to the estuary. Management of nutrient exports continues to be the critical issue to be addressed in demonstrating the acceptability of development in the inner catchment. To this end, the urban water management measures detailed in this UWMS are first and foremost directed at achieving long-term reduction and control of nutrient exports from the site.

Satterley intends that Austin Cove Phase 2 will set a new benchmark for water-sensitive urban design - and urban design in general - in the Peel Region. To this end, Satterley is committed to implementing best-practice urban water management and to significantly bettering the water quality management targets arising from both existing policies (such as the Peel-Harvey EPP) and current work by the DEC/DoW such as the CCI/WQIP program.

This UWMS addresses the issues of water supply, management of water quality within the estate and management of drainage and water flows out of the site. The aims of the UWMS include:

Water Conservation

- Minimising the consumption of high-quality (scheme or bore) water for non-potable uses.
- Promoting the harvesting and reuse of rainwater and stormwater.

Hydrology and Drainage

- Maintaining the pre-development hydrology of the site.
- Managing flood flows to protect property and the environment.

Water Quality

- Reducing and minimising the export of nutrients and other contaminants from the site to the estuary.

Lake Management

- Designing and managing water bodies within the estate to enhance beneficial uses, prevent algal blooms and minimise the need for active maintenance.

Water-Dependent Ecosystems

- Maintaining environmental water provision to wetlands and other groundwater-dependent ecosystems within and outside the project area.

The approach to these issues is summarised below.

1.2 Water Conservation

Sub-potable groundwater from the Leederville aquifer will be used in summer to supply water for irrigation and lake maintenance. Some of this water will be used to irrigate and rehabilitate the South Yunderup Sports Club oval, which is effectively unusable due to acidification and salinity. The total water requirement is estimated at 409 megalitres (ML) per year; Satterley will seek an allocation of this amount from the Department of Water (DoW).

The groundwater has a tested salinity of 1,600 mg/L TDS and is of marginal quality for irrigation, being suitable for salt-tolerant native landscaping species and some turf types. It is not suitable for irrigation of crops or pasture, and as a result is currently little-used in the area.

The use of low-quality groundwater for irrigation is possible in part because of the availability of fresh water from roof runoff and rainfall via the lake in the early part of summer. This will shorten the period in which the irrigated areas will need to cope with the higher salinity bore water.

1.3 Hydrology and Drainage

The Austin Cove site is low-lying and winter-wet, with the AAMGL at or near the surface over most of the site. The site is currently drained by a network of shallow agricultural drains mostly less than 0.5m deep. Most groundwater flow through the site is intercepted by these drains and converted to surface flow. The cleared paddocks, clay-sand soils and high water table produce very high runoff coefficients and consequent high rate of surface water discharge.

The site is within the 100-year flood plain of the Murray River, so filling is required to raise the final lot level above the 100-year flood level. Between 1m and 3m of sand fill will be placed over most of the site. Most of this fill will be yellow sand, which has a tested phosphorus retention index (PRI) mostly over 5. The use of fill has several advantages from a drainage point of view, including:

- The runoff coefficient will be considerably less than that of the existing clayey, saturated soils, so runoff generation will be significantly reduced.

- The moderate to high PRI of the fill will greatly reduce the export of phosphorus from the site compared to the existing, surface flow-dominated situation.

The drainage system proposed for the development will convert most stormwater runoff from all sizes of storm into groundwater recharge via a network of swales and multiple-use POS areas. The result will be a hydrological regime that much more closely resembles the original uncleared state of the site, when heavy vegetation cover would have produced much less runoff than currently occurs.

The features of the drainage system include:

- Runoff from within private lots (including most roof runoff) will be disposed on-site via soakwells.

- A primary network of swales and basins will trap and infiltrate all runoff from storms up to 1-year average recurrence interval (ARI) (5 year ARI in the lake catchment).

- Runoff from storms larger than 1-year ARI will progressively overflow into secondary swales within the multiple-use corridor (MUC), wetland buffers and the floodway before being released from the site.

- In the lake catchment, runoff from storms greater than 5-year ARI will overflow into the lake. The lake will overflow at its southern end into the MUC.

- Water flowing along the MUC will pass through a sequence of streams, ponds and reed beds that will further purify the water before it is allowed to leave the site.

- Roof runoff from a 16.8ha catchment will be captured and directed via a separate pipe system to the lake in order to assist winter flushing and salinity control in the lake and enhance its usefulness for irrigation.

- Subsoil drains will limit groundwater rise into the fill. Groundwater previously intercepted and converted to surface flow in the agricultural drains will now pass through several metres of adsorptive yellow sand before being captured by the subsoil drains and discharged to the MUC or secondary swales in wetland buffers and the floodway.

1.4 Water Quality

The Peel-Harvey EPP, which in 1992 set statutory limits on phosphorus exports to the Peel-Harvey Estuary from each of its major catchments, is in the process of revision, partly in recognition that its recommendations have proven difficult to put into practice. The DEC/DoW, through programs such as the Coastal Catchments Initiative (CCI) and the Peel-Harvey Water Quality Improvement Plan (WQIP), is developing new targets for nutrient concentrations and loads for the Peel-Harvey catchment. In the meantime, the DoW has advised that the target for Austin Cove should be that there is no increase in nutrient concentrations or loads over pre-development levels.

Nutrient inputs to the development will be minimised by a number of measures including:

- use of low nutrient and water demand vegetation in landscaping areas, POS and other vegetated areas;

- education of lot purchasers about the significance of nutrient minimisation and ways to reduce their nutrient inputs; and

- maintenance activities such as regular street sweeping.

Modelling with the NiDSS package suggests that measures such as these will enable nutrient inputs from the development to be reduced more than 50% compared to unmanaged urban developments, giving total nutrient input rates to the site well below both the pre-development levels and the preliminary load targets.

NiDSS models nutrient inputs, not exports. In practice, both short-term and long-term nutrient exports from the site will be considerably less than inputs due to design measures including:

- The extensive use of fill will convert most of the current surface discharge to shallow groundwater flow through the adsorptive fill, where the majority of phosphorus will be trapped.

- Subsoil drains and swales will be set above the pre-development AAMGL, so no lowering of the AAMGL (or drainage of accumulated soil nutrients) will occur.

- Retention and infiltration of the 1-year ARI storm runoff will enable an estimated 99% of surface runoff from urban areas to be captured and most of its entrained nutrients to be permanently held on site (Appendix B).

- Extensive areas of native vegetation will be retained and enhanced both within and adjacent to the project area, thereby aiding the attenuation of runoff and uptake of nutrients.

The proposed programme of nutrient control measures is consistent with the latest DoW approach to urban water management and the recently released *Peel-Harvey Coastal Catchment WSUD Technical Guidelines* (2006). The design of the stormwater system will be a first in Western Australia by utilising a dedicated system directing roof runoff exclusively to the lined lake. The direct capture of roof runoff will provide a high quality water supplement for the lake and for irrigation of Public Open Space.

Preliminary modelling using the MUSIC program has been undertaken to assess the likely effectiveness of various structural WSUD measures such as infiltration swales in reducing nutrient exports from the site. The modelling indicates reductions of about 80% to 95% in nitrogen and phosphorus exports from a WSUD-managed site compared to a non-WSUD site. The MUSIC model is still being trialled and developed for local conditions, and the data gained through the experience of Austin Cove will be made available to government agencies to facilitate its further development.

1.5 Lake Management

The 16.6ha feature lake will be lined and located in fill above the AAMGL. The lake will have a constant water level, maintained by rainfall and roof runoff in winter and by pumped bore water as required in summer. Water will be removed from the lake by evaporation and winter overflow (via the MUC). In early summer, when the salinity of the lake is below 1,600mg/L TDS, lake water will be used for irrigation. The salinity of the lake will vary between about 1,100 and 1,800 mg/L TDS in most years.

The average annual water balance of the lake is estimated as follows:

Component (all units in ML/year unless stated otherwise)	**Value**	**% of total**
Rain water input	141	32%
Groundwater input	173	39%
Roof water input	125	29%
Total Inputs	**439**	100%
Evaporation output	-228	52%
Irrigation output (begins about 2011)	-118	27%
Overflow	-93	21%
Total Outputs	**-439**	100%

The lake will receive overflow from infiltration basins within its catchment from storms in excess of 5-year ARI.

Modelling using the one-dimensional hydrodynamics model DYRESM coupled with the aquatic ecological model CAEDYM suggests that the water quality of the lake will be high and suitable for secondary contact recreation, with phosphate (PO_4-P) concentrations below 0.035mg/L and chlorophyll-*a* below 2.6 μg/L. Chlorophyll-*a* is a commonly used indicator of algal density; values of 10μg/L or more are commonly considered to indicate algal bloom conditions.

The largest source of phosphorus (the key limiting nutrient in fresh waters) is expected to be waterbirds such as ducks, which may obtain much of their food from outside the lake and then defecate in the lake. The number of birds using the lake, the proportion of their food sourced from outside, the proportion of their faeces entering the lake and the nutrient content of the faeces are all difficult to accurately estimate. However, the numbers used in the modelling are believed to represent an upper estimate of the likely nutrient input from this source. Overpopulation and other bird-related problems are only likely to arise if regular feeding of birds takes place at or near the lake. This can best be combatted by a combination of public education (by leaflets etc) and signage around the lake requesting people not to feed the birds.

The modelling indicates that stormwater inflow from a 10-year ARI storm will produce a short-term spike in both phosphate and chlorophyll-*a* levels, but that the latter will not reach bloom concentrations and both will return to normal levels by the next winter.

Further modelling of lake circulation and mixing was carried out using the three-dimensional hydrodynamic model MIKE 3. The purpose of this modelling was to further investigate whether the lake would be well mixed from end to end as well as top to bottom, whether areas of poor circulation might cause heating and algal growth, and whether stratification was likely to occur.

The results of the MIKE 3 modelling indicate that:

- The circulation in the lake will be predominantly driven by the wind. Autumn is predicted to have the least energetic circulation due to the generally lighter winds.
- Density-driven currents, due mainly to differential heating of the lake, will also influence the circulation but this effect is secondary to wind as the spatial variations in temperature and salinity are relatively small. The effect of the density-driven currents will only be apparent during low-wind periods in summer.
- Most of the time the lake will be well-mixed vertically. Some thermal stratification is predicted during daylight hours, but convection will cause the lake to cool and mix on most nights.
- No significant salinity or temperature stratification is predicted.
- The horizontal and vertical variations in nutrient concentration are predicted to be minimal.

1.6 Water-Dependent Ecosystems

Water-dependent ecosystems in wetlands and floodways adjacent to the development rely on groundwater throughflow and surface runoff for much of their water requirements. With the development of the site, the hydrological regime will shift towards a more groundwater-dominated system with lower peak flows, but the total quantity of water leaving the site and its direction of discharge will remain much the same.

The water levels and seasonal water cycle in the wetlands are expected to remain similar to current levels. The quality of water, especially in surface flow, entering the wetlands is expected to substantially improve with the implementation of the WSUD measures described in this UWMS.

In the south-west of the floodway near the discharge point of the MUC is an area of salt and acid scalding and vegetation death, probably resulting from groundwater rise following clearing of the surrounding area. With the development of the site, a relatively steady low-level winter flow of low-salinity water is expected through this area. This may give opportunities for this area to be restored to native vegetation. Rehabilitation proposals for this area are contained in the Conservation Area Management Plan.

1.7 Monitoring and Response

A comprehensive monitoring program will be implemented to confirm that the urban water management strategies put in place at Austin Cove are working as intended. This program is already underway, with monthly monitoring of groundwater levels and quality and opportunistic monitoring of surface water quality in progress since February 2006.

Future monitoring will include:

- continuation of regular groundwater quality and level monitoring;
- measurement of surface flows out of the site (perhaps including the installation of gauging stations on major drainage overflow points);
- measurement and monitoring of nutrient fluxes;
- monitoring of groundwater quality and consumption;
- further modelling of the hydrology of the development and its effect on the hydrology of surrounding areas;
- measurement of lake levels, water quality and ecological function; and
- monitoring of vegetation health in wetlands and conservation areas.

A summary of the monitoring program is shown below. The monitoring program will be refined and described in more detail in the Urban Water Management Plan (UWMP) for each stage of subdivision.

Monitoring Schedule

Monitoring Type	Location(s)	Method	**Frequency and Timing** Throughout construction (about 12 yrs) and 2 years after final completion
Groundwater Level	Monitoring Bores (to be determined)	Electrical depth probe or similar	Six times yearly, targeting groundwater maxima and minima
Groundwater Quality	Monitoring Bores (to be determined)	Pumped bore samples	Six-monthly (late summer/late winter)
Surface Flows	Exit of multiple-use corridor and/or other major drainage outflows	Water level recorder and data logger	Continuous
Surface Water Quality	Exit of multiple-use corridor and/or other major drainage outflows	Grab samples and/or rising stage samplers	4 samples annually at 2 locations Sampling to capture first flush (if possible), then 3 further samples from May to Oct
Vegetation	Wetlands and conservation areas (to be determined)	Fixed survey transects	Annually at 4 locations including control
Lake	Bore inflow, lake wide, lake profiles	Water samples and *in-situ* measurements	Monthly (bore water quality, chlorophyll-*a*, microbiological) to bi-monthly (nutrients, algae identification and enumeration)

1.8 Implementation

This UWMS presents an overview of the broad water management measures to be put in place in Austin Cove Phase 2. These broad strategies will be refined and described in more detail in Urban Water Management Plans (UWMPs) that will be prepared for each stage of subdivision.

Satterley Property Group will implement and fund the measures described in the UWMS and UWMPs for the duration of the development phase.

1.9 Compliance with TPS Provisions

The table below summarises the compliance of Austin Cove Phase Two with the draft provisions of the Shire of Murray Town Planning Scheme Amendment No. 218. The UWMS has been written in accordance with these policies.

Compliance of Austin Cove Phase 2 with Proposed TPS Provisions

Proposed Provision	Compliance
i. A baseline sampling program to determine existing quality of groundwater beneath Part Lot 1, Lots 1 and 2.	Groundwater sampling has occurred since February 2006 and is continuing.
ii. Existing site characteristics such as geology, hydrogeology and groundwater characteristics.	Extensive site investigations as described in the Environmental Assessment Report (EAR) and UWMS.
iii. Principles, objectives and requirements for total water cycle management outlined in the most recent and relevant guideline policies.	See UWMS Section 2.2.
iv. A derivation of agreed performance targets for water quality, urban stormwater and drainage treatment systems based on protection of water quality within the Peel Inlet-Harvey Estuary.	Agreed water quality and nutrient load targets based on consultation with DoW (Section 5.6.1).
v. Identification of water dependent ecosystems and an assessment of likely impact of changes in quantity, quality of groundwater and or surface water on water dependent ecosystems.	Water supply to vegetation in wetlands and floodways maintained by drainage design. Water quality will be improved by drainage management measures.
vi. Detailed pre and post development total water balance including consideration of imported scheme water, stormwater and groundwater and how these interact with the environment including the Peel Inlet-Harvey Estuary.	Existing and post-development water balance detailed in Sections 3.7, 3.8, 5.3 and 5.5.
vii. Description of existing stormwater management infrastructure and natural systems (including wetlands) and it's impact on groundwater levels.	Described in Section 3.7.
viii. Identification of the capacity of the receiving infrastructure and downstream environment to adopt to the post development water balance.	No significant change to volume of water leaving the site. Rate of water flow will more closely resemble pre-clearing regime.
ix. Discussion of existing superficial/surficial groundwater quality and quantity based on the regional district level information.	See Section 3.6.
x. Identify the purpose, design and management of the proposed water body.	See Section 4.4.
xi. Develop "Water Sensitive Urban Design" best management practices to achieve removal of pollutants and nutrients from surface water and groundwater discharges from the subject land.	All runoff from ≤1 yr ARI storm retained and infiltrated. Use of fill with medium to high PRI will promote phosphorus adsorption from surface water and groundwater.

Proposed Provision		Compliance
xii.	Develop " Water Sensitive Urban Design" best management practices to maximise stormwater detention, treatment and infiltration on site	Detailed in Section 5.3.
xiii.	Determination of predicted requirements for groundwater to be used for irrigation and or ornamental purposes at the completion of the development, and predicted impacts on the landscaped and or native vegetation on the subject land as a result of the drawdown of that required groundwater	See Section 5.2.
xiv.	The conceptual stormwater management plan for the area including consideration of the ability of the system to meet any identified targets	Detailed in Section 5.3.
xv.	Issues to be addressed through local structure planning, sub division and development	See Sections 4 and 7.
xvi.	Likely sources and infrastructure requirements for water supply and infrastructure for stormwater management	See Section 5.2.
xvii.	Monitoring for the purpose of performance monitoring and continuous improvement of the model for Urban Stormwater Improvement Conceptualisation (MUSIC)	Detailed in Section 6.
xviii.	Contingency measures to be implemented in the vent that pollution and nutrient removal and stormwater detention are not achieving agreed performance targets, and	Detailed in Section 6.
xix.	Identification or responsible timeframes for implementing the approved "Urban Water Management Strategy"	See Sections 6 and 7.

2. INTRODUCTION

2.1 Background

This Urban Water Management Strategy (UWMS) has been prepared on behalf of Satterley Property Group for Austin Cove Phase Two, pursuant to the provisions of Shire of Murray Town Planning Scheme Amendment No. 218. The Austin Cove project area covers a portion of Lot 548 South Yunderup Rd and Lots 2 and 3 Bens Rd, South Yunderup. Austin Cove Phase Two (hereinafter referred to as the project area) covers an area of 271 hectares and is located approximately 11 km south east of Mandurah and 4 km west of Ravenswood (Figure 1).

The UWMS provides a framework for the application of total water cycle management to the development incorporating stormwater drainage, nutrient and pollutant management and stormwater conservation and is based on the principles of Water Sensitive Urban Design (WSUD) (Whelans *et al*, 1993). This report is consistent with the Department of Environment and Conservation (DEC) and the Department of Water (DoW) principles of Water Sensitive Urban Design as detailed in the Stormwater Manual (Department of Environment, 2004a).

This UWMS provides an understanding of the existing surface water and shallow groundwater for the project area, and provides advice on seasonal groundwater variation, stormwater drainage, water quality considerations and flood management.

2.2 Statutory and Policy Framework

This UWMS uses the following documents to define its content, key principles, and objectives:

- Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992 (Environmental Protection Authority)
- Statement of Planning Policy 2.1: The Peel-Harvey Coastal Catchment (WA Planning Commission)
- Stormwater Management Manual for Western Australia (Department of Environment, 2004)
- Proposed Model for Integrating Urban Water Management and Land Use Planning (Essential Environmental Services, 2005)
- Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006)
- Peel Harvey Coastal Catchment Water Sensitive Urban Design Technical Guidelines (Peel Development Commission 2006)
- Shire of Murray Town Planning Scheme No.4 Amendment 218

A summary of the key objectives and criteria from these documents is provided in Table 2.1.

2.2.1 Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992

The objective of the Peel-Harvey EPP is to reduce the input of nutrients, particularly phosphorus, into the Peel-Harvey Estuary through a number of means including appropriate land management by landowners in the policy area.

The EPP established statutory targets for phosphorus export from each part of the coastal catchment of the Peel-Harvey estuary. For the Murray River coastal catchment, which includes Austin Cove, the target is 16 tonnes per annum, which translates to an average areal phosphorus export rate of approximately 0.27 kg/ha/yr across the 590km^2 coastal catchment.

Since its gazettal in 1992, the EPP has proven difficult to implement and the phosphorus targets have not been translated into meaningful land use planning tools. As part of the overall Coastal Catchments Initiative project (CCI), the EPP is currently being revised as part of the development of a broader Water Quality Improvement Plan (WQIP) for the Peel-Harvey Catchment (PHC). Included in the development of the WQIP, the DoW/DEC has undertaken predictive modelling of nitrogen and phosphorus exports from 216 sub catchments within the PHC and will be establishing nutrient targets for 17 larger reporting catchments. The WQIP is currently being reviewed by the EPA.

As the Murray River is currently complying with the Phosphorus target provided in the EPP and nitrogen targets are not provided in the EPP, recent advice from DoW (C. Zammitt pers comm., 2006) is that interim targets should be based on predevelopment water quality levels, with a policy of no net increase in concentrations and loads from predevelopment levels should be adhered to.

As part of the review process, the EPA has recently released the draft Peel-Harvey WSUD Local Planning Policy (LPP) to guide local authorities in determining rezoning and development applications in the Peel-Harvey coastal catchment. The draft LPP sets guidelines for implementation of water-sensitive urban design (WSUD), treatment of drainage, retention of vegetation and management of nutrients in the catchment. The management measures set out in this UWMS are in line with the recommendations of the draft LPP.

2.2.2 Statement of Planning Policy 2.1 (Peel-Harvey Coastal Plain Catchment)

The objectives of SPP 2.1 reflect the environmental objectives of the Peel-Harvey EPP and aim to ensure that changes to land use within the catchment are controlled so as to avoid and minimise environmental damage.

The SPP contains a number of general and specific policy provisions relating to drainage. The policy states that subdivision proposals shall make provision for a drainage system which maximises the consumption and retention of drainage on site. Biological wetland filters or other means of drainage water retention or treatment approved by the EPA are to be incorporated into drainage designs, possibly by amendment of the soils in drainage basins or by the provision of wetland filters with nutrient-retentive soil amendments. Conservation reserves are not considered appropriate biological wetland filters. Development near conservation reserves may require special constraints to protect and preserve them.

In addition, the SPP imposes a moratorium on new clearing and drainage within the catchment of the Peel-Harvey Estuary.

The SPP seeks to ensure that emphasis is given to the preservation of remnant vegetation along the fringes of surface water drainage channels. The SPP also establishes a target of achieving least a 50% cover of deep-rooted native vegetation over the catchment.

2.2.3 Stormwater Management Manual for Western Australia

The Water and Rivers Commission (now Department of Environment) released a manual for managing Urban Stormwater Quality in Western Australia in 1998 to define and describe in practical terms Best Management Practices (BMPs) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released not as a statutory requirement, but to provide a guideline for best planning and management practices, and was intended for use not only by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

The Department of Environment has recently undertaken a major review of the Manual in consultation with a working team comprising industry and government representatives. Several chapters of the revised manual have been completed and released as the first part of a staged release by DoE (Department of Environment, 2004a). The manual is anticipated to be fully complete in 2006.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (Department of Environment, 2004a), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

The then Department of Environment (now DEC/DoW) and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.

A copy of the Decision Process is presented in Appendix B, with key elements summarised in Table 2.1.

2.2.4 Model for Integrating Urban Water Management and Land Use Planning

Planning processes in the Peel Development Commission (2006) policy document are consistent with the framework and process detailed in the guideline document Proposed Model for Integrating Urban Water Management and Land Use Planning (Essential Environmental Services, 2005).

ESS (2005) focuses primarily on process integration between land use and water planning and specifying the level of investigations and documentation required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This UWMS is consistent with this process.

2.2.5 Peel Harvey WSUD Local Planning Policy

The Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006) was developed through the Federal Governments Coastal Catchments Initiative Project and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government in integrating catchment management objectives with land and resource planning in urban landscapes.

This policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles modified from DoE (2004a), in order of priority are provided to;

- Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence Interval (ARI) flood event.
- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost 'in-system' management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material).
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple-use corridor.
- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution).
- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces.

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

In addition, stormwater management is stated as having to provide (as compared to a development that does not actively manage stormwater quality);

- At least 80% reduction of total suspended solids
- At least 60% reduction of total phosphorus
- At least 45% reduction of total nitrogen
- At least 70 % reduction of gross pollutants

The policy is consistent with the Decision Process for Stormwater Management in WA (Department of Environment and Swan River Trust, 2005) which is appended to the policy, and is consistent with the objectives of the Environmental Protection Policy (Peel Inlet – Harvey Estuary) 1992.

This policy is stated as holding no legal standing, and envisages that each local government in the Peel Harvey Catchment will customise the model policy to suite is own specific requirements. At the time of preparing this UWMS, it is understood no customisation of this policy has been undertaken by the Shire of Murray.

2.2.6 Peel Harvey Coastal Catchment Water Sensitive Urban Design Technical Guidelines

The Water Quality Improvement Plan aims to reduce phosphorus discharges from the Peel-Harvey coastal catchment through changes to agricultural and urban practices and land use planning. Key recommendations to achieve load reductions include:

- Use slow-release, low water soluble fertilisers, applied after the break of season and at reduced rates, on sandy soils in rural areas. Reducing the solubility of phosphorus in fertilisers applied on agricultural areas will reduce phosphorus discharges to the estuary by 13 per cent. And in the Serpentine catchment this would result in an 18 per cent reduction.

- Undertake soil amendment on sandy soils. Using soil additives or conditioners such as 'yellow sand' and 'red mud' to help absorb phosphorus is very effective in stopping it leaching into the Peel-Harvey waters. This includes soil remediation for new urban developments in areas with sandy soils.

- Promoting the continued use of a low water soluble domestic fertiliser for domestic gardens, and designing low water and fertiliser use gardens.

- Full connection of all current and future homes to reticulated sewerage or effective alternative onsite systems to replace existing septic tanks.

- Eliminate phosphorus discharges from licensed agricultural premises, such as turf farms or intensive feedlots.

- Apply other agricultural practices which reduce phosphorus discharges including a) replacing annual pastures with perennial pastures; b) effective effluent management, and c) better managing irrigation systems:

- Strategic reafforestation of some agricultural land or combining with agriculture to produce agroforestry.

- Having local planning policies, strategies and planning conditions incorporate and implement Best Management Practices where applicable.

- All new developments to incorporate water and nutrient sensitive design according to local planning policies and the technical manual developed as one of the seven investigations.

- Improve the agricultural and urban drainage system to enhance their ability to remove nutrients during flow.

The proposed actions are a mix of voluntary and regulatory measures. The mix selected may possibly change over time if, for instance, either land uses change following further development approvals or if longer term monitoring reveals that water quality is not improving. These commitments indicate that with full uptake the phosphorus targets can be achieved within 15 years.

2.2.7 Shire of Murray Town Planning Scheme Amendment 218

Prior to final approval of the Austin Cove Outline Development Plan a number of Environmental Management Plans are to be prepared for land zoned "Special Development", pursuant to the provisions of Schedule 7 of the Shire of Murray Town Planning Scheme Amendment 218. The Environmental Management Plans are:

- **Urban Water Management Strategy**; On advice from the Environmental Protection Authority and Department of Water, a UWMS will ensure the protection of water resources, provide street drainage and ensure that the rate, quantity and quality of water leaving the site will not adversely impact on the Peel Inlet-Harvey Estuary or wetlands in the vicinity of the project area.

  This Urban Water Management Strategy shall include but is not limited to the following;

  1. A baseline sampling program to determine existing quality of groundwater beneath Part Lot 1, Lots 1 and 2.
  2. Existing site characteristics such as geology, hydrogeology and groundwater characteristics
  3. Principles, objectives and requirements for total water cycle management outlined in the most recent and relevant guideline policies
  4. A derivation of agreed performance targets for water quality, urban stormwater and drainage treatment systems based on protection of water quality within the Peel Inlet-Harvey Estuary.
  5. Identification of water dependent ecosystems and an assessment of likely impact of changes in quantity, quality of groundwater and or surface water on water dependent ecosystems
  6. Detailed pre and post development total water balance including consideration of imported scheme water, stormwater and groundwater and how these interact with the environment including the Peel Inlet-Harvey Estuary
  7. Description of existing stormwater management infrastructure and natural systems (including wetlands) and it's impact on groundwater levels.
  8. Identification of the capacity of the receiving infrastructure and downstream environment to adopt to the post development water balance
  9. Discussion of existing superficial/surficial groundwater quality and quantity based on the regional district level information
  10. Identify the purpose, design and management of the proposed waterbody
  11. Develop "Water Sensitive Urban Design" best management practices to achieve removal of pollutants and nutrients from surface water and groundwater discharges from the subject land

12. Develop “Water Sensitive Urban Design” best management practices to maximise stormwater detention, treatment and infiltration on site

13. Determination of predicted requirements for groundwater to be used for irrigation and or ornamental purposes at the completion of the development, and predicted impacts on the landscaped and or native vegetation on the subject land as a result of the drawdown of that required groundwater

14. The conceptual stormwater management plan for the area including consideration of the ability of the system to meet any identified targets

15. Issues to be addressed through local structure planning, sub division and development

16. Likely sources and infrastructure requirements for water supply and infrastructure for stormwater management

17. Monitoring for the purpose of performance monitoring and continuous improvement of the model for Urban Stormwater Improvement Conceptualisation (MUSIC)

18. Contingency measures to be implemented in the vent that pollution and nutrient removal and stormwater detention are not achieving agreed performance targets, and

19. Identification or responsible timeframes for implementing the approved Urban Water Management Strategy.

- **Lake Management Plan**; For the feature lake (central open space), a Lake Management Plan shall be prepared to the satisfaction of the Shire of Murray, on the advice from the Department of Water, to ensure that water quality and quantity, and the management and maintenance of the water body is at sustainable and appropriate levels.

- **Wetland Management Plan**; On advice from the Department of Environment and Conservation (DEC) and to the satisfaction of the Shire of Murray, a Wetland Management Plan shall be prepared to ensure that the wetland areas and buffers are protected and managed in an appropriate and sustainable manner.

- **Conservation Area Management Plan**; A Conservation Area Management Plan covering the estuary foreshore reserve adjoining the subject lots and interface to the Peel Region Park shall be prepared to the satisfaction of the Shire of Murray, on advice from the DEC to ensure that the estuary foreshore reserve and Peel regional Park areas are managed in an appropriate and sustainable manner.

- **Noise Management Plan**; A Noise Management Plan shall be prepared to the Satisfaction of the Western Australian Planning Commission, on advice from the Main Roads Western Australia, the Shire of Murray and DEC to protect the residences from potential noise impacts from traffic on the Perth Bunbury Highway.

- **Fire Management Plan**; On advice from Fire Emergency Services Authority, a Fire Management Plan will be prepared to reduce the threat to residents and fire fighters in the event of bush fire within or neat the project area.

Table 2.1 Summary of UWMS Principles and Objectives

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk • To maintain the total water cycle		
Category	**Principles**	**Objectives**
Water Supply	• Consider all potential water sources in water supply planning • Integration of water and land use planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • To maximise the reuse of stormwater	• Minimise the use of potable water where drinking water quality is not essential, particularly ex-house use.
Groundwater Levels and Surface Water Flows	• To retain natural drainage systems and protect ecosystem health • To protect from flooding and waterlogging • To implement economically viable stormwater systems • Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined environmental water requirements • Minimise change in peak winter levels at groundwater dependent wetlands due to urbanisation	• For ecological protection, 1 in 1 year ARI volume and peak flow rates maintained at pre-development conditions • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • For flood management, manage up to the 1 in 100 year ARI event within the project area to predevelopment peak flows unless otherwise negotiated • Post development end of winter operating levels at significant wetlands maintained at pre-development levels, unless otherwise determined by EWR's
Groundwater and Surface Water Quality	• To maintain or improve groundwater and surface water quality • Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system. • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality in specified environment	• Implement current known best management practice as detailed in the DoE's Stormwater Management Manual for Western Australia (2004) and the Decision Process for Stormwater Management in Western Australia. (DoE & SRT, 2005), with an emphasis on a treatment train approach including nutrient input source control, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre development levels.

3. PRE DEVELOPMENT ENVIRONMENT

3.1 Location and Topography

The project area is located on the coastal plain approximately 10 km south east of the Mandurah townsite, and approximately 70 km south of Perth. The location of the project area is shown on Figure 1.

The project area is approximately 271 hectares. Austin Cove Phase 1 and South Yunderup Rd border the property to the north, the Peel Regional Park and Peel Harvey Estuary are located to the west, the future Perth - Bunbury Highway adjoins the site to the east and rural land to the south.

Site topography is shown on Figure 2. The project area is generally flat and low-lying. Natural surface elevation ranges from 0.5m AHD to 2.5m AHD. Small sandy ridges located close to the centre of the project area reach a maximum of 2.5 mAHD. The low lying areas of 0.5m AHD are located in the south western corner and eastern portion of the project area.

3.2 Climate

The project area has a Mediterranean climate with warm dry summers and cool wet winters.

The long term (1907 – 2003) average annual rainfall at the nearby Bureau of Meteorology's Pinjarra station (009596), approximately 9 km south east of the project area, is 939 mm. At the Bureau of Meteorology's Mandurah stations (009887, 009977), approximately 7.5 km to the north west of the project area, the average long term (1907 – 2003) annual rainfall is 855 mm. The mean rainfall from the three stations is 892 mm and is considered representative of the project area. Annual rainfall is shown on Figure 3. Also shown is the average rainfall from 1975 onwards. From this it is apparent that annual rainfall has decreased by approximately 90 mm in Pinjarra and 80 mm in Mandurah, with most of this reduction occurring during the winter months. Average monthly rainfall is shown on Figure 3.

The average annual pan evaporation is approximately 1738 mm, as estimated from 20 years of data recorded at Medina, 40 km north of the project area (Bureau of Meteorology).

3.3 Geology

3.3.1 Setting

The project area is located in the central Perth Basin on the Mandurah Terrace, a major structural element of the basin (Crostella and Backhouse, 2000; Lasky and Lockwood, 2004). It is about 15 km west of the Darling Fault (the eastern margin of the Perth Basin).

The surface of the site is mapped (Figure 4) as being predominantly alluvium, estuarine, lagoonal and swamp deposits (sand, silt, clay and peat) of Holocene age (Deeney, 1989; GSWA, 1978). Some of the swamp deposits have grey, clayey, diatomaceous earth which is rich in organic matter (GSWA, 1978).

3.3.2 Stratigraphy

The stratigraphy to 250 m depth beneath the site comprises sedimentary rocks of Jurassic to Quaternary age, as summarised in Table 3.1.

Table 3.1 Stratigraphy and Hydrogeology

<table>
<tr><th>Age</th><th colspan="2">Group / Formation</th><th>Aquifer System</th><th>Thickness in AC1 (m)</th><th>Hydrogeology</th></tr>
<tr><td>Quaternary – Pliocene</td><td colspan="2">Superficial formations</td><td>Superficial aquifer</td><td>15</td><td>Local aquifer, variable salinity, generally small supplies</td></tr>
<tr><td colspan="6">UNCONFORMITY</td></tr>
<tr><td rowspan="2">Cretaceous</td><td rowspan="2">Warnbro Group</td><td>Leederville Formation</td><td>Leederville aquifer</td><td>168</td><td>Major aquifer, fresh to marginal salinity, potential for small to large supplies.</td></tr>
<tr><td>South Perth Shale / Gage Formation</td><td></td><td>17</td><td>Aquiclude / minor aquifer</td></tr>
<tr><td colspan="6">UNCONFORMITY</td></tr>
<tr><td>Jurassic</td><td colspan="2">Cattamarra Coal Measures</td><td>Cattamarra aquifer</td><td>50+m</td><td>Brackish to saline water aquifer, potential for moderate to large supplies.</td></tr>
</table>

3.3.2.1 Superficial Formations

The superficial formations, of Quaternary-Tertiary age, in the area extend from the edge of the Darling Scarp westward across the coastal plain. They unconformably overlie the Leederville Formation in the Pinjarra area and are up to 30 m thick. The superficial formations comprise interbedded sand and clay, possibly with minor limestone at depth.

3.3.2.2 Warnbro Group

The Warnbro Group, of Early Cretaceous age, comprises the Gage Formation, the South Perth Shale and the Leederville Formation. The presence of either the Gage Formation or the South Perth Shale beneath the site is uncertain based on the available lithological and geophysical log data.

3.3.2.3 Leederville Formation

The Leederville Formation is the uppermost unit of the Warnbro Group. It conformably overlies the South Perth Shale or Gage Formation (if either is present), or unconformably overlies the Cattamarra Coal Measures. The formation consists of thin to medium bedded, fine to medium grained sandstone, interbedded with micaceous siltstone, black carbonaceous claystone and local beds of conglomerate including granitic pebbles and cobbles in the east. It contains an increasing proportion of sand and is locally glauconitic and calcareous in the west. Commander (1974) describes a green, glauconitic clay that marks the top of his South Perth Shale equivalent; now recognised as the Mariginiup Member, the basal member of the Leederville Formation (Davidson, 1995). Regional lithological and geophysical bore data indicate that the Leederville Formation dips towards the west in the Pinjarra area and that the green clay marker subcrops beneath the superficial formations west of the project area. Thus the section of Leederville Formation beneath the project area is basal Leederville Formation.

3.3.2.4 Gage Formation / South Perth Shale

The Gage Formation consists of interbedded sandstone, siltstone and shale. It is the basal unit of the Warnbro Group and unconformably overlies the Cattamarra Coal Measures. The South Perth Shale consists of black shale and conformably overlies the Gage Formation (if present) or unconformably overlies the Cattamarra Coal Measures.

3.3.2.5 Cattamarra Coal Measures

The Cattamarra Coal Measures of Jurassic age underlies the Warnbro Group in the Pinjarra area. It consists of interbedded sandstone, and siltstone and claystone with individual layers reaching 10 to 70 m thick in places. The formation is 1054 m thick in nearby oil exploration well Pinjarra 1 (Jones and Nicholls, 1966) and is unconformably overlain by the Gage Formation, South Perth Shale or Leederville Formation.

3.4 Soils

The soil units of the project area are part of the Vasse Estuarine and Lagoonal System (Wells and Hesp, 1983), and are characterised by poorly drained plains that are subject to inundation adjacent to the Peel Inlet (Figure 5). These soil units have been classified as having limited soil absorption ability and waterlogging, inundation and flood risks (Wells and Hesp, 1983).

Bore logs from the field investigation completed by RPS indicate that the top 4 to 5m consist of 1 to 2m of sands or silty sands overlying a clay layer of 2 to 3m thickness. Underlying this clay layer are various thicknesses of sandy clay, clay and sand layers to a depth of approximately -15 to -20 m AHD (Deeney, 1989).

3.5 Phosphorus Retention Capacity of Soils and Fill

The phosphorus retention capacity of both *in situ* soils and fill from the proposed source (the Cougar Sands Quarry on Old Bunbury Road, Waroona) has been assessed by analysis of Phosphorus Retention Index (PRI), Reactive Iron and Reactive Aluminium content. The results of the testing are outlined below.

Table 3.2 Phosphorus Retention Capacity of *In situ* Soils and Imported Fill

Sample Description			Phosphorus Retention		
Source	*Soil Description (no. of samples)*	*Depth (mbgl)*	*Ave. PRI*	*Ave. Reactive Iron (mg/kg)*	*Ave. Reactive Aluminium (mg/kg)*
In situ Soils	Bassendean Sand (3 samples)	0.5-1.5	4	573	not analysed
	Guildford Formation Clay / Sandy Clay (3 samples)	0.25-0.75	695	531	not analysed
Imported Fill Soils	Bassendean Sand (3 samples)	-	0	5	9
	Spearwood Sand (3 samples)	-	6	24	124

Review of the available literature found few references regarding the PRI properties of Western Australian soils. Based on advice provided by Dr Dave Allen of the Chemistry Centre WA, a soil classification system was devised by which the soils were classified using their average PRI. The groupings in Table 3.3 reflect land-use capability for various agricultural scenarios.

The key features of the test results are as follows:

- The PRI of the imported Bassendean sand fill is typical of a “gutless” soil, having little or no capacity to retain phosphorus.
- The in-situ Bassendean sand has both a higher PRI and a substantially higher Reactive Iron content.
- The imported Spearwood sand has a PRI of 6. Advice from Dr Allen suggests that this soil would be expected to have a 50-100 year lifespan under broadacre agricultural use before any significant phosphorus penetrated to the water table.
- The Guildford Formation clays that underlie the bulk of the Phase 2 site have a very high phosphorus retention capacity. This result is in line with groundwater monitoring conducted across the site, which found very low levels of phosphorus in the shallow groundwater.

Table 3.3 Phosphorus Retention Classification of Soils

PRI	CLASSIFICATION	SOIL SAMPLES
0	“Gutless” soil. Poses a nutrient risk under most development circumstances where nutrient application is likely	Imported Bassendean Sands
>2	With careful management can be used for land uses such as turf farms	*In situ* Bassendean Sands
5	Suitable for low-level agriculture	Imported Spearwood Sands
>20	Suitable for high-level agriculture, and wastewater irrigation reuse programs	*In situ* Guildford Clays

The testing has shown that the yellow Spearwood sand proposed to be imported to the site as fill has a significant phosphorus retention capacity which is higher than the *in situ* Bassendean surface sands. The imported Bassendean sand has no measurable phosphorus retention capacity.

The yellow Spearwood sand will be used for the full depth of fill in all areas where phosphorus retention capacity in the fill is necessary, such as the stormwater infiltration basins and multiple use corridor. The yellow Spearwood sand fill will extend to a buffer of 50 m around these sites.

In other areas (for example residential) the top 1 m of fill will consist of the yellow Spearwood sand fill. Any fill below this top layer may consist of the white Bassendean sand fill or yellow Spearwood sand fill.

The sand supply contract being negotiated with the quarry operator recognises the two distinct soil types and makes provision for separate excavation and handling.

3.6 Acid Sulphate Soils

To assess the extent and severity of ASS across the project area, RPS has undertaken extensive sampling and testing in accordance with the DoE (now DEC) Guidelines for the Identification and Investigation of Acid Sulphate Soils (Department of Environment, 2004b).

The investigation (RPS Bowman Bishaw Gorham, April 2006) developed a revised ASS Risk Map for the Site, which has been assessed and endorsed by DEC (see Appendix A). The bulk of the site is classified as having low-nil risk for PASS (east and south) or moderate to low risk (central-western and northern).

The investigation involved sampling a total of 83 ASS locations, with the following key findings on the presence and distribution of ASS;

- Where overlying sands are present, these are typically free of any substantial pyritic acidity.
- Potential Acid Sulphate Soils (PASS) are generally associated with deeper (>1.5m) profiles that have a discernable clay content, that is soils ranging from clayey sands to clays.
- ASS risk mapping correctly identifies the eastern and far southern portions of the site as having a lower risk. Testing in these areas has found nil to low levels of PASS at depth, with generally no PASS present in near surface soils.

The acid sulphate soils testing performed on the fill soils determined the following soil characteristics.

- The pH of the soils ranged from 6.4 - 8.5, being very slightly acidic to alkaline. In all cases there was no reportable existing acidity or potential acidity (CRS suite) – hence the sands are classified as non-acid sulphate soils (NASS).
- Only two of the six samples were processed for Acid Neutralising Capacity (ANC), based on the pH_{KCl} values being >6.5 pH. These samples, QLW-3 and QLW-4, had relatively low levels of ANC of 0.04%S and 0.14%S respectively. Based on DEC guidelines, these sands are not considered to have any effective acid buffering capacity.
- Neutralising Value (NV) was also calculated by estimating equivalent $CaCO_3$ content. This test requires the particle size distribution to first be estimated. For the Bassendean Sand the particle size distribution was predominantly in the range of 0.5-1.0mm (~80%). For the Spearwood Sand 50% was in the range of 0.25-0.5mm and 50% in range of 0.5-1.0mm. The calculated NV for both sands was below the limits of reporting (<2.0%).

3.7 Hydrogeology

The major aquifer systems in the area are named after their major composite formation; the Superficial aquifer (superficial formations), Leederville aquifer (Leederville Formation) and Cattamarra aquifer (Gage Formation and Cattamarra Coal Measures). Major hydraulic confining units which are present between the major aquifer systems in parts of the metropolitan area (Davidson, 1995) are largely absent in the area. The Cattamarra Coal Measures is included in the Yarragadee aquifer in the metropolitan area.

3.7.1 Superficial Aquifer

The Superficial aquifer is an unconfined aquifer extending from the Darling Scarp westward to the coast (Commander, 1982) and has a thickness of about 15 to 25 m in the project area. It is underlain by and in hydraulic connection with the Leederville aquifer in the project area, and groundwater flow may occur between the aquifer systems where more permeable sections of each are juxtaposed.

The project area is located within the northern extent of the Waroona flow system of Deeney (1989). Recharge to the aquifer occurs by infiltration of rainfall. Groundwater flows under a very low hydraulic gradient on the water table from the south east beneath the property and exits to the west. Groundwater discharge from the aquifer occurs via evapotranspiration and as base flow to rivers and minor drainages in the area. Some groundwater is also discharged by downward leakage to the Leederville and Cattamarra aquifers, where they subcrop, to form groundwater recharge to those aquifers. Transmissivity is estimated to be about 50 m^2/d at the project area (RPS BBG, 2006)

The salinity of the superficial aquifer in the region ranges from about 500 to 3000 mg/L TDS (total dissolved solids), with higher values at the base of the aquifer (Deeney, 1989; Commander, 1982). The aquifer has a thin layer of fresh water which overlies brackish groundwater. It has potential bore yields of 100 to 200 m^3/d. The water table occurs at depths from less than 3 metres to over 15 m and has a seasonal range of about 3 m along the Murray River (Deeney, 1989). Groundwater levels found within the project area are discussed further in Section 6.

3.7.2 Leederville Aquifer

The Leederville aquifer is a confined aquifer that has a thickness of 150–170 m beneath the project area. It is overlain by the superficial aquifer and underlain by the South Perth Shale (an aquiclude) or the Cattamarra aquifer where the South Perth Shale is absent.

Recharge to the aquifer occurs by vertical leakage from the superficial aquifer. Groundwater flow is towards the west and discharge occurs offshore and also by upward leakage to the superficial aquifer to the west (Commander, 1982). The potentiometric surface in the aquifer is near the surface in the project area and artesian flows may occur in low lying areas (Allen, 1980).

Groundwater salinity is in the range 1,000 – 3,000 mg/L TDS in the thicker sandstone layers in the aquifer beneath the project area but varies laterally and tends to increase towards the west and with depth. Potential bore yields of 1,000 to 2,000 m^3/d are available from the Leederville aquifer.

The Leederville aquifer has been nominally divided into ‘upper’ and ‘lower’ Leederville aquifers for Department of Water groundwater management purposes. The lower Leederville aquifer is interpreted as that part of the groundwater flow system within the stratigraphically lower part of the formation; below the green clay aquiclude of Commander (1974).

3.7.3 Cattamarra Aquifer

The Cattamarra aquifer is a multi-layered aquifer system consisting of lenticular layers of sandstone, 10-70 m thick, interbedded with layers of siltstone and claystone. It underlies the Leederville aquifer or South Perth Shale (if it occurs) in the project area. The Cattamarra aquifer includes the groundwater in the Gage Formation where it is present. The Cattamarra aquifer is more than 500 m thick in the project area.

Recharge to the aquifer occurs by leakage from the superficial aquifer in a few small, poorly defined areas near the Darling Scarp, where the Leederville aquifer is absent and permeable sections of the superficial and Cattamarra aquifers are in hydraulic connection; and by downward leakage from the Leederville aquifer to the east of the project area where there is a downward hydraulic head potential between the two aquifer systems. There is generally an upward hydraulic head potential between the Cattamarra and Leederville aquifers west of Pinjarra. Groundwater flow is generally westward, although faulting may induce local flow to be diverted to the north or south in some areas.

Groundwater salinity within the Cattamarra aquifer is mainly greater than 2,000 mg/L TDS and generally increases with depth in the aquifer.

3.8 Groundwater Hydrology

3.8.1 Groundwater Levels

Monthly groundwater level monitoring via a network of 41 shallow piezometer bores at Austin Cove and nearby DoW bores commenced in January 2006. The locations of the monitoring bores are shown on Figure 6. Historical water levels measured in the DoW bores are shown on Figure 6. The bores show a seasonal variation in groundwater levels in the area of between 1.0 and 1.5 m.

AAMGL modelling for the site was carried out in 2007 based on long-term DoW bore data and onsite monitoring data since January 2006. Since then, onsite monitoring at the site has continued throughout 2007 and 2008. By agreement with the Shire of Murray and the DEC, the AAMGL will be remodeled using all available data (including that from 2006, 2007 and2008) in preparing Urban Water Management Plans for each stage of subdivision. The modelled AAMGL is shown on Figure 8. It can be seen that winter groundwater levels are close to the ground surface across the site, with standing water predicted in the floodway, the northern CCW wetland and the south-western claypans.

Rainfall in Mandurah during 2006 totalled 434.8 mm, which is about half of Mandurah’s long-term average of 855 mm. This was reflected in lower than average winter groundwater levels in the Mandurah area during 2006.

The highest groundwater levels at Austin Cove were reached in August 2006. Groundwater contours and modelled areas of surface inundation (based on groundwater levels and digital terrain model) are mapped on Figure 9.

The August 2006 groundwater levels closely approximate and in some areas exceed the modelled AAMGLs across the site, despite the below-average rainfall. This might be due in part to perching of groundwater on shallow clay layers (August was the wettest month in 2006). It may also be due to the influence of the existing network of agricultural drains, which would effectively cap the AAMGL at or below the ground surface over much of the site.

The on-site bore measurements and the DoW bore data suggest an annual water table variation of between 0.5m and 1.0m. On average the bores across the site varied by 0.9 m over the year, with a maximum recorded variation of 1.46 m (MB24). The maximum depth to groundwater at any bore was 2.5 m (MB19; June 2006).

3.8.2 Groundwater Flows

Regional groundwater flow direction in the superficial aquifer is westerly to north-westerly, with groundwater moving towards both the Peel Inlet and the Murray River. Groundwater measurements and modelling suggest that the groundwater gradient, groundwater throughflow, on-site recharge and discharge are all very low, with most groundwater discharge (up to 65% at winter maximum levels) being via the existing agricultural drains.

Using the pre-calibrated AAMGL model, maximum winter groundwater fluxes at the Austin Cove site were estimated as follows:

Inflows

Groundwater inflow to site (across southern boundary)	1,233 m^3/day
Rainfall recharge within site	3,885 m^3/day
Total Inflows	5,118 m^3/day

Outflows

Discharge to Peel Inlet and Murray River	1,772 m^3/day
Discharge to drains	3,338 m^3/day
Total Outflows	5,110 m^3/day

The model was calibrated so that it satisfactorily predicted observed heads across the site, based on measurements of 41 bores at winter 2006 maximum groundwater levels. The groundwater recharge across the site, determined via model calibration, was 0.3mm/day, being the equivalent of 14% of the average annual rainfall.

3.8.3 Groundwater Quality

Regular groundwater quality monitoring has been undertaken at Austin Cove since January 2006. The sampling program was developed in consultation with Sally Dodds and Stephen Wong of the DEC Land and Water Quality Branch. The assessed range of water quality parameters is consistent with the DoE (2005) *Standing Advice on Dewatering Operations in Acid Sulphate Soil Risk Areas December 2005*, with additional monitoring for phosphorus species.

Monitoring results were initially measured against the DoE (2003) Assessment Levels for Soil, Sediment and Water. Where no guideline values were provided, ANZECC (2000) Freshwater and Marine Water Quality Guidelines were used, along with ANZECC Long Term Irrigation Water Guidelines.

In January 2006 a full sampling run was undertaken on all 41 bores. These results were subsequently reviewed and a subset of 27 bores was selected for ongoing monthly monitoring. The results for the January to December 2006 monitoring program are detailed in full in the Water Quality Monitoring Report (RPS BBG, 2006) and summarised below.

Regular groundwater sampling was continued in 2007. By agreement with the Shire of Murray and the DEC, the 2007 water quality results are attached in Appendix C to this report, but the summary which follows is based on the 2006 results. The complete data set, including results from 2006, 2007 and 2008, will be used in preparing Urban Water Management Plans for each stage of subdivision.

Nutrients

- Nutrients were typically low in groundwater, with the averages across the site being of the same order of magnitude as the applicable Freshwater Guideline criteria (FWG). The mean total phosphorus concentration was ~0.12mg/L, twice the guideline, while the reactive phosphorus concentration was 0.012mg/L, which is less than the FWG of 0.03mg/L. The average total nitrogen concentration of 1.7 mg/L and the NOx concentration of 0.68mg/L are equivalent to the FWG values. Two bores, MB26 and MB28 on the southern site boundary, regularly had nutrient levels (nitrogen) grossly in excess of the FWG levels. The cause of this contamination is not known at this time.

- Total phosphorus measured in bores MB2 and MB3 in June 2006 displayed outlier results with concentrations of 36.2 and 33.5mg/L respectively. The next highest value reported was for MB30, being 1.36mg/L (June 2006). These results for MB2 and MB3 are excluded from the averages reported above.

- Total nitrogen is regularly elevated in bores MB26 and MB28 (max. 62mg/L, Nov 06 and 84mg/L, Jul 06). NO_X follows the same trends as Total N, being elevated in bores MB26 and MB28.

- Ammonia-nitrogen was measured for the months of October to December 2006. None of the bores exceeded the FWG guideline value of 2.18mg/L. Bore MB11 displayed the highest ammonia-N concentrations, with a maximum concentration of 1.88mg/L (Nov 06).

Dissolved Metals

- Aluminium concentrations have been recorded above 1mg/L, the level identified as being potentially indicative of ASS oxidation (DoE, 2004c), in twelve bores. Those bores where concentrations regularly exceed 1mg/L include MB5, MB8, MB31 and ML1B6. The maximum aluminium concentration recorded was for bore MB8 being 12.2mg/L (Jan 06). It is believed that prior to secondary filtration using disc filters (0.45µm) being introduced in the April 2006 monitoring round, earlier results for January-March may have over-predicted dissolved metal species, notably the common metals iron and aluminium. The mean concentration calculated across the routine monitor bores over the year is 0.47mg/L.

- Arsenic, chromium and cadmium concentrations are low across all monitored bores. None of the samples had concentrations exceeding the applicable LIWG. There were some detects above the FWG and MEPG but these were minor exceedences.

- Iron typically exceeds the LIWG of 0.2mg/L, exceptions being bores MB24, MB26, MB27 and MB28. The range of reported values for dissolved iron, as with aluminium, is large with a maximum concentration 91mg/L for bore ML1-B6 (Dec 06). This is an extreme reading, with the next highest bore MB7 recording 30.9mg/L (Mar 06). The mean concentration calculated across the bores is 3.7mg/L.

- Manganese exceeded the LIWG in around 50% of the bores. The FWG trigger of 1.9mg/L was only exceeded regularly in bore MB11 (to 1.6-fold), with the highest recorded value being 3.03mg/L (Mar 06); bore MB13 also recorded exceedences at this trigger level. The mean concentration calculated across the bores is 0.43mg/L.

- Nickel did not exceed the LIWG of 0.2mg/L for any bore. The FWG trigger of 0.011mg/L was commonly exceeded in around 50% of samples. The maximum nickel concentration recorded was for bore ML1B5 being 0.067mg/L (Apr 06). The mean concentration calculated across the bores is 0.012mg/L.

- Zinc exceeds both the FWG and MEPG across all bores, but seldom exceeds the LIWG value of 2.0 mg/L. The highest recorded value for zinc is 2.70 mg/L for bore MB19 (Dec 06; 1.35-fold the LIWG).

- Concentrations of selenium are typically below the limits of reporting for all bores. As the limits of reporting for selenium are higher than the FWG trigger, all samples with detectable concentrations of selenium (10 samples) exceed the FWG. Only one sample exceeds the LIWG trigger of 0.02mg/L, being bore ML1B9 with a concentration of 0.022mg/L (Sept 06; 1.1 times the LIWG).

Total Metals- Iron and Aluminium

- No guideline levels are established for total iron or total aluminium. The highest recorded concentrations for total iron and total aluminium were 779mg/L and 572mg/L respectively, at bore ML1B2 in February 2006, when large amounts of sediment were entrained in collecting the sample, thereby artificially elevating the results. The mean concentration for total iron calculated across the bores is 24.2mg/L, with total aluminium being 18.8mg/L.

pH and Salinity

- Groundwater pH is generally in the range of 5.0 to 7.5 across the site. Contouring of January 2006 data identifies a trend to more alkaline groundwater (pH 6.81 to 7.56) within the Guildford Formation soils on the eastern and southern boundaries of the site, consistent with the mapped low risk acid sulphate soils. This trend is consistent across the full year's data. The lowest recorded pH was 3.71 in bore MB22 (January 2006).

- Groundwater salinity (from field-measured EC) for January 2006 is shown as contours across the site on Figure 10. The mapping shows a zone of elevated salinity across the southern-western portion of the site from MB18 to MB11. The average salinity across all bores throughout the year is 10,560mg/L, indicating predominantly saline conditions, although there was marked variation between bores and seasons. The greatest variation was observed in Bore MB18, which showed a salinity range from 57,800 mg/L in February 2006 to 20,700 mg/L in July 2006.

3.9 Surface Hydrology

3.9.1 Existing Surface Drainage

The project area is within the catchment of the Murray River, with all drainage from the site ultimately discharging to the Peel Inlet via overflow channels and floodways of the Murray River. None of the site drainage discharges directly to the main flow channel of the Murray River. The whole of the project area is mapped within the 100-year flood fringe of the Murray River, with the South Yunderup Floodway forming the northern boundary.

An extensive network of shallow (0.5m – 1.5m deep) agricultural drains has been constructed across the site to collect and divert surface water and shallow groundwater through the wetlands to the north, from where the water travels west into the Peel Inlet. This network of drains presently constitutes the major route of water discharge from the site (Section 3.8.2) and limits seasonal groundwater levels to at or just below the ground surface over most of the site.

Figure 11 shows the existing drainage catchments and flow directions at the site. Catchment data and peak flow estimates predicted by XP-STORM modelling are shown in Table 3.4. Runoff coefficients, and hence the percentage of rainfall leaving the site as runoff, are expected to be high due to the shallow depth to AAMGL and thin sand layer overlying the relatively impermeable clay layer.

The catchment modeling was undertaken in 2007 using 2006 water level data from the site. The modeling will be updated using all available data, including that from 2006, 2007 and 2008, in preparing Urban Water Management Plans for each stage of subdivision.

The flow volumes and peak flows shown in Table 3.4 do not include the contribution of groundwater inflow to the drains, which contributes a estimated “base flow” of 3,338 m^3/day to the total winter drain flow (Section 3.8.2).

Table 3.4 Pre-Development Catchment Flows

Catchment (see Figure 11)	Area (ha)	Runoff Coef-ficient	Critical Duration (hrs) [1]					Flow Volume (m^3)					Peak Flow (m^3/s)				
			1 Yr ARI	2 Yr ARI	5 Yr ARI	10 Yr ARI	100 Yr ARI	1 Yr ARI	2 Yr ARI	5 Yr ARI	10 Yr ARI	100 Yr ARI	1 Yr ARI	2 Yr ARI	5 Yr ARI	10 Yr ARI	100 Yr ARI
A	5	0.9	48	24	24	24	24	2649	2669	3176	3505	5248	0.10	0.13	0.16	0.19	0.24
B	3	0.7	48	48	48	48	48	1457	1851	2235	2476	3757	0.05	0.08	0.11	0.12	0.15
C	55	0.9	36	36	36	36	36	28784	36602	43887	48507	73205	0.58	0.77	1.05	1.20	1.65
D	5	0.9	48	48	48	24	48	2712	3446	4160	3589	6994	0.09	0.12	0.15	0.16	0.22
E	34	0.9	36	36	36	36	36	17862	22713	27234	30100	45426	0.35	0.49	0.65	0.75	1.05
F	13	0.8	48	48	48	48	48	6665	8469	10223	11325	17188	0.19	0.25	0.33	0.39	0.52
G	116	0.9	36	36	36	36	36	61054	77637	93089	102887	155273	0.81	1.10	1.46	1.68	2.40
H	4	0.7	48	48	48	24	24	1761	2237	2701	2330	3488	0.06	0.08	0.10	0.12	0.15
I	5	0.7	48	48	48	24	48	2315	2941	3551	3063	5970	0.06	0.09	0.12	0.13	0.18
J	1	0.7	24	24	24	24	24	358	455	541	597	894	0.02	0.03	0.03	0.04	0.05
K	5	0.7	12	24	24	12	24	1394	2278	2712	2278	4480	0.10	0.13	0.17	0.21	0.25
L	33	0.7	36	36	48	48	48	13549	17230	22750	25203	38251	0.36	0.50	0.67	0.77	1.05
TOTAL[2,3]	**279**							**140560**	**178528**	**216259**	**235860**	**360174**	**2.75**	**3.76**	**5.02**	**5.75**	**7.90**

1 “Critical Duration” is the duration of storm at this ARI that produces the highest peak flow.
2. Add base flow of 3,338 m^3/day groundwater inflow to drains to total flow volumes.
3. Totals are likely to be over-estimates, as they assume (different) critical storm duration for each catchment.

3.9.2 Surface Water Quality

Surface water quality has been monitored at the site since January 2006. Five locations within the project area, as shown on Figure 6, have been regularly sampled and analysed for nutrients, metals, EC, pH, and acid sulphate soil parameters. The data from these sites must be viewed with some caution, as in most cases the sites are on the periphery of the site and were sampled from standing water with no flow from the site. As a result of the very low rainfall in 2006 there was only one occasion, in August 2006, when actual surface runoff in drains within the site was able to be sampled for nutrients. The results of that sampling, representing the averaged results from eight locations (Figure 6), are listed in Table 3.5 below as MLSW1-8.

Monitoring results were initially measured against the DoE (2003) Assessment Levels for Soil, Sediment and Water. Where no guideline values were provided ANZECC (2000) Freshwater and Marine Water Quality Guidelines were used.

Acid sulphate soil parameters are discussed in detail in the Water Quality Monitoring Report (RPS BBG, 2006).

Monitoring data have been averaged over all sampling occasions for each site except sites MLSW1-8, which are the average of eight sites on one occasion. The results are summarised in Table 3.5 and presented in full in Appendix C.

Further opportunistic surface water sampling was undertaken during a runoff event in August 2007. The results of this sampling are shown in Appendix C. All available surface water quality data will be used in preparing Urban Water Management Plans for each stage of subdivision.

Table 3.5 Pre-Development Surface Water Quality Summary

Parameter	ANZECC Freshwater Guideline Value $_1$	ANZECC Marine Ecosystem Protection Value $_2$	Average Concentrations (all units mg/L except pH)				
			MLD1-1	MLD2-2	MLD1-3	MLD3-1	MLSW1-8 (August 2006)
Nutrients							
Total Phosphorus	0.06	0.03	0.08	0.14	0.05	0.67	0.21
Filterable Reactive Phosphorus	0.03	0.005	0.02	0.02	0.01	0.16	0.18
Total Nitrogen	1.5	0.75	2.5	5.0	2.4	4.7	2.6
Total Kjeldahl Nitrogen	NG	NG	2.5	5.0	2.4	4.7	2.6
Nitrite+Nitrate	0.7	0.045	0.032	0.098	0.022	0.027	0.037
Metals and Field Parameters							
pH	6.5-8.5	7.5-8.5	7.57	5.18	7.16	7.16	
Salinity (TDS)	NG	NG	6790	34369	8027	5778	
Al	0.055	NG	0.160	3.390	0.17	0.460	
As	0.013	0.05	0.001	0.005	0.001	0.002	
Cr	0.010	0.05	0.001	0.005	0.001	0.001	
Cd	0.0002	0.007	0.001	0.0005	0.0001	0.0001	
Fe	NG	NG	3.750	8.80	3.82	6.450	
Mn	NG	NG	0.287	1.064	0.486	0.308	
Ni	0.011	0.007	0.001	0.01	0.0021	0.003	
Zn	0.008	0.015	0.010	0.027	0.019	0.013	
Se	0.005	0.07	0.009	0.041	0.010	0.009	

1 ANZECC Freshwater Guidelines for slightly-moderately disturbed systems.
2 ANZECC Marine Ecosystem Protection Guidelines for slightly-moderately disturbed systems.
NG No Guideline value

The surface water quality results may be summarised as follows:

Nutrients

- Total phosphorus concentrations are generally low by the usual standards of agricultural land, although they commonly exceed the FWG of 0.06mg/L. The greatest exceedence is at MLD3-1, whose average exceeds the FWG by 11-fold. In general, less than 25% of the phosphorus was in the filterable reactive phosphate (FRP) form, which is the most available for algal growth. The exception to this is the August 2006 samples, where the FRP concentration is strongly biased upwards by a very high concentration of 0.806mg/L recorded at site MLSW7.

- Total nitrogen across all of the sites, including the August 2006 samples, was typically in the range of 160% to 330% of the FWG. The concentrations of NOx-N were all well below the FWG of 0.7mg/L. It is therefore assumed that the bulk of nitrogen in surface-water samples is in organic forms and therefore not readily bio-available.

Total Metals

- Aluminium concentrations have been recorded above 1mg/L, the level identified as being potentially indicative of ASS oxidation (DoE, 2004b), regularly at location MLD2-2 and on two occasions at MLD3-1. More typically the other surface-water sites have aluminium concentrations ≤0.5mg/L (i.e. around 10-fold; FWG).

- Arsenic, chromium and cadmium concentrations are low across all surface-water sites. A single sample MLD2-2 (0.008mg/L, Sept 06) reported cadmium at above the MEPG value (0.007mg/L) but this was a minor exceedence.

- Iron was found to have mean values of between 4 to 8mg/L across the sampling sites. The August 2006 runoff samples had lower iron concentrations ~2mg/L. Iron in the surface-water samples generally exceeds the LIWG of 0.2mg/L.

- Manganese regularly exceeded the LIWG of 0.2mg/L in the floodway/wetland sites, but typically not in the August 2006 runoff samples. The FWG trigger of 1.9mg/L was only exceeded at location MLD2-2 (1.98mg/L, Nov. 06 and 2.7mg/L, Dec. 06).

- Nickel concentrations were low across all sites, being close to or below the LOR. The FWG trigger of 0.011mg/L was only exceeded at location MLD2-2; these being minor exceedences (0.016mg/L, Oct.06 and 0.023mg/L, Nov. 06).

- Typically zinc levels do not exceed 0.5mg/L across the sampling locations, more commonly the concentrations are equivalent to the FWG (0.008mg/L) and MEPG (0.015mg/L). None of the samples recorded concentrations in excess of the LIWG value of 2.0 mg/L. The August 2006 runoff samples were lower than the other sites.

- Selenium was only detected above the FWG on a single occasion, being at MLD2-2 (0.017mg/L, Sept. 06). On all other occasions the concentrations were below the LOR, except in December 2006 when ARL tested the samples, and reported to a lower LOR of 0.001mg/L.

<u>pH and Salinity</u>

- The pH across all sites ranged from a lowest of 3.3 (Site MLD2-2) to a highest of 8.4 (MLD1-1 and MLD1-3). The runoff waters sampled in August 2006 showed pH in the range of 5.66 to 6.5.

- The surface water salinity varies between sites and sampling occasions, from a lowest of <1,100 in August 2006 to a highest of about 140,000 year-round at Site MLD2-2. This variation reflects in large part the effect of tidal influence and evaporative concentration in some of the sampling locations. The runoff waters sampled in August 2006 were all fresh, having TDS ≤1,100mg/L.

3.10 Wetlands

Most of the site is a floodplain and is currently classified as Multiple Use (MU) management category palusplain by the Department of Environment and Conservation (DEC). The DEC's management objectives for MU wetlands are that land use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through various projects, such as Landcare. The DEC recommends that these wetlands may be considered for development provided that their hydrological and remaining ecological functions are preserved or replaced (WRC, 2001).

There is a central wetland area within the site that is classified as a Conservation Category Wetland (CCW). The drains traversing the northern and central portions of the site are also classified as CCW. CCWs are considered to be the highest priority with the objective of preserving wetland attributes and function through various mechanisms, including protection under Environmental Protection Policies and reservation in national parks, crown reserves and State-owned land (WRC, 2001).

One wetland area that adjoins the southern boundary of the main CCW in the centre of the site is classified as a Resource Enhancement (RE) management category wetland. Another RE wetland is located in the north east corner of the site. RE wetlands are those that have been partially modified but still support substantial ecological attributes and functions. The ultimate objective is for management, restoration and protection towards improving their conservation value. These wetlands have the potential to be restored to CCW status (WRC, 2001).

A portion of one of the watercourses that traverses the site is legally protected under the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (Lakes EPP).

The majority of the area proposed for development is mapped as Multiple Use category wetland (Figure 12). Water Sensitive Urban Design and Best Management Drainage Practices will be incorporated into the subdivision design as part of the Urban Water Management Strategy for the site.

The CCWs located within the centre of the site (but outside urban zoned areas) as well as west of the site have been reserved as Parks and Recreation under the Peel Region Scheme, which will provide for their long-term protection and conservation (RPS BBG, 2007a).

All CCWs and REWs located within the urban zoned areas will be set aside for conservation. Further details are provided in the Wetland Management Plan.

3.11 Existing Land Use

The project area was previously used as a beef grazing property. The site has been predominantly cleared with annual pasture species planted. Isolated pockets of native vegetation remain along the watercourses and wetlands.

Other activities that currently occur on site include bee keeping and a small scale palm cultivation operation on one lot.

The site is bounded to the east and south by farming operations. The South Yunderup canal development is located north west of the site, with the Peel Regional Park and Peel Inlet on the western border. The future Perth Bunbury Highway will form the eastern boundary of the project area.

3.12 Water Resources

The Austin Cove project area is within the Coolup Sub-area of the Murray Groundwater Area. The groundwater resources available, as advised by the Department of Water, are as follows:

Aquifer	*Total Available*	*Currently Allocated*
Superficial	20,200 ML/yr	900 ML/yr
Upper Leederville	3,500 ML/yr	945 ML/yr
Lower Leederville	5,500 ML/yr	400 ML/yr.

Applications for further allocations from the superficial and upper Leederville aquifers are currently pending with the DoW. However, the above shows that the current allocations from all of the major aquifers in this sub-area are well below the available yield. This is probably due in part to the generally poor quality of the groundwater in this area.

3.13 Murray River Floodplain

The project area is within the 100 year floodplain of the Murray River, with the floodway forming the northern boundary of the project area and the remainder of the site mapped as flood fringe. Development levels within the project area are required to be above the 100 year flood level.

DoW floodplain mapping for the Murray River is shown on Figure 13. The existing mapping is based on a 100 year flood level of 3.20 m AHD on the eastern border and 2.02 mAHD on the western border of the project area. A minimum development level in the east of 3.7 m AHD is therefore proposed to maintain a 0.5 m clearance above this level. In the western portion of the project area the minimum development level reduces to 2.52 m AHD.

This means it will be necessary to place between 1m and 3m of sand fill over the site, which will also provide adequate clearance to the underlying shallow water table.

4. PROPOSED DEVELOPMENT

4.1 Outline Development Plan

The proposed Outline Development Plan is presented on Figure 14.

Austin Cove Phase Two will comprise a mix of residential densities and housing types. A total of approximately 2350 dwelling units will occupy the phase two area, as well as a Primary School, Village Centre, Mixed Business area and an integral public open space network. The public open space areas, comprising 71.6 ha (gross), will serve recreational, drainage, conservation and amenity objectives. Table 4.1 below provides a summary of the housing strategy.

Table 4.1 Housing Strategy

Residential Density	***Dwelling Types***	***Location Criteria***	***General***
Medium Density			
Residential R20 and R25	Single and Grouped Dwellings	Base coding for the balance of the site Located to enhance passive surveillance of public spaces	Lots ranging in size from 450m^2 to 650m^2.
Medium to High Density			
Residential R30, R40 and R60	Single, grouped and multiple dwellings	Will surround areas of high amenity, such as POS, lake, village centre, mixed business and key transport connections. Generally R60 development will be located within 400m of the village centre. Located to maximise access and use of services and facilities. Located to enhance passive surveillance of public spaces.	R30 and R40 lots range in size from approximately 300m^2 to 400m^2. R60 lots include grouped or multiple dwellings.

Key elements of the Structure Plan related to urban water management include:

- Use of multiple-use corridor for detention, retention, conveyance and treatment of stormwater.
- Use of locally distributed POS areas for stormwater retention.
- Use of swales within road reserves for drainage, with lot alignment appropriately matched to these areas to avoid unnecessary vehicle crossovers.
- Maintenance of key discharge points from the project area to the receiving environment.

4.2 Precincts and Staging

The land release program will commence in January 2009 and end in 2020. This is a period of 12 years with a development and release program of four stages per year totalling approximately 200 lots per year. Development will commence at the north-eastern end of the site and progress south then west. The release program will be controlled to meet market requirements.

4.3 Landscape Response

The purpose of the public open space areas is to provide a readily useable, aesthetic and liveable environment to potential residents from day one. Landscaped open space areas shall incorporate features and facilities to both encourage residential growth and to provide public, aesthetic and site character building amenities to residents. Landscape works will contain and maximise both aesthetic and functional uses where possible.

A key element of the landscape response will be maintenance minimisation, whereby all elements and components will be selected and designed to minimise ongoing maintenance issues and costs. Best practice techniques in sustainable landscapes will be employed, including selection of low water-demanding plant species in accordance with Water Corporation guidelines.

Landscaping within private allotments is by far the largest component of landscaping area within new urban development, therefore represents the area where the greatest water efficiencies can be achieved. As such, the upmost importance will be placed on promoting and mandating the installation of waterwise landscapes through the front and rear landscape rebate packages. This will be achieved through an ongoing comprehensive marketing package promoting community and resident education. Programs to achieve water efficiencies will be detailed in the Urban Water Management Plans (UWMPs).

4.4 Feature Lake

The centrepiece of the development will be a 27 ha park containing a 16.6 ha lined lake within the eastern section of the estate, which will serve active and passive recreation, landscape, irrigation and urban water management functions.

The lake will be lined with PVC or HDPE and will be disconnected from the superficial aquifer. The lake will have a constant water level and a maximum depth of 3 m. The base of the lake is at -0.5 mAHD. The lake level will be maintained in summer by sub-potable groundwater water obtained from a deep aquifer bore located within the open space. In winter the lake will receive water from direct rainfall and roof runoff as well as from the bore (if required). Under normal conditions no stormwater runoff will enter the lake; however under high rainfall conditions (greater than approximately a 5-year ARI storm event), excess water from the drainage infiltration basins will overflow into the lake.

Excess water from the lake will overflow at the south-eastern corner into a multiple-use corridor that runs west through the project area before discharging into the floodway. Overflow from the lake will occur regularly in winter during significant storm events.

The lake shoreline will comprise a variety of hard and soft edge treatments, with more formal edges such as walls in the southern, more densely inhabited area and softer edges such as sedges and sandy beaches in the north. Boardwalks will be placed at key focal points around the village centre to allow for alfresco dining opportunities, while limestone lot retaining walls will provide direct lot frontage onto the water body. Soft edge treatments will include grass edges with concrete mowing kerbs, sandy beaches and planted reed beds and other water tolerant species to create habitat opportunities for fauna. The edges will feature a shallow (0.5m), 1m wide bench at the water's edge to ensure public safety before grading at a slope of 1:3.5 into deeper water.

Active recreation possibilities such as kayaking, canoeing and rowing will be possible on the lake. Small launching jetties will be provided that will enable the community to launch small water craft such as canoes and rowing boats. The lake water will be maintained to a quality suitable for "secondary contact recreation" (e.g. boating) but will not be suitable for swimming. Signage along the perimeter of the lake will be provided to advise against swimming in the lake.

The parkland adjoining the lake will consist of open grassed spaces for informal active recreation bounded and defined by both feature tree avenues and groups of trees. Tree species will be a mix of native and exotic species. Shrub planting is planned to be used as spatial definition and colour where required, primarily consisting of native water-wise vegetation. Shrub plantings will primarily consist of lower growing species to enable clear vision and security of views.

A range of recreation facilities will be provided for within the open space surrounds including picnic shelters, playgrounds, BBQ's, street furniture, boardwalks, lookouts and public art.

The lake surrounds will be graded away from the lake to prevent surface runoff carrying nutrients and other contaminants from entering the lake.

The feature lake will be used as an irrigation water source during the early part of summer when the salinity is less than that of the available bore water (nominally 1,600 mg/L TDS).

Further details of the lake design, operation and management are provided in the Lake Management Plan (BES, 2007).

5. URBAN WATER MANAGEMENT STRATEGY

5.1 Overview

Austin Cove is the first major land-based urban development to be undertaken in the inner Peel-Harvey catchment since the early 1990s, when the Peel-Harvey Stage 2 ERMP, the Peel-Harvey EPP and Statement of Planning Policy 2.1 set limits on clearing, drainage and phosphorus exports to the estuary. Management of nutrient exports continues to be the critical issue to be addressed in demonstrating the acceptability of development in the inner catchment. To this end, the urban water management measures detailed in this UWMS are first and foremost directed at achieving long-term reduction and control of nutrient exports from the site.

The overall UWMS encompasses the issues of water supply, management of water quality within the estate and management of drainage and water flows out of the site. The aims of the UWMS include:

Water Conservation

- Minimising the consumption of high-quality (scheme or bore) water for non-potable uses.
- Promoting the harvesting and reuse of rainwater and stormwater.

Drainage

- Maintaining the pre-development hydrology of the site.
- Managing flood flows to protect property and the environment.

Water Quality

- Minimising the export of nutrients and other contaminants from the site.

Lake Management

- Designing and managing water bodies within the estate to enhance beneficial uses, prevent algal blooms and minimise the need for active maintenance.

These factors are discussed in detail in the following chapters.

5.2 Water Source Planning Strategy

5.2.1 Water Conservation

Development of the estate will lead to a demand for water for residents as well as irrigation of public open spaces and maintenance of the feature lake. Sub-potable groundwater from the Leederville aquifer will be used in summer to supply water for irrigation and lake maintenance. Some of this water will be used to irrigate and rehabilitate the South Yunderup Sports Club oval, which is currently effectively unusable due to acidification and salinity. The total water requirement is estimated at 409 megalitres (ML) per year; Satterley will seek an allocation of this amount from the DoW.

A source of groundwater from the Leederville aquifer has been identified with a tested salinity of 1,600mg/L TDS. This water is of marginal quality for irrigation, being suitable for salt-tolerant native landscaping species and some turf types. It is not suitable for irrigation of crops or pasture, and as a result is currently little used in the area.

The use of low-quality groundwater for irrigation is possible in part because of the availability of fresh water from roof runoff and rainfall via the lake in the early part of summer. This will shorten the period in which the irrigated areas will need to cope with the higher salinity bore water.

Water conservation measures implemented to reduce scheme water consumption within the development include:

- use of higher density residential zoning and smaller lots to reduce garden use of water;
- use of low-quality groundwater for irrigation of POS and common areas; and
- maximising onsite retention of stormwater.

Details on water use efficiency, waterwise gardening and other water-related campaigns are described in the following.

HOUSEHOLD WATER USE EFFICIENCY

All single dwellings within Austin Cove Phase 2 will be required to comply with the Stage 1 provisions and part of the Stage 2 provisions of the *5 Star Plus Water Use in Houses Code* (Department of Housing and Works, 2007). Under the Code, houses will need to comply with the following Deemed-to-Satisfy (DTS) provisions:

Stage 1 Provisions

<u>DTS1 - Water Use Efficiency</u>

(a) All tap fittings other than bath outlets and garden taps must be minimum 4 stars WELS rated.
(b) All showerheads must be minimum 3 stars WELS rated.
(c) All sanitary flushing systems must be minimum 4 stars WELS rated dual flush.

<u>DTS 2 – Swimming Pool Covers and Blankets</u>

An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover, blanket or the like that is designed to reduce water evaporation and is listed on the Smart Approved Watermark Scheme.

<u>DTS 3 – Hot Water Use Efficiency</u>

All internal hot water outlets (taps, showers, washing machine water supplies) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NZS 3500:2003: *Plumbing and Drainage, Part 4 Heated Water Services.* The pipe from the hot water system or recirculating hot water system to the furthest hot water outlet must not exceed 20 metres in length or 2 litres of internal volume.

Stage 2 Provisions

Compliance with the following Stage 2 provisions will be encouraged:

<u>DTS 4 – Alternative Water Supply Use Capacity</u>

All sanitary flushing systems and washing machines must be able to be connected at a later date to an appropriate alternative water supply without the need to break, or cut into the fabric of the building to run new pipes.

DTS 5 – Grey Water Use Capacity

All shower, bath, laundry trough and washing machine drains must be able to be connected at a later date to an appropriate grey water diversion system without the need to break or cut into the fabric of the building to run new pipes.

WATERWISE LANDSCAPING

Satterley Property Group (SPG) will provide a full landscape package for the front and rear of each lot, which will be governed by strict guidelines on species selection, planting layout and water conservation.

COMMUNITY EDUCATION

An active Community Education program will be established by SPG and fostered in conjunction with the Shire of Murray to advise residents and the wider community on how the waterwise landscape techniques employed within the public open space areas can be incorporated into residents' gardens to minimise water usage and protect the surrounding environment.

The community education program will include:

- demonstration of waterwise landscaping techniques in public open space areas and display villages, coupled with provision of information regarding the techniques employed;
- distribution of leaflets, posters and newsletters through the project's community information network, on topics including fertilising habits, composting, car washing detergents and practices, lawn and garden cutting disposal, techniques for minimising stormwater runoff pollutants);
- drain stencilling and plaques in key visible locations;
- erection of historic, educational and interpretative information signage in public areas; and
- articles and advertisements in local newspapers.

These initiatives are outlined in more detail below.

1. Demonstration of Waterwise Landscapes

   Waterwise landscaping will be applied to both Public Open Space areas and to individual lots via landscaping packages. Landscaping to open space areas is typically provided by the developer and to lot purchasers via a rebate system at the time of sale. As a result, the developer has the ability to set the benchmark in this regard. In broad terms, this landscape response to both open space and lot landscaping will aim to achieve the following water conservation principles:

   - minimise the extent of water-consuming planting;
   - minimise the extent of fertiliser-dependent planting; and
   - maximise the use of water conserving elements and techniques,

   Waterwise landscaping measures that will be adopted in Public Open Space areas and/or lot landscape packages include:

   - Use of waterwise irrigation systems that employ large droplet emitters, subsurface trickle irrigation systems, and moisture sensors and weather stations.

- Maximum harvesting and redirection of stormwater from hard surfaces into landscape areas or storage facilities.
- Use of porous pavements that allow infiltration at source of rainfall runoff and irrigation overspray, preventing unnecessary evaporation.
- Use of salt-tolerant, drought-resistant local native species suited to the prevailing site conditions.
- Hydrozoning of plantings (grouping plants on the basis of similar water requirements).
- Restriction of irrigated turf to active recreation areas only, keeping it to the minimum consistent with functional and aesthetic requirements.
- Increased use of non-planting ground treatments such as mulches and gravel.
- Keeping planted areas dense and consolidated (sparse scattered plants are more difficult to water efficiently than ones that are in defined areas).
- Mulching of all garden beds to minimise water loss.
- Use of soil additives in landscaped areas to assist in water retention, reduce fertiliser demand and provide better plant growth.
- Avoidance of planting lawn on slopes or in narrow necks or paths which are difficult to water efficiently and maintain.
- Use of phosphorous free fertilisers.

2. Distribution of Educational Information

Welcome packs provided to each lot purchaser at the point of sale will contain information outlining the sensitive nature of the environment in which the Austin Cove development is located and encouraging specific recommended water conservation techniques.

The welcome packs will be reinforced by ongoing community education through the distribution of a community newsletter and the constant display of informative material on estate signage and/or within the Sales Offices and other community-based buildings.

Other initiatives that may be implemented include:

- Fostering local community groups and events such as cleanup days, revegetation projects and drain stencilling programs.
- Garden and lawn care workshops run or endorsed by a “celebrity gardener”.
- Provision of web links on the Austin Cove website to information on waterwise gardening, catchment protection, groups and resources available to residents.

3. Drain Stencilling and Plaques

Stormwater drain stencilling program will be used to help the community develop a greater awareness of the connection between drains and the natural environment. Drain stencilling techniques on stormwater side entry pits, with text such as “Peel Inlet Starts Here”, have provided an effective measure in discouraging illegal discharges (e.g. used engine oil, paint, sediment, garden wastes, wastewater from pet hydrobaths, cement wash waters, etc.) to stormwater and groundwater and also illegal dumping of solid and liquid wastes.

The drain stencilling exercise can involve the local community, in particular local schools, who can develop an artistic graphic and the text component of the stencil as part of a community based art program. This encourages greater ownership and preservation of the local waterways by the local community, who in turn are more likely to adopt the techniques of water conservation around the home.

4. Erection of Information Signage in Public Areas

The provision of historic, education and interpretative signage around wetlands, water bodies and key retained bushland areas within the development can provide information relating to the importance and sensitive nature of the local flora and fauna.

This signage can outline how the areas have developed over time and why they have been retained within the development. The signage can describe what impacts inappropriate water use or conservation activities by individual residents can have in increasing pressures on flora and fauna in the development area and beyond.

5. Local Newspaper Articles

Articles placed in local newspapers can reach audiences not reached by direct advertising, signage and other means. By providing article text directly to the newspaper, SPG can ensure the accuracy and relevance of the information contained in the articles.

5.2.2 Irrigation Water Source

About 47.2 hectares of grassed and landscaped areas will require irrigation within the estate, representing about 17% of the total area of Phase 2. This comprises:

- POS, multiple-use corridors and wetland buffers 34 ha
- Verges to above areas (typically 10%) 3.4 ha
- South Yunderup Oval (by agreement with Shire of Murray) 2.4 ha
- Freeway buffer 5.4 ha
- Street trees and verges, medians etc. 2.0 ha

The total water consumption for these areas at full development (assuming a nominal irrigation rate of 7.5 ML/ha/yr) will be up to 354 megalitres per year.

Irrigation water will be supplied by a combination of Leederville groundwater, harvested rainwater and roof runoff via the feature lake and separate irrigation lake (see Section 5.4).

Exploratory drilling and test pumping undertaken in 2006 by Rockwater Pty Ltd demonstrated the availability of groundwater with a salinity of about 1,600mg/L TDS from the Leederville aquifer at a depth of 45-81m. The test results indicated that continuous abstraction at up to 2,160m^3/day could be sustained without excessive drawdown. The actual irrigation requirement for the estate is predicted to be up to 1,600m^3/day on an intermittent basis. Water will be supplied by two bores, with one primarily used for irrigation and the other primarily for lake maintenance (see below).

Given the presence of acid sulphate soils across the northern and central-western portions of the Phase 2 project area, together with the generally high salinity of the shallow groundwater, the developer will advise purchasers of land in the estate (probably by means of a notification on the contract of sale) that private bores are not to be used at the site. In order to minimise the consumption of scheme water for garden irrigation, purchasers will be provided with information and incentives to encourage the planting of water wise gardens.

5.2.3 Feature Lake Water Source

The lined feature lake (see Section 5.4) will be maintained at a constant water level by means of a combination of pumped Leederville groundwater, roof runoff and direct rainfall. Groundwater will be the primary water source in summer, with up to 1,500m^3/day being required in mid-summer to replace evaporative losses from the lake. In winter, direct rainfall onto the lake plus roof runoff harvested from about 16.8ha of roofs will maintain lake levels and create periodic overflows into the multiple-use corridor (see Section 5.3.3). The annual water inputs to the lake will comprise about 141,000m^3 of direct rainfall, 125,000m^3 of roof runoff and 173,000m^3 of bore water.

The input of roof water to the lake is important to assist in flushing accumulated salts from the lake during winter, thereby avoiding the need to create artificial turnover during summer by excess input of bore water. This flushing of the lake will also enable low-salinity water from the main lake to be used for irrigation in the early part of summer, improving the capability of the lawns and gardens within the estate to cope with irrigation with marginal groundwater (1,600 mg/L TDS) in the latter part of summer.

In order to protect the water quality of the lake, no storm runoff from roads or other surfaces (other than roofs) will be permitted to enter the lake under normal conditions. Although the lake will be a part of the drainage system, only overflow runoff from storm events greater than 5-year ARI will enter the lake (see Section 5.3.3).

5.2.4 Total Groundwater Requirement

Based on the results of computer simulations of the lake water balance and irrigation demand (using historical rainfall data), the overall water requirement for the fully developed estate is estimated as follows:

Groundwater input to lake	173
Total irrigation allowance	354
Less: Irrigation supplied from lake	-118
Total Groundwater Requirement	**409 ML/year**

5.3 Surface Water Management

5.3.1 Stormwater Drainage Strategy

The drainage system at Austin Cove Phase 2 will be designed and managed in accordance with best management practices set out in the *Stormwater Management Manual for Western Australia* (Department of Environment, 2004), the *WA Stormwater Management Objectives, Principles and Delivery Approach* (Department of Environment, 2004a) and the *Decision Process for Stormwater Management in WA* (DoE and SRT, 2005).

The volume and rate of drainage will be managed such that development does not adversely affect downstream flood levels or flood risk for existing developed areas. The generally adopted design criteria for new development areas is that post development flows are attenuated/compensated to pre-development levels, to protect downstream areas from flooding and erosion.

In regards to water quality management, the UWMS proposes the use of a treatment train approach including both structural and non-structural controls as follows:

Structural Controls

- Retention and infiltration of frequent storm events by means of swales.
- Creation of ephemeral retention/detention areas within POS areas.
- Use of vegetated multiple-use corridors and wetland buffer areas to convey overflow drainage from storm events greater than 1 year ARI.
- Use of fill with moderate to high phosphorus retention index (PRI).

Non-Structural Controls

- Planning practices - POS location and configuration, use of water wise native species.
- Maintenance practices - street sweeping, stormwater systems, POS.
- Education of residents regarding water wise gardens and other water conservation measures.

In general, runoff from the site will be minimised by maximising infiltration. Consistent with DoE (2003), local swales and other structures will be employed to retain and infiltrate the 1 year ARI 1 hour event as close to source as possible to minimise runoff and potential erosion.

5.3.2 Stormwater Catchments

The stormwater drainage system is divided into 35 catchments in three main zones:

- Zone 1 (the eastern sector – catchments 18, 19, 22, 23, 25, 26, 28, 29, 30 and 35)), overflowing to the feature lake via swale basins.

- Zone 2 (the western sector, adjoining the multiple-use corridor - catchments 3, 4, 5, 10, 11, 12, 13, 32 and 33), overflowing to the multiple-use corridor via swale basins.

- Zone 3 (western, northern and eastern boundaries – catchments 1, 2, 6, 7, 8, 9, 14, 15, 16, 17, 20, 21, 24, 27, 31 and 34), overflowing to swale basins around the perimeter of the site.

Figure 15 shows a preliminary post-development catchment plan for the site. The drainage catchments have been designed in order to match post-development surface flow directions and quantities as nearly as possible to the pre-development conditions.

5.3.3 Stormwater System Operation

In essence, the stormwater system will operate as follows:

- All runoff from impervious surfaces within private lots will be infiltrated within the lots, except for a 16.8ha part of the lake catchment from where roof runoff will be piped to the lake.

- **Zone 1** Runoff from catchments within the lake catchment for storm events up to 5 year ARI will be retained and infiltrated in swale basins located in the central POS surrounding the lake. Runoff from storms in excess of 5 year ARI will progressively overflow into the lake, from where water will overflow at the southern end into the multiple-use corridor.

- **Zone 2** Runoff from catchments in the western sector for storm events up to 1 year ARI will be retained and infiltrated in swale basins located on the edges of the multiple-use corridor. These will be located adjacent to the filled area, with basin inverts set at or slightly above the existing natural surface. Due to the presence of clay at shallow depth in this area, there will be little vertical infiltration, with most detained water infiltrating horizontally through the bund wall. Hence there will be seepage from each swale, with a resulting outflow at the northern extent of the multiple-use corridor. Nutrient stripping will occur within the swale by a combination of vegetation and soil uptake. Runoff from storms larger than 1 year ARI will progressively overflow to the multiple-use corridor, flowing west through a series of streams, reed beds, ponds and other features designed to slow and further purify the water before it exits the site at the south-west corner (Figure 15). Drainage lines and wetland areas within the corridor will contain mass plantings of water tolerant native tree and shrub species. The maximum water depth in these areas will not exceed 0.9m.
- **Zone 3** Runoff from these catchments for storm events up to 1 year ARI will be retained and infiltrated in swale basins located in POS, road verges and the floodway. Runoff from storms greater than 1 year ARI will progressively overflow off site into the floodway and wetland buffers.
- The swale basin inverts (floors) will be set above the AAMGL, generally at the existing natural surface, to ensure that they are dry for most of the time. The swales will be designed to retain low flow events such that water does not pass from one swale to the next until it has filled to a depth of approximately 200mm. Outflow from the basins will not exceed the estimated pre-development flows.
- The swales, where possible, will be planted with native vegetation to minimise irrigation and fertilisation requirements. Only those swales in locations that would be otherwise (e.g. active open space), will be grassed and irrigated, underlain and/or surrounded by sand fill with a moderate to high phosphorus retention index (PRI), which will be specified at the time of supply. The swales will mostly have side slopes of 1 in 6 so as to maximise their usefulness for recreation.
- Stormwater from the 100-year ARI storm will be conveyed off site by means of basins, roads and public open space. The peak discharge from the site under these conditions is expected to be considerably less than the pre-development condition as a result of a decreased runoff coefficient (see Section 5.3.5).

5.3.4 External Catchments

On the eastern boundary of the Study Area, there is a small catchment between the Perth Bunbury Highway and Buchanan Drain. The southern section of this catchment flows to a drain that is located along the eastern edge of the Highway alignment, before heading north east and discharging to Buchanan Drain. The northern section of the catchment will drain under the Highway via balancing pipes and discharge into the drainage swale along the eastern boundary of the Study Area, discharging north to the floodway channel (same as predevelopment discharge). Importation of fill for Austin Cove will therefore not have any impact on the drainage from these catchments.

There may be an external catchment draining into the project area from the south, however the available contour data available for that area (5 m) is inadequate to determine a catchment area or flow directions. More detailed elevation data for the area south of the project area is currently being obtained. If it is found that there is an external catchment area to the south, a drainage path linking into the multiple-use corridor will be provided.

5.3.5 Stormwater Modelling

Stormwater modelling for the pre-development and post-development situations was carried out using the MODRET infiltration modelling package.

For the predevelopment (existing) land-use, an assumed broadacre runoff coefficient of 86% was adopted, based on the presence of low permeability soils and surface saturation over most of the project area in winter. For the post-development model, the following runoff coefficients applied for various land uses:

- Residential 0% (on-site infiltration)
- Passive POS 0% (local infiltration)
- Road & Road Reserve 90% (including 10% from residential lot paved areas)
- Drainage Basin 100%

These runoff coefficients are typical of those used to represent post-development runoff from urban areas on the coastal plain. The overall post-development runoff coefficient using the above breakdown is 25%, which is less than the estimated pre-development runoff volume due to the importation of fill and increased infiltration.

The locations of the swales were determined based on topographic contours, depth to groundwater and POS locations specified in the Structure Plan. Catchment boundaries were determined based on preliminary road levels and slopes.

Aquifer parameters were based on infiltration testing within the proposed swale locations using a borehole permeameter. Where filling is proposed, the hydraulic conductivity of the fill material was incorporated. Soil porosity was assumed as 10%, based on the soil types present.

Bore logs from the soil testing indicate that there is generally a surface layer of sand of varying thickness overlying sandy clay or clay, underlain by further bands of sand, sandy clay, clayey sand and clay. Since the presence of the clay below the sand will significantly restrict vertical infiltration, it was assumed that the top of the clay layer forms an effective base of the aquifer. Therefore only the top sand layer is considered in the infiltration modelling. In some locations, where only a thin sand layer exists, most infiltration is horizontal.

The design storms modelled by MODRET were calculated with reference to the methodology in *Australian Rainfall & Runoff* (AR&R) (Institution of Engineers Australia, 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchments. Storm durations modelled ranged from 30 minutes to 72 hours. The modelling found that the critical duration (i.e. the duration at that ARI requiring the greatest volume of storage) for all basins was 72 hours.

In Zone 3, the MODRET model was used to size the basin swales to the 1 year ARI event and then model overflow from the swales in the 2, 5, 10 and 100 year ARI events. In Zones 1 and 2, Modret was used to size swales to the 5 year and 1 year ARI respectively, with overflow in greater events modelled using the XP-STORM model (as described below).

The results of the modelling are shown in Table 5.1. Based on these results, the total area required for flood storage for the 1 year ARI event is 7.3 ha, representing approximately 2.6% of the project area.

Basin sizes, shapes and configurations shown in this UWMS will be subject to review as detailed planning and design proceeds. Final details of the basins will be provided in the Urban Water Management Plans for each stage of subdivision.

5.3.6 Stormwater Overflow Modelling

The stormwater modelling software XP-STORM was used to model the stormwater overflow from the swale basins in Zones 1 and 2 into the lake and multiple-use corridor.

The model incorporates each of the catchments in Zones 1 and 2, as well as the lake and the multiple-use corridor sections. Catchment storage volumes calculated from MODRET are included in the model, along with catchment areas and swale inverts.

Overflow from the lake will be conveyed to the multiple-use corridor by pipe culvert. This pipe will be sized to prevent excessive water level rise in the lake during the 100 year ARI event.

There are three road crossings proposed for the multiple-use corridor. It has been assumed that box culverts will be used to convey flow. These will be sized to convey the 100 year flow.

Additional in-line storage is proposed within the multiple-use corridor segments to provide further flow compensation for storm events.

The design storms modelled by XP-STORM were calculated with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers Australia, 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchments. Storm durations modelled ranged from 30 minutes to 72 hours.

Results of the modelling are shown in Table 5.1. It was found that the critical duration for most basins was 72 hours.

Table 5.1 Post-Development Stormwater Flows and Basin Sizing – Catchments 1 to 12

Catchment	1	2	3	4	5	6	7	8	9	10	11	12
Catchment Data												
Zone	3	3	2	2	2	3	3	3	3	2	2	2
Total Area (ha)	7.84	10.90	8.35	8.96	2.02	4.73	2.61	5.76	4.85	4.6	7.09	7.39
Effective Impervious Area (ha)	2.160	2.592	2.261	2.070	0.653	1.498	0.655	1.080	1.323	1.272	2.124	1.800
Basin Data												
Basin Sized to Contain (yr ARI)	1	1	1	1	1	1	1	1	1	1	1	1
Basin TWL Area (ha)	0.08	0.22	0.35	0.33	0.11	0.11	0.07	0.07	0.13	0.20	0.33	0.28
Basin Storage (m^3)	330	990	1570	1460	440	490	300	290	640	880	1460	1250
1 Year ARI												
Model Used	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret
Critical Duration (hrs)	24	72	72	72	72	72	72	72	72	72	72	72
Flood Storage (m^3)	310	980	1540	1400	400	410	300	250	620	820	1410	1170
72 hr Storm Overflow Volume (m^3)	0	0	0	0	0	0	0	0	0	0	0	0
2 Year ARI												
Model Used	Modret	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	XP-Storm
Critical Duration (hrs)	24	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m3)	190	390	480	420	150	120	100	130	220	270	470	380
72 hr Storm Peak Flow (m3/s)	0.007	0.007	0.061	0.055	0.021	0.002	0.002	0.003	0.004	0.03	0.057	0.048
5 Year ARI												
Model Used	Modret	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	530	840	900	800	270	360	220	300	460	510	870	720
72 hr Storm Peak Flow (m^3/s)	0.012	0.016	0.057	0.051	0.022	0.008	0.003	0.006	0.007	0.034	0.057	0.048
10 Year ARI												
Model Used	Modret	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	790	1170	1200	1070	360	540	310	430	630	680	1140	950
72 hr Storm Peak Flow (m^3/s)	0.021	0.022	0.068	0.062	0.03	0.010	0.006	0.008	0.011	0.38	0.064	0.054
100 Year ARI												
Model Used	Modret	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	2180	2840	2660	2420	780	1500	730	1130	1490	1500	2520	2120
72 hr Storm Peak Flow (m^3/s)	0.038	0.033	0.09	0.08	0.03	0.020	0.009	0.018	0.018	0.05	0.084	0.071

Table 5.1 (cont.) Post-Development Stormwater Flows and Basin Sizing – Catchments 13 to 24

Catchment	13	14	15	16	17	18	19	20	21	22	23	24
Catchment Data												
Zone	2	3	3	3	3	1	1	3	3	1	1	3
Total Area (ha)	5.17	5.32	5.29	6.38	7.03	7.84	7.92	4.98	12.98	5.06	7.09	4.80
Effective Impervious Area (ha)	1.53	1.305	1.314	1.553	2.034	1.908	1.728	1.107	3.101	0.819	1.215	1.170
Basin Data												
Basin Sized to Contain (yr ARI)	1	1	1	1	1	5	5	1	1	5	5	1
Basin TWL Area (ha)	0.25	0.10	0.11	0.13	0.22	0.40	0.30	0.18	0.16	0.15	0.20	0.10
Basin Storage (m^3)	1100	460	590	660	680	1350	1040	510	730	530	680	230
1 Year ARI												
Model Used	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret
Critical Duration (hrs)	72	72	72	72	72	NA	NA	72	72	NA	NA	72
Flood Storage (m^3)	1020	400	550	640	680	NA	NA	490	640	NA	NA	280
2 Year ARI												
Model Used	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	Modret	Modret	XP-Storm	XP-Storm	Modret
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	290	120	150	220	300	0	0	170	250	0	0	160
72 hr Storm Peak Over Flow (m^3/s)	0.041	0.002	0.003	0.004	0.007	0	0	0.003	0.006	0	0	0.003
5 Year ARI												
Model Used	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	Modret	Modret	XP-Storm	XP-Storm	Modret
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	570	340	370	490	640	0	0	380	740	0	0	350
72 hr Storm Peak Over Flow (m^3/s)	0.042	0.008	0.006	0.008	0.014	0	0	0.006	0.016	0	0	0.007
10 Year ARI												
Model Used	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	Modret	Modret	XP-Storm	XP-Storm	Modret
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	770	480	540	690	900	990	1080	520	1100	470	810	480
72 hr Storm Peak Over Flow (m^3/s)	0.046	0.010	0.012	0.014	0.016	0.05	0.052	0.009	0.021	0.035	0.037	0.009
100 Year ARI												
Model Used	XP-Storm	Modret	Modret	Modret	Modret	XP-Storm	XP-Storm	Modret	Modret	XP-Storm	XP-Storm	Modret
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	1760	1290	1380	1690	2210	2220	2200	1230	3040	1000	1590	1220
72 hr Storm Peak Over Flow (m^3/s)	0.088	0.016	0.017	0.020	0.028	0.075	0.095	0.015	0.050	0.032	0.07	0.019

Table 5.1 (cont.) Post-Development Stormwater Flows and Basin Sizing – Catchments 25 to 35

Catchment	25	26	27	28	29	30	31	32	33	34	35
Catchment Data											
Zone	1	1	3	1	1	1	3	2	2	3	1
Total Area (ha)	5.75	5.12	7.73	2.65	9.02	11.09	6.56	4.21	4.89	3.85	14.75
Effective Impervious Area (ha)	1.278	0.929	1.458	.524	1.894	2.849	1.125	0.990	1.170	0.360	2.520
Basin Data											
Basin Sized to Contain (yr ARI)	5	5	1	5	5	5	1	1	1	1	5
Basin TWL Area (ha)	0.22	0.16	0.13	0.09	0.46	0.67	0.03	0.16	0.18	0.05	0.61
Basin Storage (m^3)	770	560	370	310	1710	2520	210	670	790	110	2270
1 Year ARI											
Model Used	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret	Modret
Critical Duration (hrs)	NA	NA	72	NA	NA	NA	24	72	72	72	NA
Flood Storage (m^3)	NA	NA	350	NA	NA	NA	210	650	710	100	NA
2 Year ARI											
Model Used	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	Modret	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	0	0	190	0	0	0	150	230	270	50	0
72 hr Storm Peak out Flow (m^3/s)	0	0	0.004	0	0	0	0.005	0.03	0.03	0.001	0
5 Year ARI											
Model Used	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	Modret	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	0	0	430	0	0	0	340	410	490	100	0
72 hr Storm Peak out Flow (m^3/s)	0	0	0.009	0	0	0	0.007	0.03	0.03	0.002	0
10 Year ARI											
Model Used	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	Modret	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	790	580	600	330	610	970	460	540	640	150	810
72 hr Storm Peak out Flow (m^3/s)	0.039	0.028	0.011	0.016	0.056	0.086	0.010	0.05	0.05	0.003	0.76
100 Year ARI											
Model Used	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	XP-Storm	Modret	XP-Storm	XP-Storm	Modret	XP-Storm
Critical Duration (hrs)	72	72	72	72	72	72	72	72	72	72	72
72 hr Storm Overflow Volume (m^3)	1620	1180	1530	670	1840	2810	1170	1180	1400	370	2450
72 hr Storm Peak out Flow (m^3/s)	0.05	0.053	0.023	0.030	0.073	0.111	0.021	0.085	0.085	0.005	0.099

Table 5.1 (cont.) Post-Development Stormwater Flows and Basin Sizing: Catchments P1 to P5 and Lake

Catchment	P1 [1]	P2	P4	P5	LAKE
Catchment Data					
Total Area (ha)	11.0	14.4	9.7	9.1	15.9
Effective Impervious Area (ha)	2.725	3.396	2.76	2.08	15.9
1 Year ARI					
Model Used	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]
Critical Duration (hrs)	72	72	72	72	0
Flood Storage (m^3)					
2 Year ARI					
Model Used	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]
Critical Duration (hrs)	72	72	72	72	72
72 hr Storm Outflow Volume (m^3)					
72 hr Storm Peak Out flow (m^3/s)	0.059	0.055	0.48	0.04	0.035
5 Year ARI					
Model Used	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]
Critical Duration (hrs)	72	72	72	72	72
72 hr Storm Outflow Volume (m^3)					
72 hr Storm Peak Outflow (m^3/s)	0.059	0.055	0.48	0.04	0.035
10 Year ARI					
Model Used	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]
Critical Duration (hrs)	72	72	72	72	72
72 hr Storm Outflow Volume (m^3)					
72 hr Storm Peak Outflow (m^3/s)	0.083	0.076	0.063	0.052	0.047
100 Year ARI					
Model Used	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]	XP-Storm [2]
Critical Duration (hrs)	72	72	72	72	72
72 hr Storm Outflow Volume (m^3)					
72 hr Storm Peak Outflow (m^3/s)	0.16	0.16	0.13	0.12	0.11

1 Flows in catchment P1 represent integrated flows from catchments P2, P4, P5 and Lake, since these catchments discharge via P1.

Integrating the pre-and post-development modelling results in Tables 3.2 and 5.1, the following values for pre-and post-development drainage discharges from the site can be estimated.

Table 5.2 Pre- and Post-Development Total Discharge

Storm Event	Daily Flow (m^3/day) (excluding groundwater flow and POS)		Peak Flow (m^3/sec) (excluding groundwater flow and POS)	
	Pre-development	Post-development	Pre-development	Post-development
1 yr ARI	92,758	0	2.75	0
2 yr ARI	117,662	6,178	3.76	0.44
5 yr ARI	138,712	8,208	5.02	0.62
10 yr ARI	158,138	15,466	5.75	1.51
100 yr ARI	232,793	23,846	7.90	1.92

The modelling results presented in Table 5.2 suggest that the post-development surface discharge from the site is expected to be approximately an order of magnitude less than the pre-development flows. This is due to two reasons:

- Decrease in catchment areas. Post development catchment areas have been significantly reduced. With the importation of fill, residential lots will infiltrate runoff on-site and are assumed not to contribute to stormwater drainage. Therefore road reserves are the major catchment of the stormwater system, with some contribution from the POS areas. This reduces the catchment area from 280 ha pre development to 60 ha post development.

- Retention of 1 year ARI storm event on site. The post development system provides storage within each catchment to contain the 1 year ARI storm event (5 yr in Zone 1) on site, with infiltration to groundwater providing the mechanism for outflow. This storage, along with additional storage within the multiple-use corridor, significantly reduces peak flow rates, as well as total outflow volume.

While surface water discharge from the stormwater system is calculated to decrease due to development, flow from subsoil drainage is expected to be significant, due to the area under infiltration within the project area. Depending on the final configuration of the subsoil, subsoil flow volumes may be 6 to 10 times the post-development stormwater discharge volume. Flow rates will depend on subsoil pipe diameters and achievable gradients. Subsoil drainage will generally flow towards the northern boundaries.

5.4 Constructed Lake Management

A large lined lake is proposed within the eastern section of Austin Cove. The lake water level will be set above existing AAMGL and will have no hydraulic connection with the superficial aquifer. The lake will serve general amenity and drainage functions. The lake will have a total area of about 16.6ha. The lake nominal water level is designed at 2.5m AHD and the base of the lake is at -0.5m AHD. The lake will be managed so that the input of bore water is minimised and the availability of water for irrigation is maximised. To achieve this, the operation will include the following:

- In summer, the lake level will be maintained at 2.3m AHD rather than the nominal 2.5m AHD full level. This will maximise the lake capacity to capture rainfall and roof runoff in winter.

- At the end of summer, the lake level will be allowed to fall to approximately 2.2m AHD in order to maximise the lake capacity to capture early winter rainfall and roof runoff.

- At the end of winter, the lake level will be at or close to 2.7m AHD when irrigation commences. Bore water will not commence until the lake level is drawn down to below 2.3m AHD. This will maintain the freshness of the lake water (relative to bore water salinity) and hence, it will maximise the lake water capability for irrigation

Groundwater from the Leederville Aquifer will be used to keep water levels constant during the summer months. The lake is predicted to lose about 228,000m^3 of water each year through evaporation and will receive approximately 141,000m^3 from direct rainfall on the lake.

The lake is to be developed in two stages: the first (northern) stage of 6.8ha will be completed in about year 3 of the project and the second (southern) stage of 9.8ha about two years later. When the second stage is completed, both parts will be united to form one water body. The relationship between surface area and volume (bathymetry) at each depth is shown on Figure 16.

Table 5.3 summarises the relative timing of lake construction and historical data used in the lake modelling.

Table 5.3 Timing of Lake Construction and Historical Data Used in Computer Modelling

Calendar Year	Project Year	Lake Year	Data Year used for Lake Water Balance Modelling	Roof area draining to lake (ha)	Notes
2008	1	-	-	-	
2010	3	1	1987	4.5	1/9/2010: Start of water balance and salinity modelling. North Lake completed and empty.
2012	5	3	1989	9.2	1/1/2012: South Lake assumed completed and joined to North Lake.
2012	5	3	1989	9.2	1/6/2012: Start of nutrient circulation modelling.
2015	8	6	1991	16.2	31/12/2015: End of nutrient circulation modelling.
2029	22	20	2006	16.8	31/12/2029: End of water balance and salinity modelling.

5.4.1 Water Balance and Salinity Modelling

Water balance and salt modelling of the lake was conducted for a 20 year period from initial construction, incorporating the expected staging of lake construction and development of roads and roof areas. The modelling covers the period 1 September 2010 to 31 December 2029 using the proposed project staging and real historical meteorological data from the equivalent dates in 1987 to 2006. This period was one of generally below-average rainfall but contained at least one ten-year storm event (in July 1991, representing July 2014 in the model). The modelled scenario is detailed below.

Lake area:	16.6 ha
Nominal water level:	2.5m AHD
Overflow occurs at:	2.7m AHD
Bore water inflow occurs at:	2.3m AHD (end of summer level: 2.2m AHD)
Water Inputs:	

(1) Direct rainfall on lake surface using monthly rainfall measured at Pinjarra Station from the period 1 September 1987 to 31 December 2006, assuming 22 mg/L salinity (Hingston and Gailitis, 1976), 0.001 mg/L TN and 0.001 mg/L TP.

(2) Roof water runoff based on 90% rainfall falling on a roof area of up to 16.8haas shown in Table 5.3, assuming same concentrations of salt, TN and TP as rainfall.

(3) Bore water to top-up the lake with salinity of 1,600mg/L, TN of 0.01 mg/L, TP of 0.01 mg/L and PO_4-P of 0.003mg/L, as measured by Rockwater (2006). Bore water quality is assumed constant throughout the simulation.

Water Outputs:

(1) Evaporation based on 85% of average pan evaporation (Luke *et al*., 1988) measured at Medina Station 1990-2000.

(2) Irrigation when lake salinity is 1,600mg/L or less. When lake water salinity is above 1,600mg/L, groundwater at 1,600mg/L will be used for irrigation via the irrigation lake.

(3) Lake overflow during winter via multiple-use corridor into salt marshes and ultimately Peel Inlet.

Figure 17 shows a graph of fluctuations in water level and salinity over the 20 year period from 2011 (initial lake filling) to 2029. The north lake is effectively filled to 2.3m AHD after four months, with a volume of approximately 120,000m^3. The graph also shows the dip in water level to 1.1m AHD in January 2012, when the south lake is expected to be completed and joined to the north lake. From that time on the water level will be held within the range of 2.2m and 2.5m AHD with an arrangement as explained above.

The salinity graph on Figure 17 shows that the lake salinity will vary seasonally between a winter minimum (due to rainfall and roof runoff) of about 1,100mg/L TDS to a summer maximum (caused by bore water input and evaporation) of around 1,800mg/L. Section 5.2.3 discussed the importance of roof runoff to maintaining the water and salt balance of the lake. The salinity will peak in the first year after filling begins and then gradually decline as the area of roofs contributing runoff increases. The annual salinity cycle will reach semi-equilibrium by 2016 and will thereafter vary annually with rainfall and evaporation.

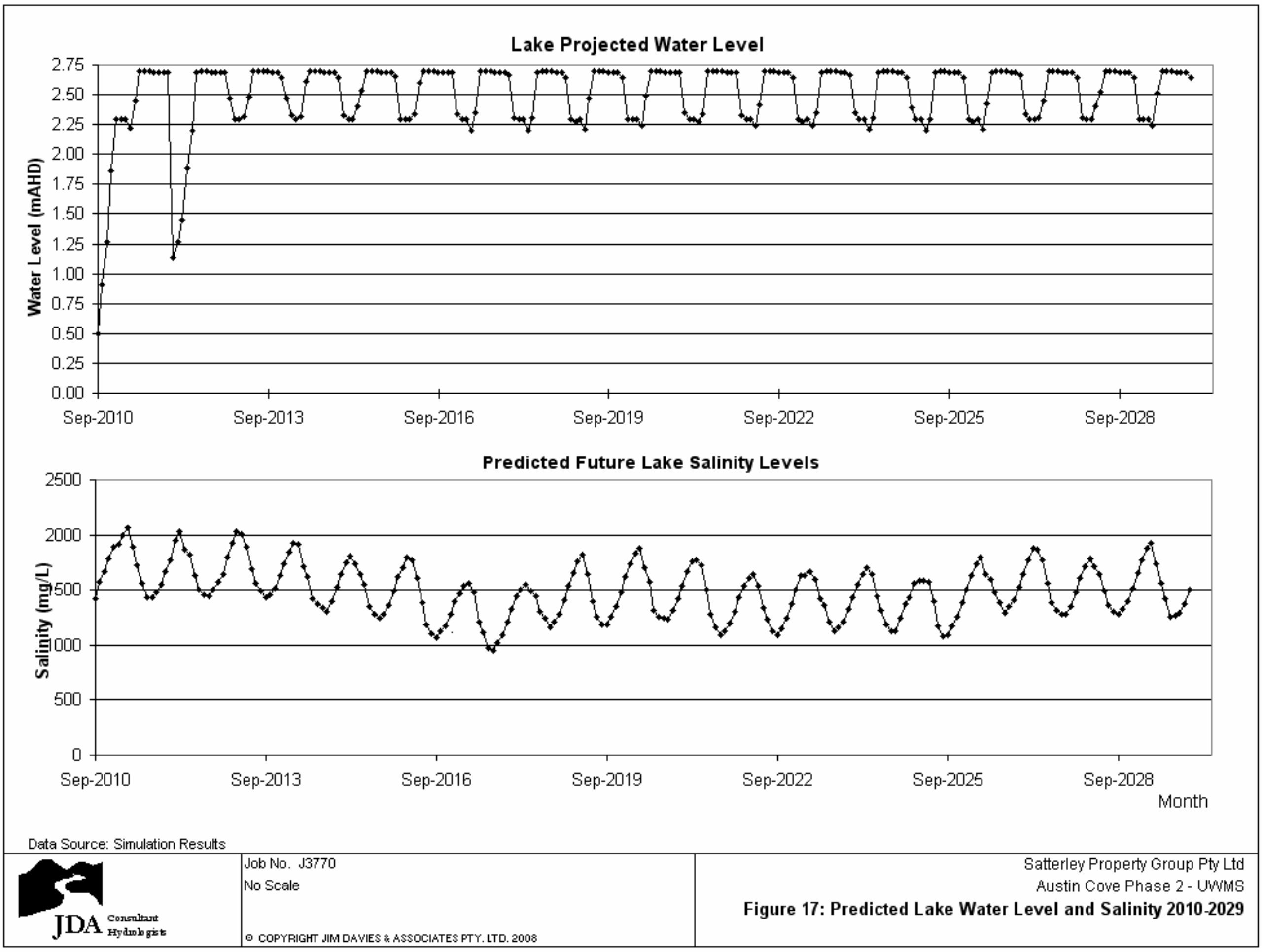

Figure 17 **Predicted Lake Water Level and Salinity 2010-2029**

The graph also shows that the salinity of the lake will be less than that of the bore water for at least the early part of summer, enabling the feature lake to be used as a superior source of irrigation water. Irrigation will switch to using bore water via the irrigation lake later in summer, when the salinity of the lake reaches that of the bore water.

Figure 18 shows the 3-year moving average bore water allocations for lake top-up and irrigation, assuming that 118ML/yr of water is drawn from the feature lake for irrigation.

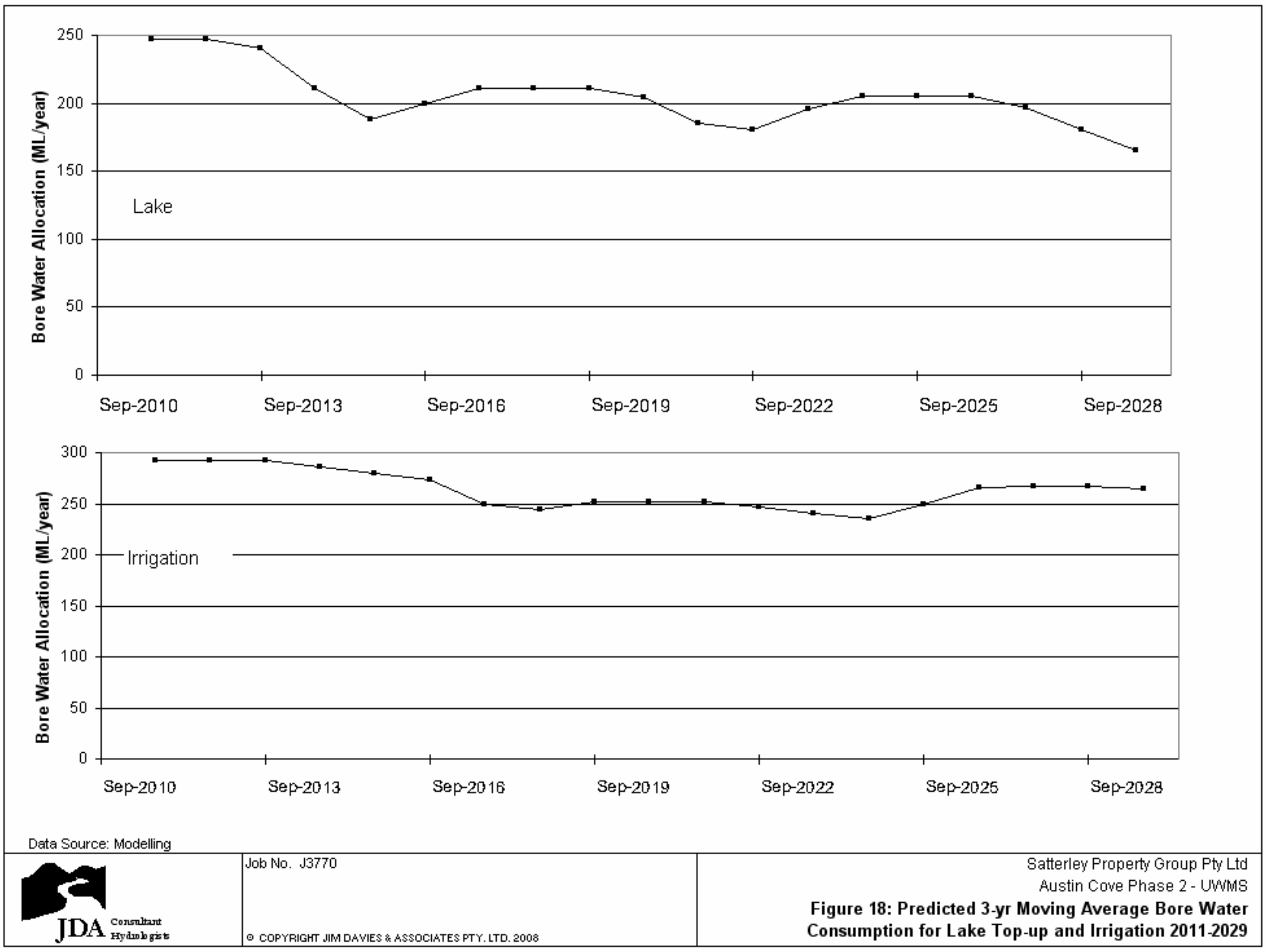

Figure 18 Predicted 3-yr Moving Average Bore Water Consumption for Lake Top-up and Irrigation 2011-2029

Table 5.4 shows an overall summary of the lake water balance and bore water requirement for the years of the completed lake, 2012 to 2029.

Table 5.4 Annual Water Balance for Main Lake 2012 to 2029[1]

Component (all units in ML/year unless stated otherwise)	**Value**	**% of total**
Rain water input	141	32%
Groundwater input	173	39%
Roof water input	125	29%
Total Inputs	**439**	100%
Evaporation output	-228	52%
Irrigation output (begins about 2011)	-118	27%
Overflow	-93	21%
Total Outputs	**-439**	100%

1 The calculation starts after Stage 1 of the lake development is finished (year 3 of the project) and Stage 2 completed in year 5 of the project.

Table 5.5 shows a summary of average salt loads in the feature lake over the simulation period from January 2011 to December 2029. From an initial salt loading of 220 tonnes due to lake filling with bore water, the total salt load will gradually decrease at 2% per year until it reaches semi-equilibrium in about

2016. The table shows that the annual salt input is almost entirely due to bore water inflow, and is balanced by overflow and irrigation outflow.

Table 5.5 Modelled Annual Salt Loads 2012 - 2029

Component (all units in tonnes/year annual average)	**Salt Load**	**% of total**
Rain water input	3	1%
Bore water input	276	98%
Roof water input	3	1%
Total Inputs	**282**	100%
Irrigation output	-154	54%
Overflow output	-133	46%
Total Outputs	**-287**	100%
Net Salt Load	**-5**	**-2%**

5.4.2 Nutrient Modelling

The water quality of the feature lake was modelled using the one-dimensional hydrodynamics model DYRESM coupled with the aquatic ecological model CAEDYM. This coupling allows for investigations into the relationships between physical, biological and chemical variables in water bodies over seasonal and inter-annual timescales. A JAVA-based modeller was used to output the results. All software is freeware provided by the University of Western Australia's Centre for Water Research (http://www.cwr.uwa.edu.au/services/models.php?mdid=4). The CAEDYM package includes comprehensive processes of the C, N, P, Si and DO cycles, several size classes of inorganic suspended solids and phytoplankton dynamics (Hipsey et al., 2006).

The water nutrient and chlorophyll-*a* concentrations in the lake were modelled over a representative 4.5-year period beginning in June 2012 when both parts of the lake have been constructed and the lake is full, incorporating actual monthly rainfall for the years 1987 to 1991 and evaporation data for 2002 to 2006. These years represent a range of annual rainfall from 825mm to 1,048mm, compared to a long-term average (20 years) of 840mm for the region. The water quality for bore water and rainfall were applied using the values described in Section 5.4.1.

To simulate the potential faecal phosphorus loading from ducks and other waterbirds using the lake, a constant loading of phosphorus in the form of Particulate Organic Phosphorus Labile (POPL) at 92 grams per day was incorporated in the model. This loading rate simulates the faecal phosphorus load from a nominal population of 10 ducks per hectare occupying the lake, obtaining all or most of their food from external sources (including the Peel-Harvey Estuary, foraging in parkland surrounding the lake and feeding by humans) and depositing 50% of their faeces in the lake.

Values for waterbird numbers, faecal loadings and the phosphorus content of faeces were obtained from a number of local and international sources including Halse *et al.* (1993), Jaensch *et al.* (1988), Government of Northern Ireland (2006) and State of Idaho (2006). The rate of 92 grams/day adopted for the modelling is considered to be towards the upper end of the range of estimates. More details of the method used to estimate waterbird phosphorus loadings are provided in the Lake Management Plan.

Because the lake is designed to only receive stormwater overflow from a greater that 5 year ARI storm, the nutrient model does not include any nutrient or water loadings from stormwater. To model the effect of inflow of runoff from a 10-year 72 hour ARI storm, a simulation was run with a storm water inflow of 0.15 m^3/s (based on the stormwater modelling) for three days in July 2014 (corresponding to 2-4 July 1991 rainfall data). The nutrient content of the storm water was assumed to be 0.22mg/L NO_3, 0.34mg/L NH_4, 0.1mg/L PO_4, 1.5mg/L TKN, 0.68mg/L TP, and 1.5mg/L TN (WESROC, 2007).

Other inputs to the model included:

(1) An initial (hypothetical) temperature profile (day 153 year 2012).

(2) An initial water quality which includes chlorophyll-*a* of 0.01µg/L, DO of 8.1mg/L, PO_4-P of 0.005mg/L, Particulate Organic Phosphorus Labile (POPL) of 0.005mg/L, NO_3-N of 0.005mg/L, NH_4-N of 0.01mg/L and pH of 7.5.

(3) One-dimensional lake bathymetry.

(4) Daily meteorological fluxes consisting of:
- measured solar radiation 2001-2005 (by satellite over Mandurah)
- measured cloud cover 2000-2004 (Perth Airport)
- measured air temperature and wind speed 2001-2005 (Mandurah)
- measured evaporation 2002-2006 (Medina)
- measured rainfall 1989-1993 (Pinjarra), corresponding with the period used in the water balance and salt modelling.

(5) Daily inflow (bore water and roof runoff water) with water quality as described in previous sections and assumed constant throughout the simulation, except for a 3 day period in the study of the storm runoff water effect. Temperature of bore water was assumed to be a constant 23^{o}C (Groundwater survey of Leederville Aquifer, 2001). The temperature of roof runoff water was adapted from air temperature by taking into account the height of the measurement station (8m) and surface water-air drag coefficient using Tennessee Valley Authority method (1972).

(6) A phosphorus (as POPL) input of 92mg/day to simulate the faecal nutrient load contributed by water birds.

(7) Daily outflow to irrigation.

The volumes and salinity of inflows and outflows were estimated from the water balance and salt modelling. All meteorological flux values are plotted in Appendix D.

The ecological state of a water body is governed by three principal factors:

- physical state (turbulence, light penetration, temperature);
- chemical state (ionic strength and composition, nutrient availability); and
- biological state (species composition, growth and grazing).

These factors act at different time scales. Under steady-state conditions, the ecological state varies in response to changes in the wind stress and surface heating, which usually occur in cycles at a frequency of several hours to days. The relatively short time scale of these two meteorological components makes them important for lake dynamics. In winter, low light availability, low temperature and complete vertical mixing of the water column (physical factor) typically override biological and chemical factors. In spring and summer, water temperature, light intensity and water column stability increase as the irradiance increases.

Model Results

Typical seasonal patterns predicted by the model for temperature, orthophosphate (PO_4-P) concentration and chlorophyll-*a* in the lake are shown on Figures 19-21. The contours for other parameters are given in Appendix D.

Lake dynamics is determined primarily by the seasonal fluctuation of solar heating and wind forcing. Due to maximum solar heating and minimum rainfall, the temperature reaches a maximum in summer. However, inflow of relatively dense (due to higher salinity) bore water and moderate wind speeds prevent the lake water column from stratifying. The prevailing summer south-westerly wind that blows along the axis of the lake also helps to maintaining mixing throughout the year, as shown on Figure 19.

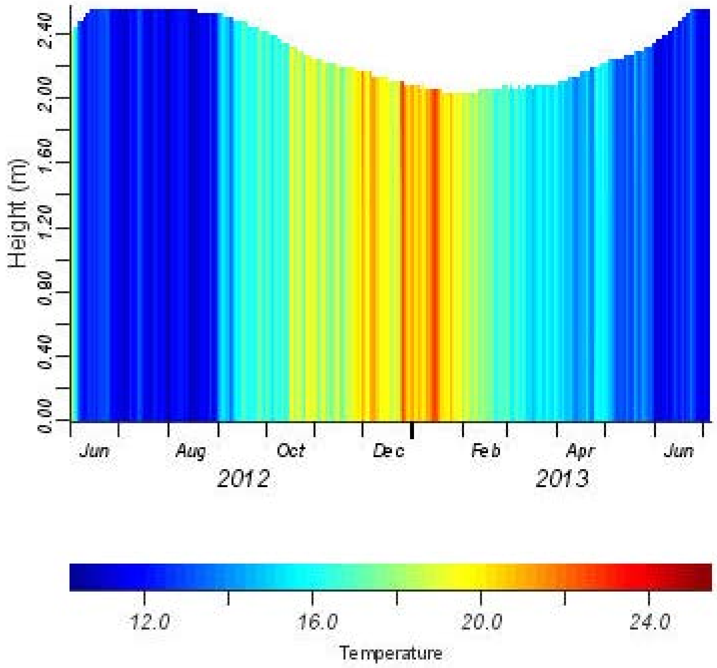

Figure 19 Simulated Temperature (^oC) June 2012 – June 2013

Figure 20 shows that the orthophosphate concentration of the lake reaches a seasonal maximum of just under 0.035 mg/L in mid-summer 2016, falling (due to sedimentation and flushing with rainfall and roof water) to less than 0.006 mg/L in winter. The summer maximum is slightly above the trigger level for algal growth, but well below the level at which phosphorus ceases to be limiting to algal growth (about 0.05mg/L). The Total Phosphorus concentration is expected to be low throughout the year, with a maximum of about half of the Freshwater Guideline of 0.06mg/L. Nitrogen levels are also predicted to remain low throughout the year (see Appendix D).

Figure 21 shows that chlorophyll-a levels in the lake are expected to remain below 2.2 μg/L throughout the year. This is well below the level of 10 μg/L that is typically taken as indicating algal bloom conditions.

Chlorophyll-a is a commonly used indicator of algal density; values of 10μg/L or more are commonly considered to indicate algal bloom conditions. A target limit of 10μg/L of chlorophyll-a is commonly applied to urban lakes and waters used for primary and secondary contact recreation (AEC 1987, Queensland Health 2001, Environment ACT 1997).

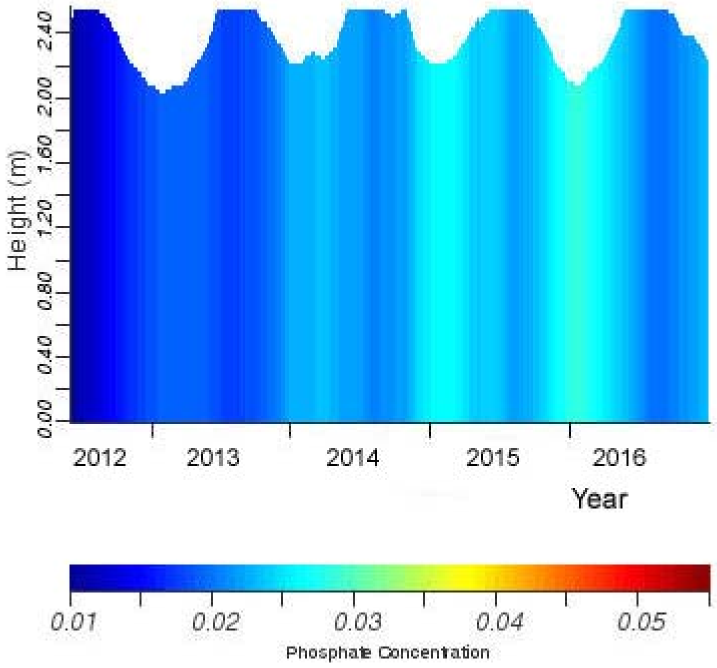

Figure 20 **Simulated PO_4-P Concentration (mg/L) June 2012 – December 2016**

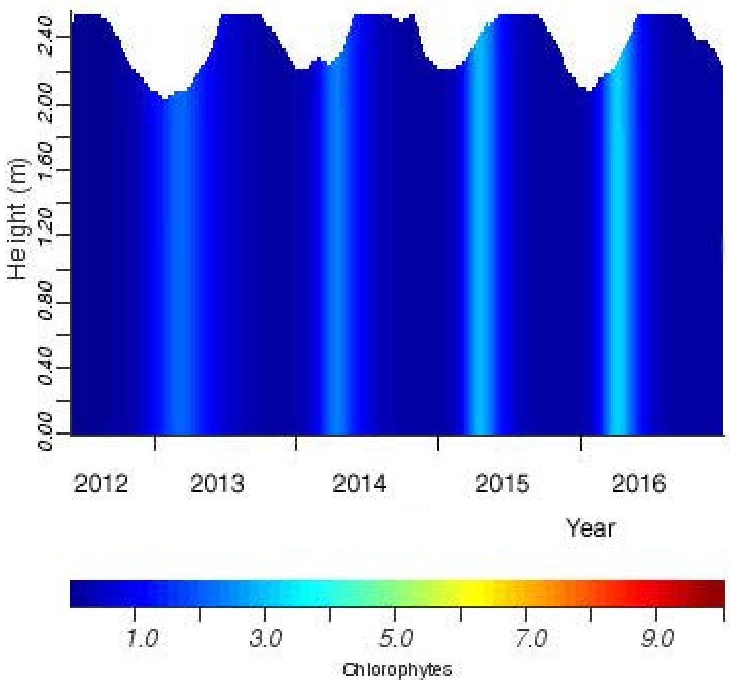

Figure 21 **Simulated Chlorophyll-*a* Concentration (µg/L) June 2012 – December 2016**

The conclusion from the nutrient simulation is that the water quality of the lake is expected to be high throughout the year.

Effect of Bird Faecal Phosphorus Loads

The comparison of the simulation result with and without Particulate Organic Phosphorus Labile (POPL) of 92g/day from bird excreta indicates that bird faeces contributes an estimated 65% of the total orthophosphate load in the lake water. Comparison of simulations with and without bird faeces shows that this additional increment of phosphorus gives rise to only an additional 0.4μg/L of chlorophyll-a in the water column. This suggests that the chlorophyll-a concentration is relatively insensitive to bird faecal inputs, and that a bird population greater or less than that estimated should have relatively little impact on the water quality of the lake. The phosphorus simulations shown on Figures 20 to 23 include a daily input of 92g/day from bird faeces.

Overpopulation and other bird-related problems are only likely to arise if regular feeding of birds takes place at or near the lake. This can best be combatted by a combination of public education (by leaflets etc.) and signage around the lake requesting people not to feed the birds.

Effect of 10-year ARI Storm Water Runoff on Nutrients and Chlorophyll-a

Storm water overflow from a 10-year ARI storm represents a potentially significant pulse of nutrient inputs to the lake. A season in which 10-year ARI storm flows enter the lake may be considered a worst-case scenario for the lake water quality. A comparison of PO_4-P and chlorophyll-*a* concentrations with and without 10-year ARI storm water inflow is shown in Figures 23 and 24. The figures show that the nutrient input from storm water creates a second peak of chlorophyll-*a* concentration (2.6μg/L) in the winter of the storm, but the concentration has declined to normal levels before the following summer.

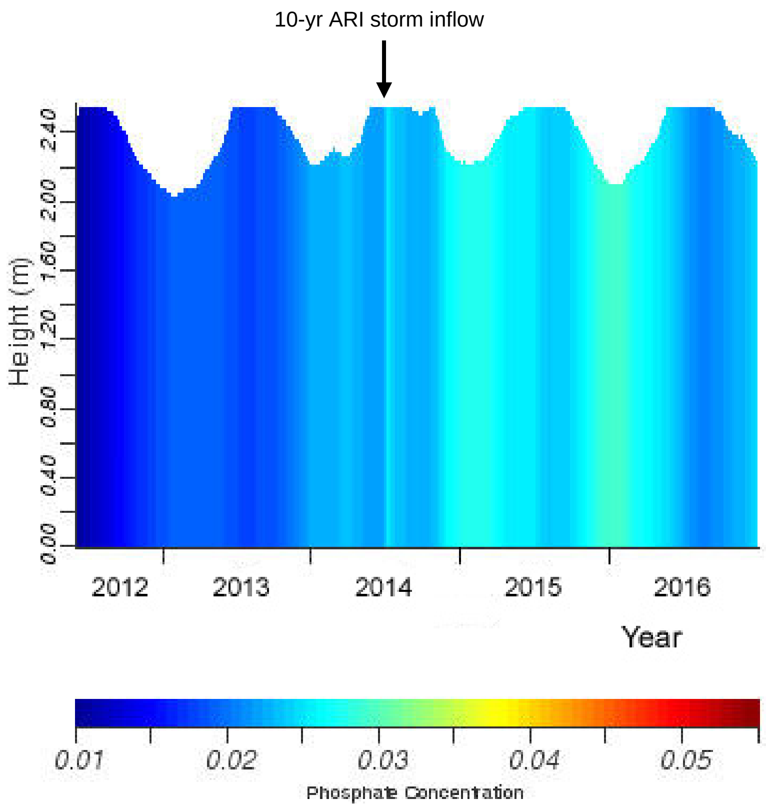

Figure 22 **Simulated PO_4-P concentration (mg/L) June 2012 – December 2016 with 10-year ARI storm runoff in year 2014**

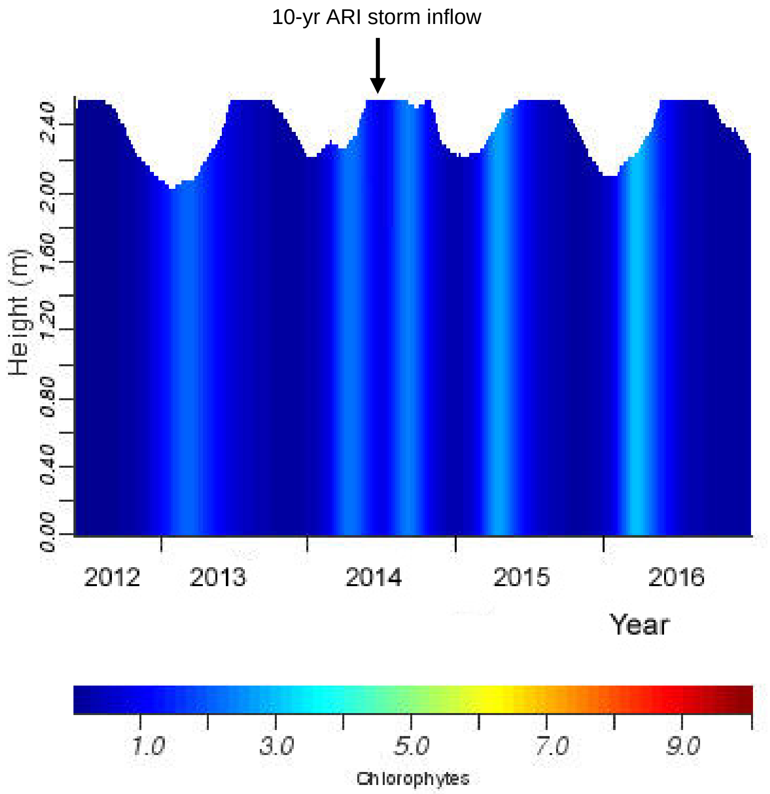

Figure 23 **Simulated chlorophyll-*a* concentration (µg/L) June 2012 – December 2016 with 10-year ARI storm runoff in year 2014**

5.4.3 Lake Circulation Modelling

Satterley Property Group commissioned Worley Parsons to conduct three-dimensional hydrodynamic modelling of the feature lake in order to assess the circulation and vertical mixing within the lake. The full report of the circulation modelling study is presented in the Lake Management Plan (BES, 2007) and summarised below.

5.4.3.1 Model Description

The Danish Hydraulics Institute's MIKE 3 model was used for the study. MIKE 3 is regarded as the state of the art for simulating three-dimensional free-surface flows. It is applicable to simulations of hydraulics, water quality and sediment transport in rivers, lakes, estuaries, bays, coastal areas, seas and other water bodies. MIKE 3 simulates unsteady flow taking into account density variations, bathymetry and external forcing such as meteorology, tidal elevations, currents and other hydrographic conditions.

Simulations were completed to represent three seasonal cases:

Summer	1 January 2001 – 2 February 2001
Autumn	2 April 2001 – 4 May 2001
Winter	16 June 2000 – 17 July 2000

Spring conditions are similar to both autumn and summer in part, and therefore the expected response in spring can be extrapolated from the other runs. The model was run for a period of 4 weeks for each of the three seasons. These periods were chosen as representative of typical wind and atmospheric conditions in that season.

The following points summarise the key model parameters:

1. The model was run with a 5 second time-step.

2. The model was a closed system with no open boundaries. The lake will be lined and perched and therefore inflows from ground water were neglected.

3. The model included wind forcing as well as atmospheric forcing and heat exchange to simulate density driven flows. The simulations have been set up using the best currently available metrological data (combined Perth and Mandurah data sets).

4. Hourly wind data for Mandurah was obtained from the Bureau of Meteorology for the simulation periods.

5. Meteorological data for the selected model periods was provided by the Bureau of Meteorology (BOM) for the closest meteorological stations to the site. Air temperature, relative humidity, and rainfall from Mandurah, evaporation from Medina station and cloud cover from Perth Airport were used. The air temperature, relative humidity, clearness (inverse of cloud cover), evaporation and precipitation data for the simulation periods is presented in the Lake Management Plan.

6. Inflows to the lake included direct rainfall, roof runoff and bore water inflow (topping up the lake during dry months) as follows:
   - Roof runoff will be directed into the lake via 12 inflow points distributed around the lake as shown on Figure 24.
   - The rate of the bore water inflow was assumed to be 0.025m3/s. The location of the bore water inflow is shown on Figure 24.
   - Inflow from direct rainfall is accounted for in the atmospheric forcings.

7. Overflow was assumed to occur whenever the lake water level reaches 2.7m AHD. Overflow discharge rate was not limited; i.e. once the water level exceeded 2.7m AHD all water above that level was assumed to be released in the following hour of the simulation. The location of the overflow point is shown on Figure 24.

8. Nutrient fluxes were modelled, including Orthophosphate (PO_4) and Total Kjeldahl Nitrogen (TKN). The nutrients were modelled conservatively and no allowance was made for any nutrient uptake as a result of biological processes.

The initial lake conditions were as follows:

Water Property	**Winter**	**Summer**	**Autumn**
Temperature (˚C)	16.0	23.0	19.0
Salinity (PPT)	2.5	2.5	2.5
PO_4 (mg/L)	0.003	0.003	0.003
TKN (mg/L)	0.08	0.08	0.08

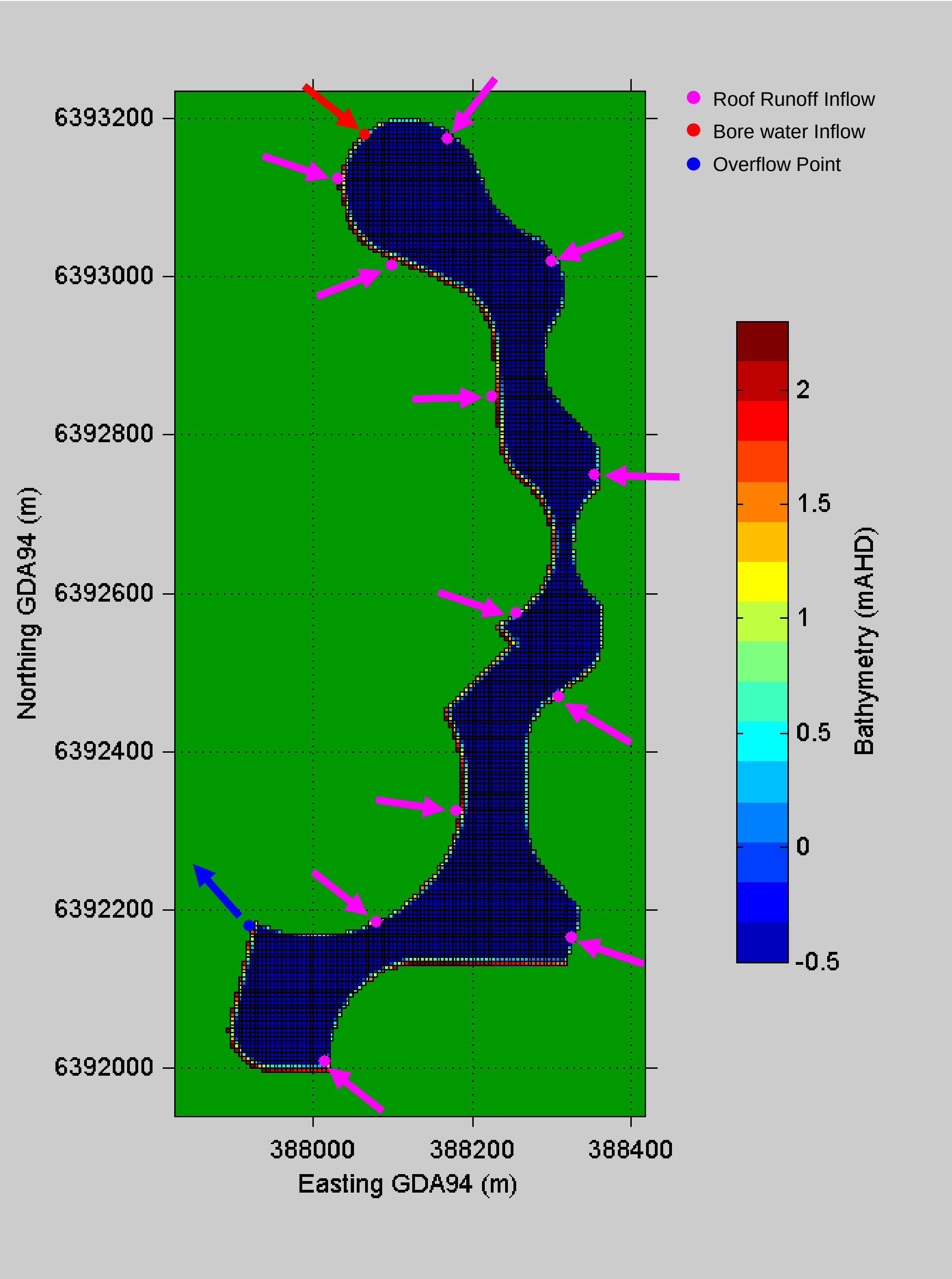

Figure 24 **Location of Inflow and Outflow Points Overlain on the Model Bathymetry**

5.4.3.2 Results

Animations of the current magnitude and direction in the surface and bottom layers for each season have been prepared to assist in the interpretation of the model results. The animations show that there are no zones of poor circulation in the lake. The animations are presented on a companion CD which forms a part of the Hydrodynamic Modelling report.

Circulation and Mixing

Generally the modelled circulation within the lake is dominated by wind forcing. The majority of the time the surface currents are in the same direction as the wind and the magnitude is proportional to the wind strength. The bottom currents are generally in the opposite direction to the surface currents, indicating circulation, turnover and mixing of the water within the lake. Typical circulation currents in the lake under the influence of wind are shown on Figure 25.

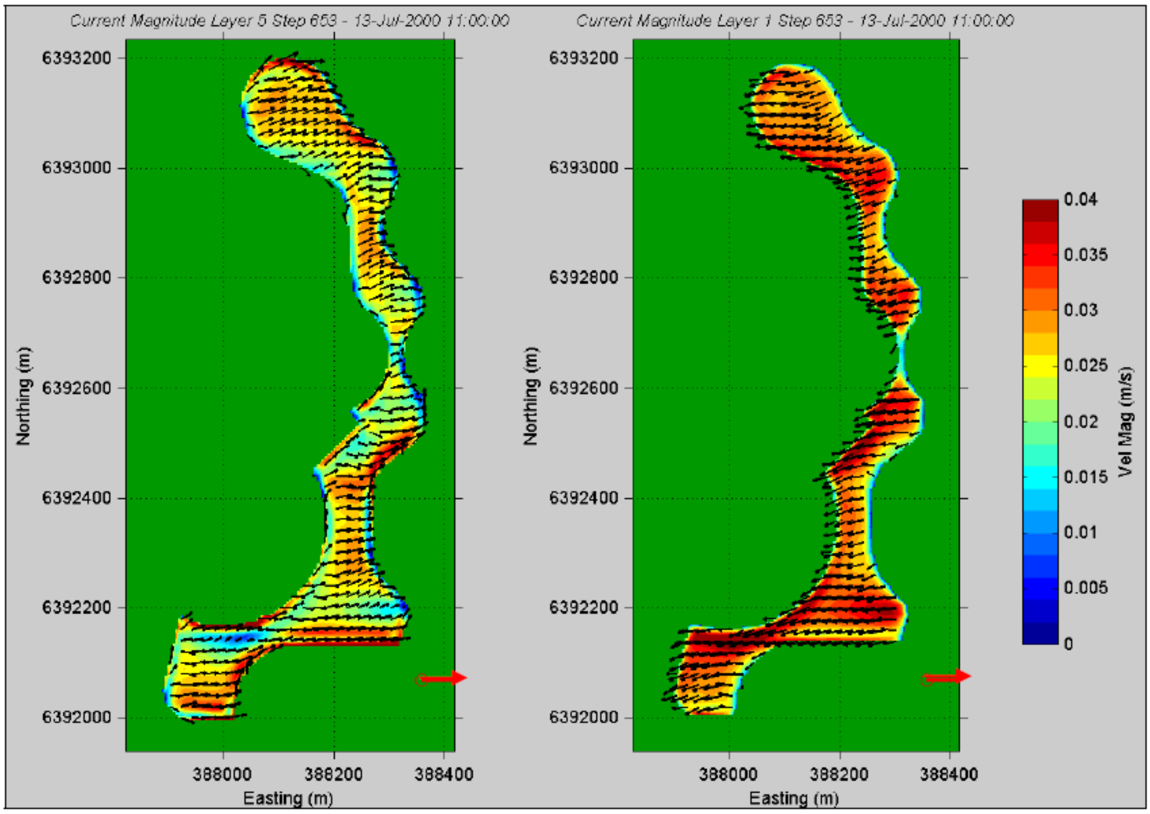

Figure 25 **Typical Surface (left) and Bottom (right) Currents in Winter.**
Red Arrow Indicates Wind Direction.

Density-driven currents, driven mainly by differential heating of the lake, will also influence the circulation but, due to the dominance of the wind, this effect is only apparent during times of low wind. An example of this is shown on Figure 26 when the wind speed is less than 0.5 m/s. A cross-section of the spatial temperature distribution at this time (Figure 27) shows that, despite this low wind, the lake water column will not be stratified.

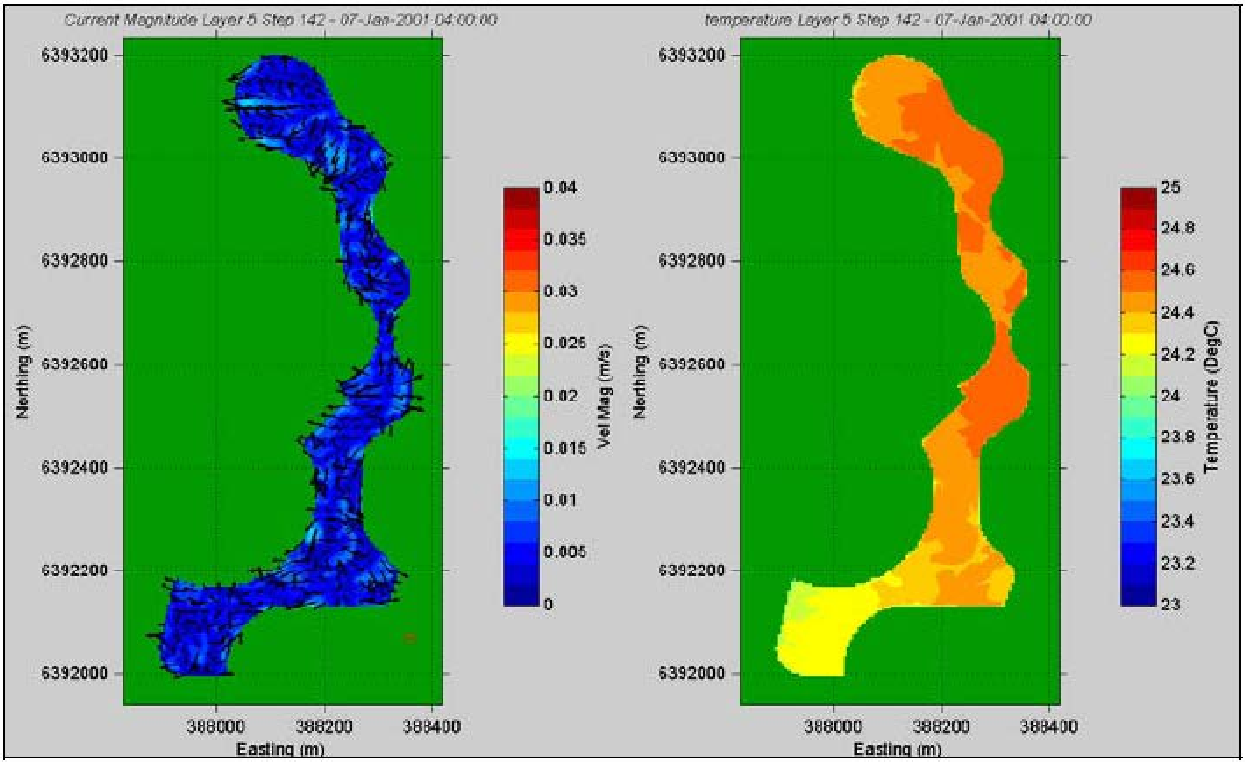

Figure 26 **Velocity Magnitude and Direction (left) and Temperature (right) in the Surface Layer for one day in Summer.**

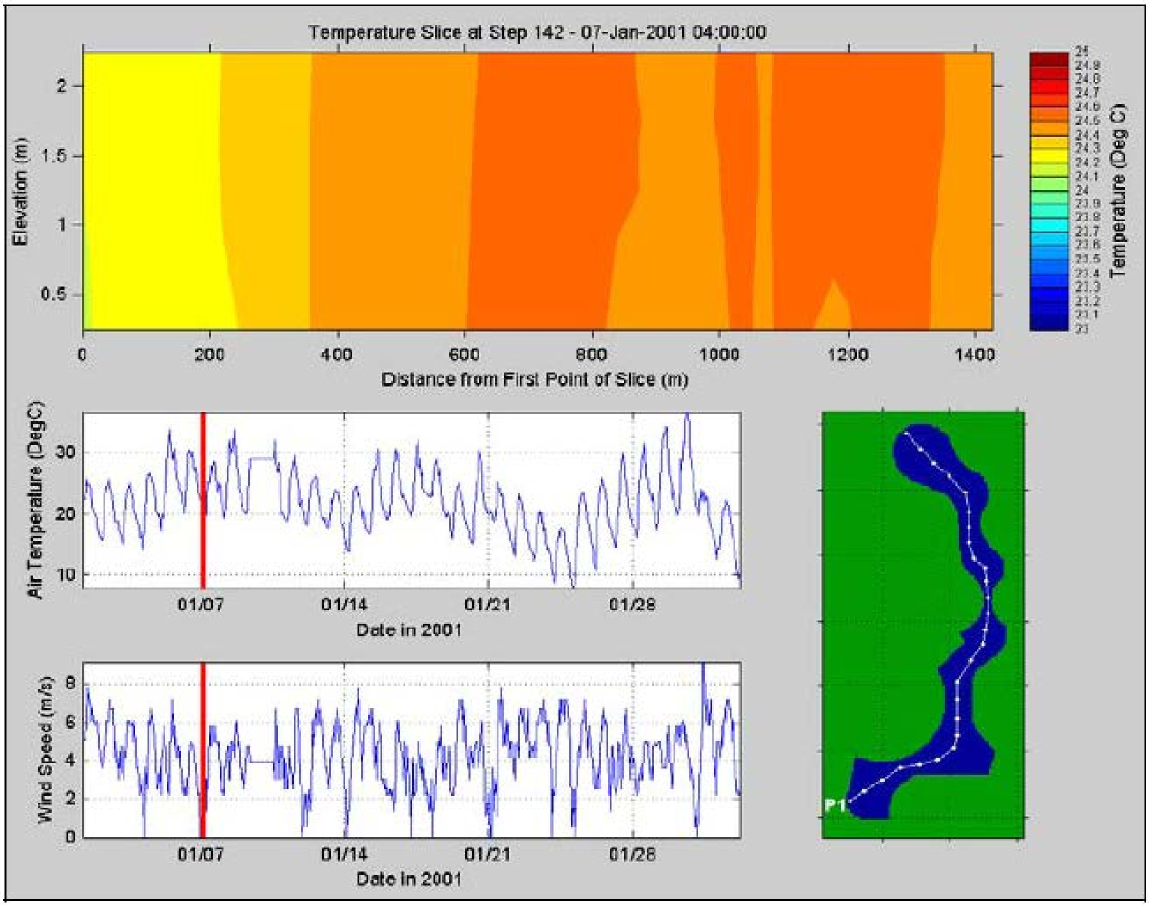

Figure 27 **Temperature Slice Along the Lake (top), Air Temperature (middle) and Wind Speed (bottom) on the Same Day as Figure 26.**

The modelling shows that over the one-month simulation periods the lake does not completely mix over its entire length, although some end-to-end mixing does occur. The model also suggests that the narrowing of the lake in the middle at the road crossing is the reason for the less than perfect mixing. The option is available to optimise the circulation between the two halves of the lake by widening the central constriction, if further modelling indicates that this is warranted.

Comparison over the seasons reveals that the autumn period is predicted to have the least energetic circulation and mixing, which is expected due to the generally lighter winds. However, the mixing in summer (the critical period for water quality) is more efficient due to the stronger winds. Figure 28 illustrates the degree of mixing between the two halves over a typical month in summer.

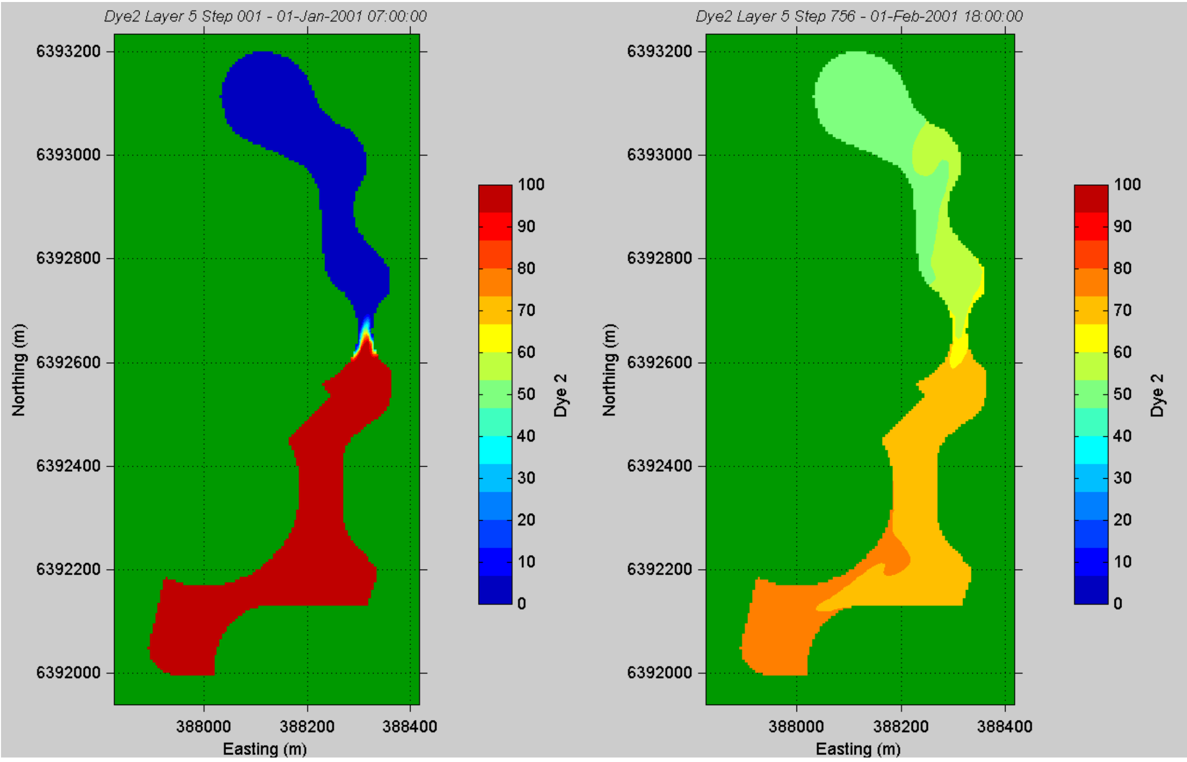

Figure 28 **Initial (left) and Final (right) Mixing (dye tracer concentration) over One Month in Summer**

Salinity and Temperature

Spatial Variation – Density Driven Currents

The spatial variation in temperature and salinity was assessed to predict the influence of density-driven flows on the circulation of the lake, by comparing time-series extracted at a range of points within the lake. The results reveal that there are minimal variations in salinity across the lake for all sections.

There are some significant spatial variations in surface temperature across the lake during the autumn and summer simulations. These variations are generally during daylight hours when the surface layer is heated by solar radiation. However, convective cooling during the night will mix the water column, ensuring that any stratification is short-lived. The winter simulation has minimal variation across the lake, indicating that the lake is generally well mixed throughout the winter months. Sample time-series plots of temperature and salinity across the lake for the summer simulation are shown on Figure 29.

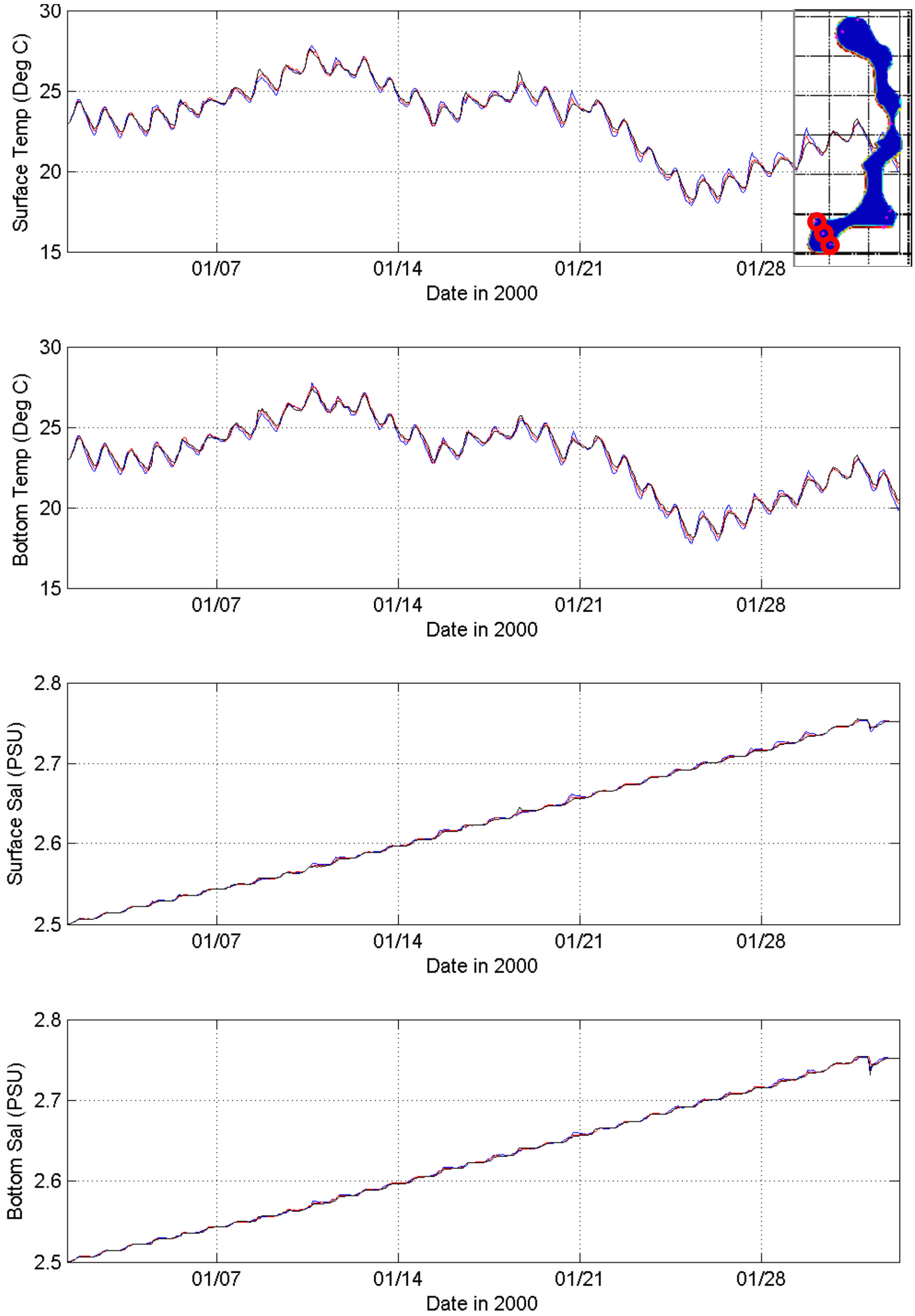

Figure 29 **Time-series Plots of Temperature and Salinity in the Surface and Bottom Layers in Summer**

Stratification

Stratification prevents or hinders vertical mixing of the water column. Stratification occurs mostly in summer when solar heating and light winds enable a warm, less-dense surface layer to form on top of the cooler, denser and (usually) nutrient-rich deeper waters. If this is prolonged, biological activity in the bottom sediments can cause the bottom waters and the sediment surface to become anoxic, creating conditions favourable to the release of phosphorus from the sediments.

Time-series plots of temperature and salinity through the water column for each season simulation were used to assess stratification. Sample plots for the summer simulation are shown on Figure 30.

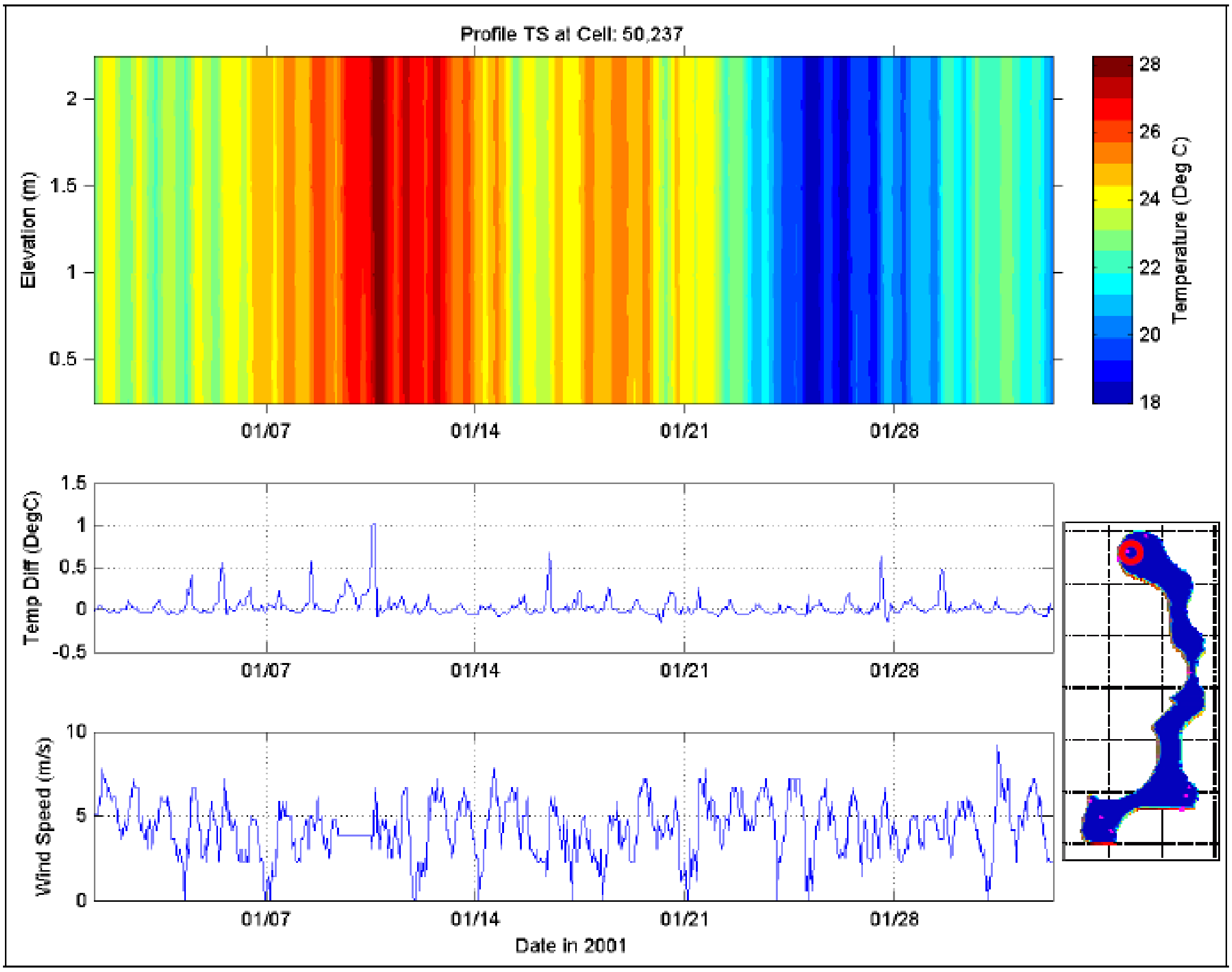

Figure 30 **Time-Series Temperature Profile (top) and Temperature Difference between Surface and Bottom Layers (middle) at Inflow Point in Summer. Wind Magnitude is shown in bottom panel.**

The plots reveal that the lake will be well mixed most of the time. Some temperature stratification is evident during daylight hours, but the lake cools and mixes at night. This type of stratification is not predicted to persist for longer periods. No significant salinity stratification is predicted.

5.4.3.3 Conclusions

The main conclusions from the circulation modelling are:

- The circulation in the lake will be predominantly driven by the wind. Autumn is predicted to have the least energetic circulation due to the generally lighter winds.

- Density-driven currents, due mainly to differential heating of the lake, will also influence the circulation but this effect is secondary to wind as the spatial variations in temperature and salinity are relatively small. The effect of the density-driven currents will only be apparent during low-wind periods in summer.

- Most of the time the lake will be well mixed vertically. Some thermal stratification is predicted during daylight hours, but convection will cause the lake to cool and mix on most nights.

- No significant salinity or temperature stratification is predicted.

- The horizontal and vertical variations in nutrient concentration are predicted to be minimal.

5.4.4 Lake Infrastructure Maintenance

The lake water quality and hydrology have been designed so as to be as nearly as possible maintenance-free, with the only normal management inputs being monitoring of the automatic systems that control water levels and irrigation outflows, plus periodic monitoring of water quality and ecological state.

The physical structures of the lake and ancillary equipment will require periodic maintenance in according with equipment specifications. These maintenance activities will include:

- Periodic (probably annual) inspection of irrigation pumps, fountains, bore pumps, cleaning of pump screens.

- Scheduled servicing and eventual replacement of pumps and fountains.

- Inspections and repair as necessary of lake walls, boardwalks and other structures.

- Regular surveillance and removal as necessary of litter and aquatic plants.

These maintenance activities will be carried out by the Satterley Property Group until at least two years after the completion of construction of the estate, after which they will be handed over to the Shire of Murray.

Full details of the lake infrastructure maintenance program are given in the Lake Management Plan (BES, 2007).

5.5 Groundwater Management

5.5.1 Groundwater Levels

The AAMGL in the Phase 2 project area is currently estimated to be at or close to the ground surface. The AAMGL will not be lowered by subsoil drainage as the fill required to raise the natural surface or flood protection will also provide sufficient clearance between finished land surface and groundwater levels. However, subsoil drains will be employed to prevent excessive groundwater rise following development, as described below.

5.5.2 Subsoil Drainage

The AAMGL at the site is currently "capped" by the ground surface and the existing agricultural drains. With the filling of the site for development, the AAMGL could rise between 0.5m and 1m into the sand fill. To prevent problems of waterlogging, subsoil drains will be installed in all areas where the depth of fill is less than two metres. The subsoil drains will consist of slotted pipes surrounded by graded aggregate bedding material. Generally, the invert of the subsoil drainage pipes will be 1.0 to 1.5 metres below road level. The subsoil drains will be placed with their inverts above the pre-development AAMGL and will discharge into the multiple-use corridor and/or into the secondary swales in the floodway and the Perth-Bunbury Highway buffer.

The water flowing into the subsoil drains will be water that would previously have flowed across the site as drain flow or overland flow. Therefore the quantity of this water will not change but its path will change from open drain flow to groundwater seepage and back to drain flow. Because the water will pass through several metres of adsorptive sand prior to being captured by the subsoil drains, its quality – particularly in terms of suspended solids and phosphorus – is expected to be significantly better than that of the water currently flowing in the drains.

5.5.3 Impact of Soil Compaction and Lake Construction on Groundwater Levels

RPS has assessed the significance of soil compaction (necessary for geotechnical purposes) and the installation of the north-south feature lake, in terms of their likely impacts on shallow groundwater transmissivity and water levels post-development. This work was undertaken by adapting the existing Austin Cove Groundwater Model to simulate the effects of the proposed lake and compaction zones over both the Phase 1 and Phase 2 areas. The results from the two models were then compared.

The existing Austin Cove model was developed to simulate proposed dewatering activities during construction and also to predict Average Annual Maximum Groundwater Levels (AAMGLs) for the site. A full description of the model and its calibration is reported in *Austin Cove Development Phase 1, South Yunderup – Acid Sulfate Soils and Dewatering Management Plan* (RPS, 2006). Model calibration established the maximum acceptable mean absolute residual (MAR) error was not greater than 0.25 metres (25cm) between the modelled heads at observation points (i.e. monitor bores) and the observed heads. Hence the accuracy of the model in predicting water levels is considered to be in the order of ±25cm.

The features of the pre-development and post-development models are detailed below:

Model 1 (Pre-development)

- A single-layer model with a hydraulic conductivity of 2.22m/day specified over the full depth of the saturated aquifer thickness.
- The inclusion of drains as identified from the feature survey, with an equivalent hydraulic conductivity of 1,280m/day. In the model, the drains are only active when groundwater levels are above the drain invert level.

Model 2 (Post-Development)

- A three-layer aquifer model to effectively simulate the lake and compaction areas:
    - Layer 1 extended from the ground-surface to a level of -0.5mAHD, which is consistent with the maximum depth of the lake along its length (~3m below existing ground surface). In the area of the lake the model hydraulic conductivity in Layer 1 was reduced to near zero, to simulate the lined lake's effect as an impervious barrier. The rainfall recharge on the lake area was set to zero as none of the rainfall on the lake would enter the groundwater system.

- Layer 2 extended from -0.5mAHD to -2mAHD. For both Layer 1 and Layer 2, outside the area of the lake, the hydraulic conductivity of the soils was assigned a value of 1.8m/day, which is approximately 20% less than the original modelled conductivity of 2.22m/day. Hence the full depth of influence of compaction was modelled as a conservative ~4mbgl .
- For Layer 3, extending from -2mAHD to around -20mAHD, no change was specified to the aquifer from the original model and the hydraulic conductivity was retained at 2.22m/day.

The models were run for the winter period, when groundwater levels and rainfall recharge are both at their maximum. The groundwater levels simulated from the revised model were compared to the original model, with the results presented on Figure 31. Based on this comparison the following conclusions can be drawn:

- Groundwater level increased by approximately 1cm in the Phase 1 compaction area.
- Groundwater levels in the vicinity of the lake decreased marginally as a result of the removal of rainfall recharge over the area of the lake.
- Groundwater levels in the Phase 2 compaction area increased by up to 7cm, most noticeably along the drains. Water level increases in the area of the drains appear to be a response to the relatively low rates of groundwater seepage into the drains.

In summary, the model results indicate that construction of the lake and soil compaction across the Phase 1 & 2 areas will have minimal impact on shallow groundwater transmissivity and hence groundwater levels. Predicted post-development changes in water table are less than the model's accuracy tolerance of ± 25cm.

5.6 Nutrient Management

5.6.1 Water Quality Targets

A description of the water quality targets set by the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (Peel-Harvey EPP) and the process by which it is being reviewed under the Peel-Harvey Water Quality Improvement Plan (WQIP) was provided in Section 2.2.1. Recently, water quality guidelines provided in the Peel-Harvey WSUD Local Planning Policy (PDC 2006), produced as part of the CCI project, specify that average input rates of nutrients from new developments in the Peel-Harvey catchment should not exceed 15 kg P/ha/yr or 150 kg N/ha/yr.

Early consultation with DoW indicated that water quality targets for the Austin Cove development would be the same as the Swan-Canning water quality targets (SRT, 2004). With the completion of phase one of the Coastal Catchments Initiative (CCI) project and the finding that Murray River is currently complying with the Phosphorus targets provided in the EPP, the DoW has advised that that interim targets should be based on pre-development water quality, with a policy of no net increase in concentrations or loads from pre-development levels. It is recognised that future water quality targets may be outlined in the Peel-Harvey Water Quality Improvement Plan (WQIP).

Pre-development monitoring data from Austin Cove (Sections 3.7.3 and 3.8.2) indicate that the water quality on and beneath the site is varied and indicative of past land use.

Management and reduction of nutrient loads leaving the project area is a high priority in the development of Austin Cove. The following initiatives and features of the site and development mean that groundwater and surface water quality are likely to improve or at least remain consistent with current conditions:

- Development without the requirement for lowering the groundwater table due to the use of extensive filling.

- The use of fill with a medium to high phosphorus retention index (PRI), reducing the leaching of nutrients (particularly phosphorus) through the soil profile.

- The implementation of water sensitive urban design and best drainage management practices, including the use of linked multiple-use corridors, enabling nutrients to be filtered from urban stormwater before the water is released into vegetated swales and eventually into the Peel Inlet.

- The preservation of large areas of existing native vegetation and wetlands, along with the creation and further enhancement of vegetated swales and wetland buffers.

5.6.2 Pre and Post Development Nutrient Inputs

Pre- and post-development nutrient loads were modelled using the NiDSS package. NiDSS is a tool developed by JDA Consultant Hydrologists to assist in land use management planning and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient inputs for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for evaluating the effectiveness of various nutrient input management measures.

NiDSS calculates the total expected nutrient input for a particular development by aggregating individual nutrient inputs from different land uses (private lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient inputs can then be determined by turning individual controls on or off or varying their effectiveness. The results present modelled estimates of:

- total phosphorus (TP) and total nitrogen (TN) application to an area;

- reductions due to source control measures such as education and street sweeping;

- reductions due to in-transit controls such as gross pollutant traps and water pollution control ponds; and

- the cost of nutrient reduction/removal (in present value terms) for a selected WSUD program.

NiDSS was applied to the project area to model existing land use and the implementation of the Outline Development Plan. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work by Gerritse *et al.* (1991,1992) on rural-residential lots.

The results of the NiDSS modelling are presented in full in Appendix E and summarised below.

Pre-Development Nutrient Inputs

Pre-development (existing) rural land use is estimated to have nutrient input loadings of approximately 16.4 kg P/ha/yr and 49.4 kg N/ha/yr. These estimates are based on typical fertiliser application rates for broadacre pasture, which has been the dominant land use in the project area.

Post-Development Nutrient Inputs

With the land use change proposed in the Outline Development Plan and assuming no WSUD, the project area is estimated to have nutrient input loadings of 21.9 kg P/ha/yr and 90.4 kg N/ha/yr. The phosphorus load would be 146% of the PDC (2006) recommended phosphorus target of 15 kg/ha/yr and 60% of the nitrogen target of 150 kg/ha/yr. This is consistent with the findings of the DoW/DEC WQIP modelling, which found that non-WSUD urban land use can generate higher phosphorus loads than broadacre agriculture.

The NiDSS model shows that implementation of recognised non-structural WSUD measures could achieve reductions of more than 50% in phosphorus and nitrogen inputs compared to non-WSUD developments.

Table 5.6 shows the characteristics of two examples of water quality management programs based on source controls including the use of native plantings for residential and POS areas, street sweeping and education campaigns. In these examples, it assumes an education effectiveness of 25% and 33% respectively: that is, 1 in 4 or 1 in 3 people will adopt the WSUD principles as listed. These effectiveness percentages are considered realistic.

The scenarios shown in Table 5.6 are examples only. There are many other combinations of management options available that can also be used to achieve a similar result.

Table 5.6 Management Options Adopted in Example WSUD Programs

NiDSS WSUD Parameter	Description of WSUD Parameter	WSUD Scenario 1	WSUD Scenario 2
Street Sweeping	% of street area regularly swept	100%	100%
Education Effectiveness	% of people adopting WSUD principles	25%	33%
Community Education on Fertiliser Use	Fertiliser application as per manufacturers' recommendations	✓	✓
Community Education on Pet Waste	Proper disposal of waste in rubbish bins	✓	✓
Balanced Planting Regime[1] (from exotic gardens)	% of exotic gardens replaced with a balanced planting regime	40%	50%
Balanced Plating Regime[1] (from Lawn area)	% of lawn area replaced with a balanced planting regime	60%	50%
Native tree planting in POS	Native plants used in POS plantings.	30%	50%

Table 5.7 shows the modelled nutrient inputs resulting from the two WSUD management scenarios outlined in Table 5.6.

Table 5.7 Pre- and Post-development Nutrient Inputs Modelled Using NiDSS

Nutrient	Pre-development (existing land use)	Target (PDC, 2006)	Post-development (without WSUD)	Post-development (with WSUD Scenario 1)	Post-development (with WSUD Scenario 2)
Total Phosphorus Input (t/ha/yr)	16.4	15	21.9	10.3	8.9
Total Nitrogen Input (t/ha/yr)	49.4	150	90.4	44.7	41.5

Table 5.7 shows that, with the implementation of readily available WSUD measures, the nutrient inputs to the Austin Cove site under full development are expected to be well below both current inputs and the targets recommended in the Peel-Harvey WSUD Local Planning Policy (PDC 2006). Further details of the NiDSS model and the scenarios modelled are presented in Appendix E.

Relationship Between Nutrient Inputs and Exports

NiDSS models nutrient inputs to the site, not exports from the site to the receiving environment. The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a "front" in a complex series of adsorption and desorption reactions. Nitrogen, also, is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The NiDSS modelling shows that long-term nutrient inputs to the site – and hence exports – are expected to be well below the current targets. In practice, nutrient exports from the site in both the short and the long term will be considerably less than inputs due to a number of design features of the development. These include:

- In the short term, the use of fill with a medium to high PRI (higher than that of existing soils) will divert the great majority of existing surface drainage into infiltration, with water seeping through several metres of adsorptive yellow sand before being allowed to leave the site. Groundwater that is currently intercepted and converted to surface flow by the agricultural drains will pass through high-PRI sand fill and be stripped of phosphorus before entering the subsoil drains or leaving the site as shallow groundwater flow.

- In the long term, the capture and infiltration of the runoff from at least the 1-year ARI storm will enable an estimated 99% of urban runoff to be infiltrated and most of its entrained phosphorus to be permanently retained on the site (see Appendix B).

5.6.3 MUSIC Modelling

The Department of Water has advised (C. Zammitt, 2006 pers. comm.) that the MUSIC model is currently being calibrated for Western Australian conditions and is not entirely suitable to assessing the water quality performance of the various WSUD BMPs to be implemented at the project area. One limitation is that the model is designed for eastern states catchments with clay-based soils, and does not deal well with the situation where zero surface flow leaves a catchment during a storm, as will occur regularly at Austin Cove due to the high degree of on-site infiltration. In order to run the model for Austin Cove, it was necessary to assume that no infiltration would occur, either in swale basins or elsewhere in the development area.

However, as no alternative model exists for Western Australia, MUSIC has been used to give an indicative estimate of surface water quality leaving the Austin Cove site.

Post-development water quality targets for Austin Cove are to be based on pre-development monitoring, with a target of no net increase in nutrient loads or concentrations. MUSIC results are compared against both pre-development surface water monitoring targets and Swan-Canning targets for comparison.

Table 5.8 Water Quality Targets

Water Quality Target	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Austin Cove (Based on mean values from pre development surface water monitoring)	2.6	0.21
Swan-Canning	2.0	0.10

For the purpose of MUSIC, the project area was divided into five sub-catchments based on post-development surface water flow. Table 5.9 below provides details of the catchments included within each. An annual rainfall of 799mm was used to calibrate the model, which is between the long term (852mm) and short term (772mm) average rainfall recorded at Mandurah.

Table 5.9 MUSIC Sub-Catchments

MUSIC Sub-Catchment	Austin Cove Catchments (see Figure 15)
1	18, 19, 22, 23, 25, 26, 28, 29, 30, 35.
2	14, 15, 16, 17, 20, 24, 27, 31.
3	1, 2.
4	6, 7, 8, 9, 21, 34
5	3, 4, 5, 10, 11, 12, 13, 32, 33.

Surface water draining from the site under present conditions contains nutrients from cattle manure, fertilisers and other minor sources. This water is directed into the existing drainage network where it quickly moves off site with no treatment. With the implementation of WSUD principles in the development, surface water overflowing from infiltration basins under high rainfall conditions will undergo sequential treatment through vegetated swales and the multiple-use corridor to reduce its nutrient content before being discharged to the environment.

The sequential treatment processes employed for each of the MUSIC catchments for the purposes of the model are as follows:

MUSIC Sub-Catchment 1

10 Urban Catchments → 10 Swales → Feature Lake → 4 Linked Infiltration Basins (POS 1,2,4,5) → Receiving Environment.

MUSIC Sub-Catchment 2

8 Urban Catchments → 8 Linked Infiltration Basins → Receiving Environment.

MUSIC Sub-Catchment 3

2 Urban Catchments → 2 Linked Infiltration Basins → Receiving Environment.

Music Sub-Catchment 4

6 Urban Catchments → 6 Infiltration Basins → Infiltration Basin (POS 3) → Receiving Environment.

MUSIC Sub-Catchment 5

9 Urban Catchments → 9 Infiltration basins → 4 Linked Infiltration Basins (POS 1,2,4,5) → Receiving Environment.

The results of the MUSIC modelling are summarised in Table 5.10 below. The results indicate that nutrient concentrations are greatly reduced from pre- to post-development. An even greater reduction in nutrient loads is expected, due to the infiltration of the great majority of surface flow on site.

Table 5.10 Nutrient Concentrations Predicted by MUSIC

Parameter	Austin Cove Target (pre-development surface water monitoring)		MUSIC Sub-Catchments									
			1		2		3		4		5	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
Flow-weighted daily mean (mg/l)			NF	NF	0.32	0.003	0.157	0.002	NF	NF	NF	NF
Mean concentration (mg/l)	2.6	0.21	NF	NF	0.21	0.002	0.007	0.007	NF	NF	NF	NF
Maximum Concentration (mg/l)	3.8	0.33	NF	NF	1.86	0.23	2.64	0.40	NF	NF	NF	NF
Minimum Concentration (mg/l)	1.6	0.1	NF	NF	0.00	0.00	0.00	0.00	NF	NF	NF	NF

TN: Total Nitrogen, TP: Total Phosphorus, NF: No Flow from Austin Cove Phase Two to floodway or wetland buffers during average rainfall events.

MUSIC predicts that, under average rainfall conditions, no surface water will flow into the receiving environment from sub-catchments 1, 4 and 5. Even during worst-case scenarios where it was presumed that 100% of sub-catchments 1, 4 and 5 were impermeable, no surface flow was predicted. This is due to the large infiltration capacity provided by the swale basins on site.

Surface water flow from sub-catchment 2 is still predicted to occur, which will maintain regular surface water flows into the wetland area.

MUSIC indicates the expected nutrient reduction in nitrogen and phosphorus concentrations in outflows based on the expected reductions achieved by elements of the treatment train approach being implemented at the project area. The predicted loads are shown in Table 5.11.

Table 5.11 Nutrient Load Reductions Predicted by MUSIC

Parameter	Sources		Residual Load		Reduction (%)	
	Sub-Catchment 2	Sub-Catchment 3	Sub-Catchment 2	Sub-Catchment 3	Sub-Catchment 2	Sub-Catchment 3
Flow (ML/yr)	84.9	36.5	11.9	12.0	86	67.1
TP (kg/yr)	35.7	15.1	1.56	2.56	95.6	83
TN (kg/yr)	250	103	16.3	22.8	93.5	77.9

As the MUSIC model may in the future be used to assess the performance of stormwater systems at the conceptual design stage in Western Australia, pre- and post-development monitoring results from Austin Cove will be provided to DoW to aid in the development of MUSIC.

5.7 Salt Scald Area Management

5.7.1 Introduction

In the conservation area north-west of the Phase 2 project area, where the multiple-use corridor adjoins the conservation area, is a large area (~21 ha) of salt and/or acid scalding and degraded land. Other, smaller areas of salt scalding are located elsewhere in the floodway.

Historical aerial photography suggests that this scalding has developed since 1957, primarily as a result of groundwater table rise brought about by clearing of the surrounding farming properties. The site does not show any evidence of salt scarring prior to the commencement of agricultural activities. Other possible contributing factors are the construction of agricultural drains that discharge into the area and the presence of downstream drains that might permit saline estuarine water to invade the area. The effect on the natural vegetation in these saline areas has been a slow progression from *Melaleuca* shrublands over Herbland on winter wet clay flats to Samphire (Saltbush) and Herbland flats.

Groundwater monitoring undertaken during 2006 showed that winter water tables were at or near the surface over the area of the floodway. The groundwater level in bore MB15 at the centre of the salt scald did not fall below 0.8m below ground level at any stage of the year.

Groundwater quality measured at MB15 indicates that salinity is typically in the order of 22,000mg/L, around two-thirds that of seawater. The groundwater also displays pronounced ASS oxidation effects, with pH ranging between pH 4.0 to 6.4. It is apparent that the high water tables, elevated salinities and low pH all conspire against plant growth.

5.7.2 Drainage Function

Stormwater overflows and subsoil drainage flowing down the multiple-use corridor will exit from the site into the area of the salt scald before finding their way, via existing drainage lines, into the Peel Inlet. The drainage modelling carried out using MODRET and XP-Storm suggests that the volume and frequency of major stormwater flows through this area will be less following development, but that much of this flow will probably be replaced by a slower, more consistent flow generated by discharge of infiltrating water via the subsoil drainage system and the multiple-use corridor.

5.7.3 Proposed Rehabilitation

Rehabilitation will be undertaken strategically within the Parks and Recreation area, focussing on areas of degradation. A Rehabilitation Management Plan will be prepared separate to the Conservation Area Management Plan. Rehabilitation works within salt affected areas is a developing science, and success is dependent on long-term monitoring and a staged approach to revegetation. Preparation of a Rehabilitation plan will also require input from the DEC and the Shire of Murray.

All rehabilitation works will be carried out in accordance with EPA *Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems* (2006), which outlines the following standard objectives for consideration prior to undertaking rehabilitation:

- safe, stable and resilient landforms and soils; appropriate hydrology;
- providing visual amenity, retaining heritage values and suitable for agreed land uses;
- resilient and self sustaining vegetation comprised of local provenance species;
- reaching agreed numeric targets for vegetation recovery; and
- comprising habitats capable of supporting all types of biodiversity.

Development will return the hydrological regime to a state much more closely resembling the original uncleared state of the site. However, it will take some time after reinstatement of the original hydrological regime for the salt affected areas to be flushed of excess salt.

Therefore, instead of simply revegetating all the salt affected areas, ecological restoration will be carried out through the revegetation of the conservation area between the northern boundary of the Phase 2 development areas, and the fence line delineating the Lot boundaries of the two square lots in the south-west corner of the site. This area is of least ecological value and, therefore, disturbance through revegetation will be less prominent in this area. The salt scar areas will also be left to naturally regenerate.

Areas adjacent to the Conservation Areas will be revegetated with deep-rooted perennial species of local provenance. The aim of this is to help lower the water table to approximate pre-clearing levels and, therefore, slow and eventually reverse the trend of increasing salinity. The vegetation in the Conservation Areas will then adjust to the improved conditions at a pace that is suited to the species involved. This method is more appropriate in an area with high conservation values than direct planting, as it does not compromise the floristic integrity of the vegetation. Additionally, the vegetation adapts by itself at a rate appropriate to the conditions and is more stable and resilient.

The placement of revegetation will depend on the results of the hydrological modelling. Salt scalds in rural landscapes are usually caused by the removal of deep-rooted perennial species upslope from the scald. Revegetation therefore should focus on reestablishment of deep-rooted perennials upslope of the saline areas, not in the saline areas themselves. Additionally, it is difficult to rehabilitate areas that are already saline. There are very few species that are tolerant of high salinity, and none of these are deep rooted enough to lower the water table. The salt scalds in the Conservation Areas are currently vegetated with shallow-rooted, salt-tolerant native herbs and Samphire shrubs.

A detailed rehabilitation plan will be prepared that will establish the most effective method of rehabilitation and will ensure compliance with up-to-date rehabilitation practices and with input and approval from the DEC and the Shire of Murray.

5.8 Wetland Management

The wetland areas within and adjacent to the Phase 2 project area will be managed in accordance with the Wetland Management Plan (WMP) and Conservation Area Management Plan (CAMP) prepared by RPS.

These management plans details a range of proposed management measures, including; management of the buffers and POS areas to the wetlands immediately adjacent to the development boundary, the provision of interpretive signage to educate local residents, rehabilitation works within the wetland areas, weed control within the wetland areas, access control, fire management, and the protection of wetland hydrology.

In addition, groundwater monitoring and vegetation health and weed monitoring will be undertaken on a regular basis to ensure that development is not having a detrimental impact to the wetland areas within and adjacent to the Phase 2 project area.

Detailed in the WMP and CAMP are contingency measures which allow a response to any detrimental impacts that may arise from the development’s associated activities.

The CCW's and RE wetlands that are within the urban zoned areas are to be retained and enhanced to make them a feature of the development. A 50m vegetated buffer will be retained or established around all wetlands areas and watercourses mapped as CCW within and adjacent to the site and a 30m buffer has been applied around the two RE wetlands located within the centre and the north east portion of the site.

Outside the development plan area, CCW's located west of the site and adjacent to the Peel Estuary which may be impacted by Austin Cove Phase Two have been given a 50m buffer to mitigate impacts from weed infestation and uncontrolled access.

5.9 Acid Sulphate Soil Management

The development design has sought to manage Acid Sulphate Soils in accordance to the preferred DoE practice of avoidance. On the basis of the ASS investigations the feature lake design has been amended so that the footprint is restricted to the eastern portion of the Phase 2 project area where a low level of ASS is present. The lined feature lake will require only a relatively shallow cut (2-2.5mbgl).

With the site requiring substantial filling, and a vacuum sewerage system being proposed, the requirement to excavate into natural soils for the provision of services has been removed, hence avoiding ASS.

RPS has completed a detailed site assessment for Acid Sulphate Soils and is in the process of preparing an Acid Sulphate Soils and Dewatering Management Plan, which will detail the construction practices to be followed to ensure effective handling, treatment and disposal of ASS and produced water.

5.10 Mosquito Management

As a result of this development there will be an influx of new residents which will create some associated risk of nuisance and health issues resulting from substantial mosquito populations breeding in the surrounding areas (RPS BBG, 2007b).

The presence of the Peel Inlet, Murray River, Yunderup canals, numerous seasonal wetlands within the vicinity of the site and the proposed artificial lake suggests that mosquito related nuisance and health issues may be experienced (RPS BBG, 2007b).

In response to this a detailed Mosquito Management Plan has been prepared by RPS. This MMP identifies the most significant mosquito breeding habitats in the vicinity of Austin Cove, and describes the design and management measures which will be undertaken to limit the risk of mosquito related nuisance and health issues. These measures include:

- The provision of mosquito buffers, through ensuring vegetation (which mosquitoes use as transportation corridors) does not immediately abut residential lots.
- Aligning the development in the direction of prevailing summer winds, allowing for mosquitoes to be blown through the development without conglomerating in cul-de-sacs or pockets.
- Consideration being given to the types and location of street lighting, with lights in populated areas employing low-attractant yellow bulbs and some highly-attracting white lighting being deliberately located away from residential lots to act as a decoy to mosquitoes.

- Limiting periods of water retention in the drainage system, which could be used by mosquitoes as a breeding location.

- Designing the feature lake so as to avoid as nearly as possible warm shallow or stagnant areas that favour mosquito breeding.

Detailed within the management plan is the agreement between the developer and the Shire of Murray to make a financial contribution to the Peel CLAG, which undertakes a helicopter-borne spraying program throughout the Peel/Harvey Region from September to May each year (RPS BBG, 2007b).

The management plan also prescribes an ongoing monitoring and contingency program for the artificial lake created within the POS area of Phase 2 Austin Cove, the responsibility of which will be with the developer until the completion of a five year period when responsibility for all public infrastructure within the development will be handed over to the Shire of Murray (RPS BBG, 2007b).

5.11 UWMS Summary

Table 5.12 provides an overall summary of key elements of the strategy with an assessment in relation to DoE (2004) principles and objectives for stormwater management in W.A.

Table 5.12 Urban Water Management Strategy Summary

Principle	Key UWMS Elements Ensuring Compliance with Principle
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	• Maintain flow paths for existing catchments (Figures 11 and 15) • All runoff from storm events less than 1 year ARI (5 yr in lake catchment) retained and infiltrated. • 10 year and 100 year ARI peak flows maintained well below current discharge levels. • Subsoil drainage installed above AAMGL.
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	• Smaller lot sizes (R30 zoning) to reduce nutrient input compared to typical urban development • Nutrient input in the project area well within PDC (2006) limits. • Use of treatment train approach to stormwater management • Application of source controls – street sweeping, education to reduce nutrient application, native plantings, passive POS areas, in-lot soakwells. • Application of structural controls – retention/detention areas, swales. • Ongoing monitoring programs and performance review processes.
Water Conservation To maximise the reuse of stormwater	• All runoff from storm events less than 1 year ARI (5 yr in lake catchment) infiltrated. • Roof runoff from 16.8ha catchment directed to lake to maintain water quality, supply high-quality irrigation water and reduce bore water demand. • Native plantings within POS areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	• Existing drains located below the AAMGL on property boundaries will remain to maintain the existing hydrological regime of wetlands. • Surface flows into CCW maintained.
Economic Viability To implement stormwater systems that are economically viable in the long term	• Use of proven structural WSUD technology. • Use of source control techniques to minimise cost of nutrient management.
Public Health To minimise the public risk, including risk of injury or loss of life to the community	• Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements. • No interference with South Yunderup 100-year floodway.
Protection of Property To protect the built environment from flooding and waterlogging	• Use of fill to raise development area above 100-year flood level. • Downstream areas protected by restricting stormwater discharge to below existing levels for storm events up to 100 year ARI. • Subsoil drainage implemented to control seasonal groundwater rise to existing AAMGL.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	• Use of swales within POS areas for stormwater infiltration and conveyance. • Integration of drainage and POS functions.
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	• Development of the UWMS in accordance with government agency guidelines and best management practice recommendations. • Reporting of outcomes of post development monitoring programs to assist in assessing system performance, with outcomes guiding future urban water management.

6. MONITORING AND RESPONSE

6.1 Monitoring Program

A comprehensive monitoring program will be implemented to confirm that the urban water management strategies put in place at Austin Cove are working as intended. This program is already underway, with monthly monitoring of groundwater levels and quality and opportunistic monitoring of surface water quality in progress since February 2006.

Future monitoring will include:

- continuation of regular groundwater quality and level monitoring;
- monitoring for acid sulphate soil impacts during and after construction (to be detailed in the Phase 2 Acid Sulphate Soil and Dewatering Management Plan);
- measurement of surface flows out of the site (perhaps including the installation of gauging stations on major drainage overflow points);
- measurement and monitoring of nutrient fluxes;
- monitoring of groundwater quality and consumption;
- further modelling of the hydrology of the development and its effect on the hydrology of surrounding areas;
- measurement of lake levels, water quality and ecological function; and
- monitoring of vegetation health in wetlands and conservation areas.

The data gained from this monitoring will serve several functions. Firstly, the results from the early stages of development will provide design data on site hydrology, drainage behaviour and the effectiveness of various WSUD measures for refinement of later stages over the expected 12-year life of the project.

The results will also provide valuable feedback and data to assist regional water quality initiatives such as the WQIP and MUSIC modelling, as well as providing guidance in the planning of future developments in the eastern catchment of the Peel-Harvey.

The following sections briefly describe the proposed monitoring programs for surface water, groundwater and wetland vegetation. A summary of the monitoring program is shown in Table 6.1. These monitoring programs will be refined and described in more detail in the Urban Water Management Plan (UWMP) for each stage of subdivision.

Table 6.1 Monitoring Schedule Summary

Monitoring Type	Location(s)	Method	Frequency and Timing Throughout construction (about 12 yrs) and 2 years after final completion
Groundwater Level	Monitoring Bores (to be determined)	Electronic depth probe or similar	Six times yearly, targeting groundwater maxima and minima
Groundwater Quality	Monitoring Bores (to be determined)	Pumped bore samples	Six-monthly (late summer/late winter)
Surface Flows	Exit of multiple-use corridor and/or other major drainage outflows	Water level recorder and data logger	Continuous
Surface Water Quality	Exit of multiple-use corridor and/or other major drainage outflows	Grab samples and/or rising stage samplers	4 samples annually at 2 locations Sampling to capture first flush (if possible), then 3 further samples from May to Oct
Vegetation	Wetlands and conservation areas (to be determined)	Fixed survey transects	Annually at 4 locations including control

6.1.1 Surface Water Monitoring

Monitoring of surface water flows and chemistry will be undertaken at selected infiltration basin overflows and at drainage exit points from the project area. Flow monitoring might include construction of a gauging weir and/or water level recorder at the outlet of the multiple-use corridor. The multiple-use corridor is expected to carry low-level flow (much of it originating from subsoil drains) for much of winter and will be regularly sampled in winter. Water quality monitoring of other drainage overflows is likely to be less regular, perhaps involving the use of rising-stage samplers on major overflow paths or opportunistic sampling using live weather data from the Department of Agriculture and Food website (http://agspsrv34.agric.wa.gov.au/climate/livedata/sumpages.htm) to predict the commencement of basin overflows.

The surface water samples will be analysed for a suite of parameters including:

- pH, EC, TSS
- Nutrients - TP, TN (with components including FRP, TKN, NO_X)
- Acid sulphate soil parameters including metals, total acidity etc.

Preliminary surface water quality criteria have been developed for the project based on the results of pre-development monitoring and advice from the DEC/DoW. If the WQIP program produces revised water quality or nutrient export targets in future, these will be incorporated in the monitoring program where applicable.

The preliminary surface water quality criteria are:

- The concentration of any major nutrient or acid sulphate soil species at any major exit point from the site should not exceed the average pre-development concentration by more than 10% on two successive sampling occasions.

- The flow-weighted mean concentrations of nutrients in drainage leaving the site should not exceed 2.6 mg/L of total nitrogen or 0.21 mg/L of total phosphorus on two successive sampling occasions.

6.1.2 Groundwater Monitoring

Groundwater levels and quality have been monitored monthly since February 2006 but this level of sampling, having established a sound water quality baseline, need not be continued. Monitoring of water levels will be carried out about six times per year, with the measurements timed to "bracket" the expected highest and lowest groundwater levels. Groundwater sampling and analysis will be carried out twice yearly, timed to target maximum and minimum groundwater levels. The monitoring will be undertaken on a subset of the original 41 bores. Monitoring records from 2006 are currently being reviewed to select suitable bores for the future program. Some bores may require reinstatement or minor relocation following earthworks.

The groundwater samples will be analysed for the same parameters as surface waters.

Preliminary groundwater level and quality criteria based on monitoring data to date and advice from the DoW are as follows:

- The average winter maximum groundwater level across the site should not exceed the pre-development average annual maximum groundwater level by more than 10% for two successive years.
- The average summer minimum groundwater level in the vicinity of wetlands should not fall below the pre-development annual average minimum groundwater level by more than 10% for two successive years.
- The concentration of any major nutrient or acid sulphate soil species in any bore, and for the site overall, should not exceed the average pre-development concentration by more than 10% on two successive sampling occasions.

6.1.3 Lake Monitoring

The feature lake will be monitored to ensure that its water quality is remaining high, the water balance is as predicted and the lake does not pose a health hazard or nuisance. The monitoring program will focus on nutrients, salinity, major ions, algal density and microbial health in the bore water, the main lake, the irrigation lake and overflows. Additional monitoring for aesthetic/social matters such as litter, structural integrity, insects, nuisance aquatic plants and fish is detailed in the Lake Management Plan (BES, 2007).

A proposed lake monitoring program is outlined in Table 6.2.

Table 6.2 Lake Monitoring Program

Parameter	Source/Method	Frequency
Inflows and Outflows Quantity Bore inflows volume Irrigation outflows volume	Pump operating records	Recorded continuously Audited annually
Overflow volume	Water level recorder on overflow weir	Recorded continuously Audited annually
Rainfall and evaporation	Bureau of Meteorology; Dept of Agriculture	Obtained annually
Bore Water Quality pH Salinity (TDS) Total & Dissolved Iron Hardness (as $CaCO_3$) Total P Filterable Reactive P Total Kjeldahl Nitrogen Nitrite + Nitrate Ammonia-N Heavy metals: Al, As, B, Cd, Cr, Cu, Fl, Pb, Mn, Ni, Zn	Water supply bore(s)	**First Year:** • Dec, Mar, Sept, May **Subsequent Years:** • Mar, Sept **Salinity only:** • Monthly Sept-May (first year)
Stormwater Inflow Quality pH, EC, TSS Hardness (as $CaCO_3$) TP, FRP, NO_X, TKN, NH_4-N Heavy metals: Al, As, B, Cd, Cr, Cu, Fl, Pb, Mn, Ni, Zn Faecal coliforms, enterococci Total Petroleum Hydrocarbons (TPH)	Inflow points (13): grab samples and/or rising stage samplers	Opportunistic – average once every 5 years
Lake Water Quality Total P Filterable Reactive P Dissolved Organic P Particulate Organic P Total Kjeldahl N Nitrite + Nitrate Ammonia-N Dissolved Organic N Particulate Organic N Dissolved Organic Carbon Particulate Organic Carbon Total & Dissolved Iron Hardness (as $CaCO_3$) Heavy Metals: Al, As, B, Cd, Cr, Cu, Fl, Pb, Mn, Ni, Zn Faecal coliforms, enterococci Chlorophyll-*a* & Phaeophytins OC & OP pesticides Total Petroleum Hydrocarbons (TPH)	Lake wide sampling (10 locations) Three-depth sampling (in summer and spring) or surface water sampling (in winter and autumn) in the cross-transect sampling (8 locations) for nutrients (P, N, C), chlorophyll-*a* and phaeophytins. In summer and spring periods, the sampling depths are to be determined from temperature profiles which include: upper layer, interface and bottom layer.	**Lake profiles, nutrients, algae, chlorophyll-*a*, and microbial:** • Dec, Mar, Jun, Sept (first and second years) • Monthly (subsequent years) **Other parameters:** • Dec, Mar, Jun, Sept (first year) • Jan, Mar, Sept (subsequent years) Plus event sampling after stormwater inflows (average once every 5 years)
Temperature pH Salinity (EC) Turbidity/Light Penetration Dissolved oxygen Redox potential	Lake profiles in the cross-transect sampling (8 locations) from dinghy	

Table 6.2 Lake Monitoring Program (cont)

Parameter	Source/Method	Frequency
Algae	Visual surveillance	Monthly
	Algae identification and enumeration	As for lake water quality
	Chlorophyll-a monitoring	As for lake water quality
Aquatic Plants	Visual surveillance	Six monthly
	Public correspondence	Continuous
Fish	Visual surveillance	Six monthly
	Public correspondence	Continuous
Birds	Visual surveillance	Six monthly
	Public correspondence	Continuous
Insects	Visual surveillance	Six monthly
	Public correspondence	Continuous
	Larval counts	Monthly Jan-Aug Weekly Sep-Oct Fortnightly Nov-Dec

6.1.4 Wetland Monitoring

Changes in the hydrology of the site could affect vegetation in the wetlands and conservation areas adjacent to or downstream of the project area. Such changes could include the populations and zonation of vegetation in and around wetlands, invasion of dryland species into wetlands and drowning of semi-aquatic species in deeper wetlands.

Changes in wetland hydrology will be detected by the groundwater monitoring program described above. The impact of any hydrological changes will be measured by vegetation monitoring at fixed points in selected wetlands and conservation areas.

Transects will be established through the wetland areas, with monitoring to include:

- assessment of the composition, structure and health of the remnant vegetation; and
- assessment of the presence of weeds including species type and extent of invasion. Recommendations to be made regarding appropriate control methods if required.

The vegetation monitoring will be carried out annually in spring, when the largest number of species is expected to be identifiable. The results will be reported annually to the DEC.

6.2 Contingency Responses

Contingency responses based on the below will be available for implementation in case the results from any of the surface water, groundwater or vegetation monitoring programs breach the criteria. These contingency response actions will be further developed and set out in the UWMP for each stage of subdivision.

Table 6.3 Contingency Responses

<table>
<tr><th>Monitoring Type</th><th>Criteria for Assessment</th><th>Contingency Action
1. Assess if an isolated, project area or regional occurrence.
2. Determine if due to the development or other external factors.
3. Perform appropriate contingency action as required (examples provided below).
4. Record and report in the annual report any breach and action taken.
5. If necessary, inform residents of any required works and their purpose.</th></tr>
<tr><td>Groundwater Level</td><td>Excessive rise or fall in groundwater level.</td><td>1. Review design and operation of subsoil and stormwater drainage systems.
2. Perform maintenance as required.</td></tr>
<tr><td>Groundwater Quality</td><td>Excessive nutrient or acid sulphate parameter concentrations.</td><td rowspan="2">1. Identify and remove any point sources.
2. Reinforce community education/awareness program.
3. Review operational and maintenance (eg fertilising) practices.
4. Consider alterations to POS areas including landscape regimes and soil amendment.
5. Consider modifications to the stormwater system.
6. Consider initiation of community based projects.</td></tr>
<tr><td>Surface Water Quality</td><td>Excessive nutrient or acid sulphate parameter concentrations.</td></tr>
<tr><td>Vegetation</td><td>Adverse change to vegetation health, zonation or population in wetland or conservation area.</td><td>1. Confirm hydrological change as cause by reference to water level monitoring data.
2. Consider changes to drainage system e.g. reducing height of basin overflows to permit more frequent surface outflow from the site.</td></tr>
</table>

6.3 Reporting

The developer will submit annual monitoring reports to the Shire of Murray and the DEC throughout the estimated twelve-year construction period and for a further two years after final completion. The reports will contain the results of all monitoring undertaken during the previous monitoring period and a discussion of any breaches of criteria and actions taken. The reports will also review the water level and water quality criteria in the light of monitoring results and suggest any revision of the criteria deemed necessary.

7. IMPLEMENTATION

7.1 Urban Water Management Plans

Pursuant to Shire of Murray Town Planning Scheme Amendment No. 218 and processes defined in EES (2005) and PDC (2006), Urban Water Management Plans (UWMPs) will be prepared for each stage of subdivision at Austin Cove Phase 2. The UWMPs will typically address:

- Demonstrated compliance with UWMS criteria and objectives to the satisfaction of Shire of Murray and DEC.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Protection of waterways, wetlands and their buffers, remnant vegetation and ecological linkages.
- Identify the purpose, design and management of proposed artificial water bodies.
- Management of subdivisional works.
- Management of disease vector and nuisance insects.
- Identification of areas of open space requiring irrigation and fertiliser use.
- Details of current soil conditions within open space areas and a determination as to whether fill and or soil amendment is required to optimise nutrient retention.
- Determination of the overall characteristics of landscape treatments proposed within identified open space areas.
- Fertiliser and irrigation schedule.
- An auditing and reporting program for fertiliser and water application to the subject land, including a Sampling and Analysis Plan to specify the overall sampling collection, storage, analytical specification and reporting methodology.
- Monitoring program.
- Contingency plans (where necessary).
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.

7.2 Stormwater System Operation and Maintenance

The surface drainage system will require regular maintenance to ensure its efficient operation. The following operating and maintenance practices will be required periodically:

- Inspection of drains, manholes etc. and removal of debris to prevent blockages.
- Street sweeping to reduce particulate build up on road surfaces and gutters.
- Mowing of grassed infiltration basins and open channels.
- Removal of accumulated sediment and litter from infiltration basins.
- Application of phosphorus-free or low- phosphorus fertilisers for maintenance of grassed swales.
- Inspection of subsoil drainage function.

7.3 Transfer of Responsibility

Satterley Property Group will establish, undertake and fund the monitoring programs detailed in this UWMS up to and for two years after the completion of the development; a total expected program duration of about 14 years. At the end of this time the monitoring programs will either be discontinued or, if the Shire of Murray or other authority wishes to continue them, handed over to the relevant authority. A final monitoring report will be prepared at the end of the last year of monitoring by the developer.

The maintenance and operation of the stormwater drainage system for each stage of subdivision will be handed over to the Shire two years after the practical completion of subdivisional works for that stage. Handover of each stage will be subject to the stormwater and other systems being in good working order.

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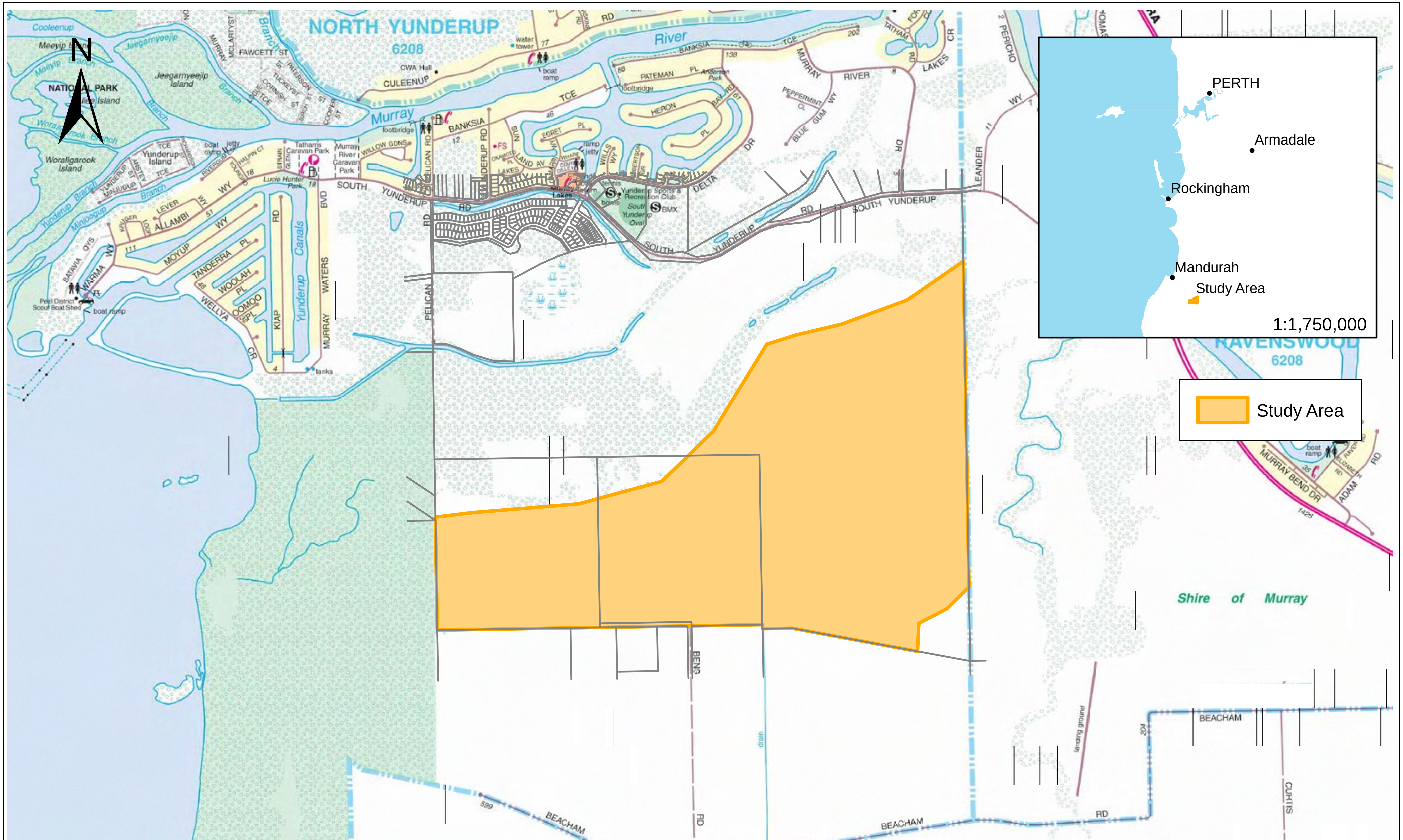
Figures



JDA Consultant Hydrologists

Job No: J3770

Scale: 1:25,000

0 200 400 600 800 Metres

Satterley Property Group

Austin Cove Phase Two: UWMS

Figure 1: Location Plan

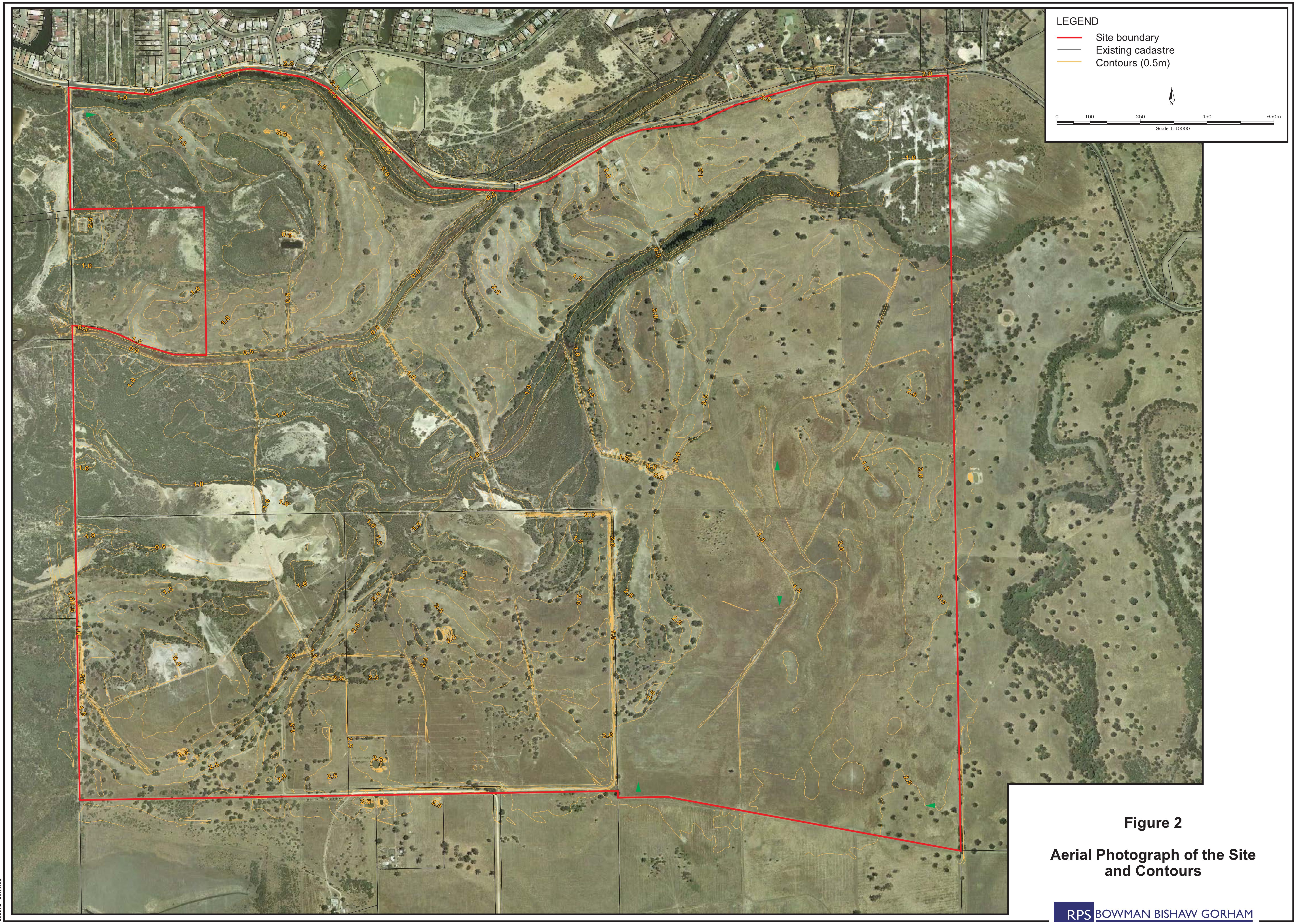
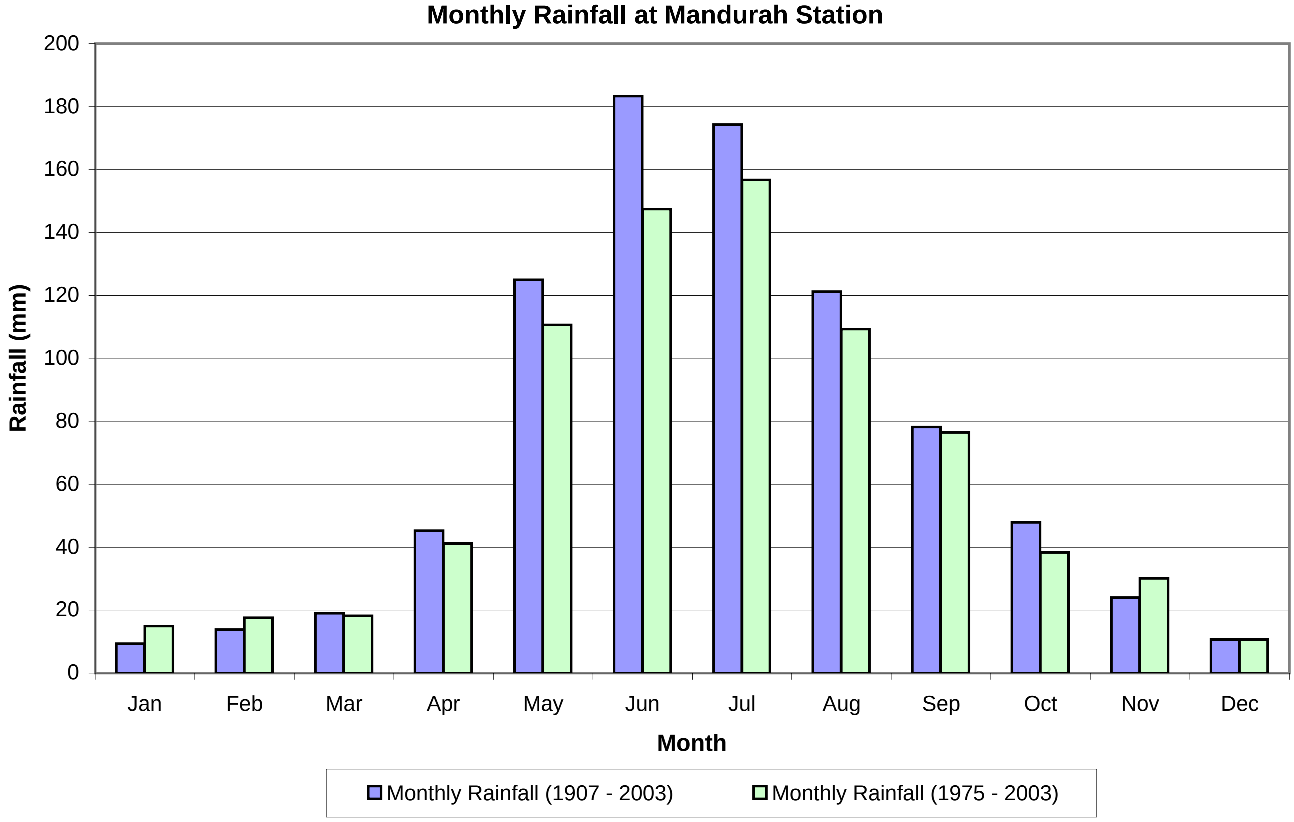
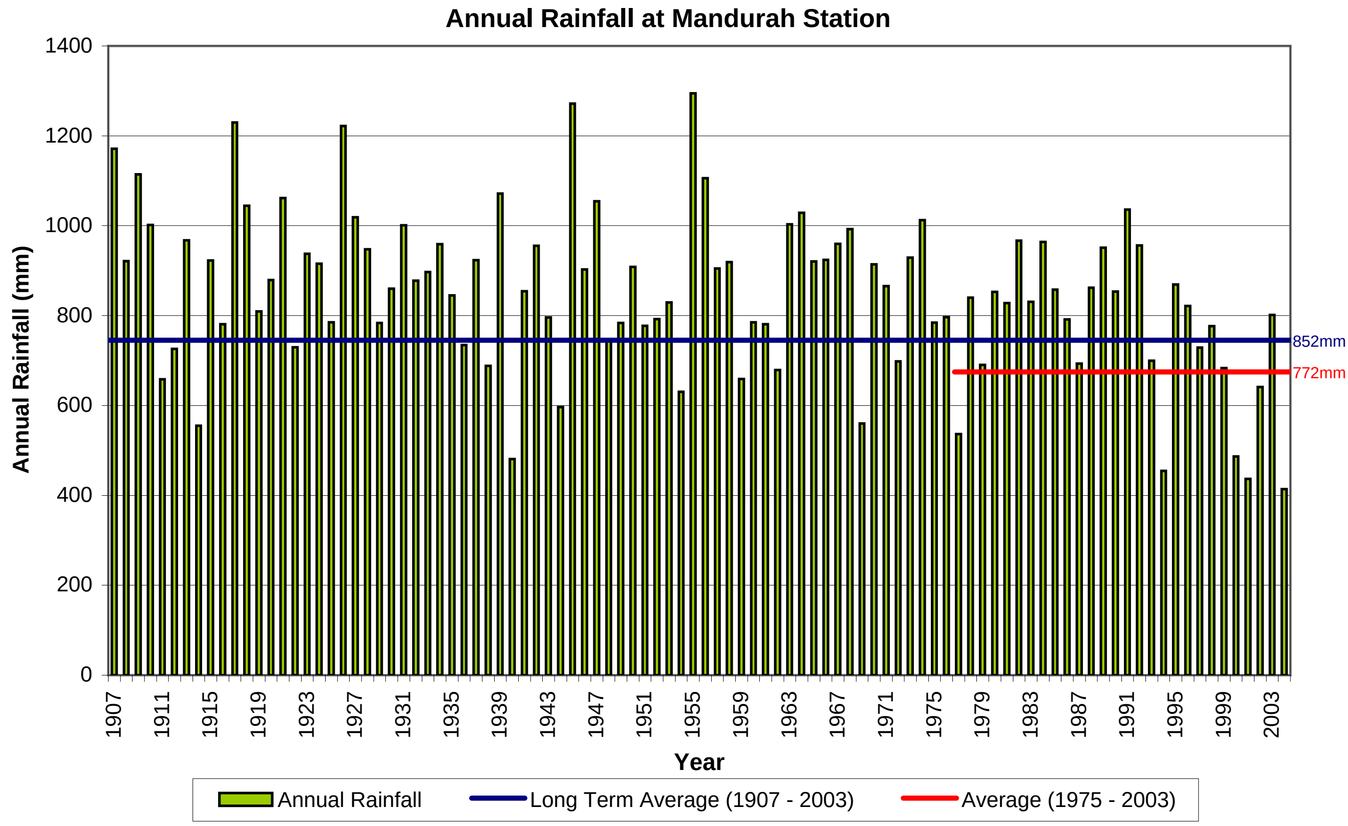


Figure 2

Aerial Photograph of the Site and Contours

RPS BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS





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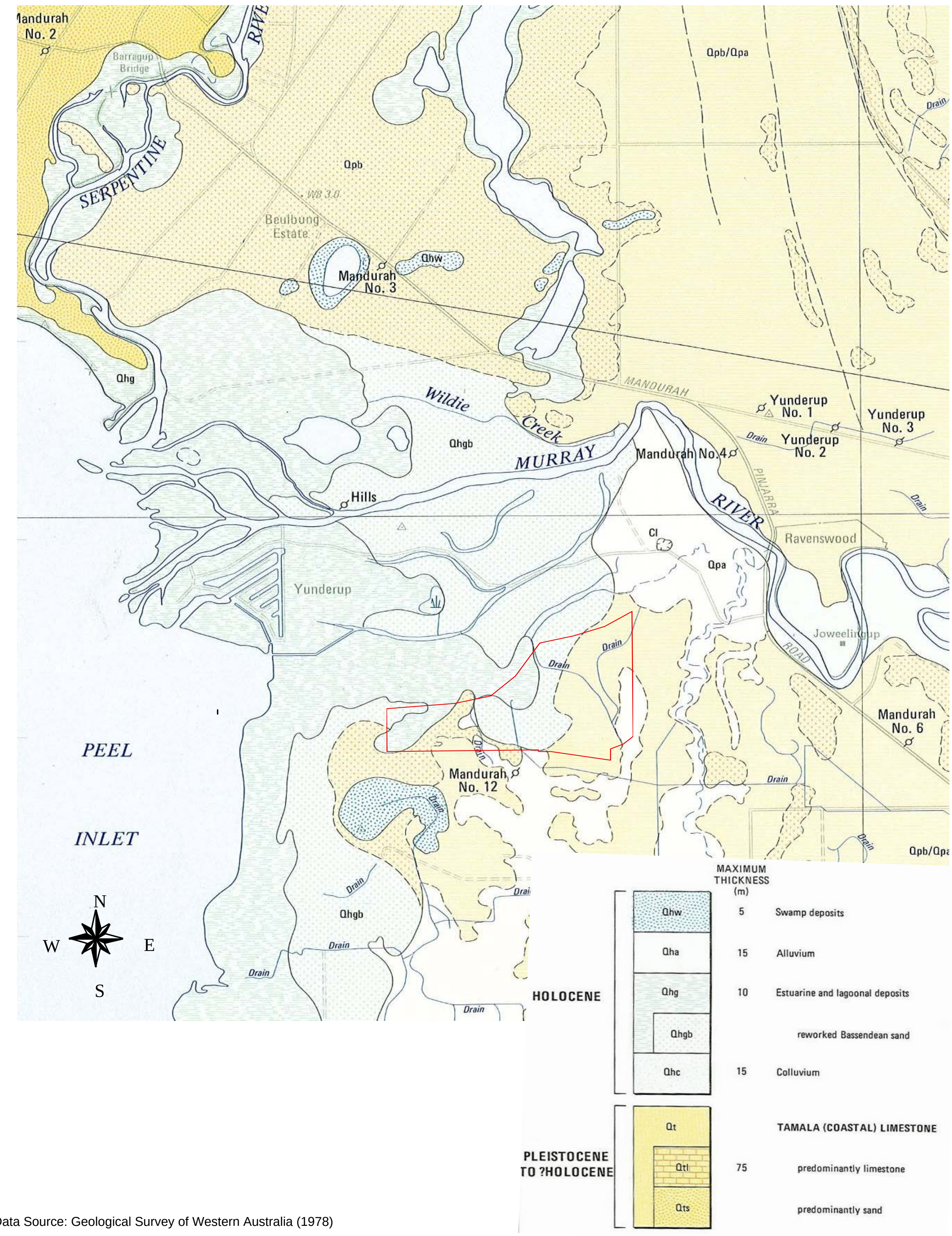
Job No. J3770

Satterley Property Group

Austin Cove Phase Two UWMS

Figure 3: Mandurah Annual and Monthly Rainfall



Data Source: Geological Survey of Western Australia (1978)

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Job No. J3770
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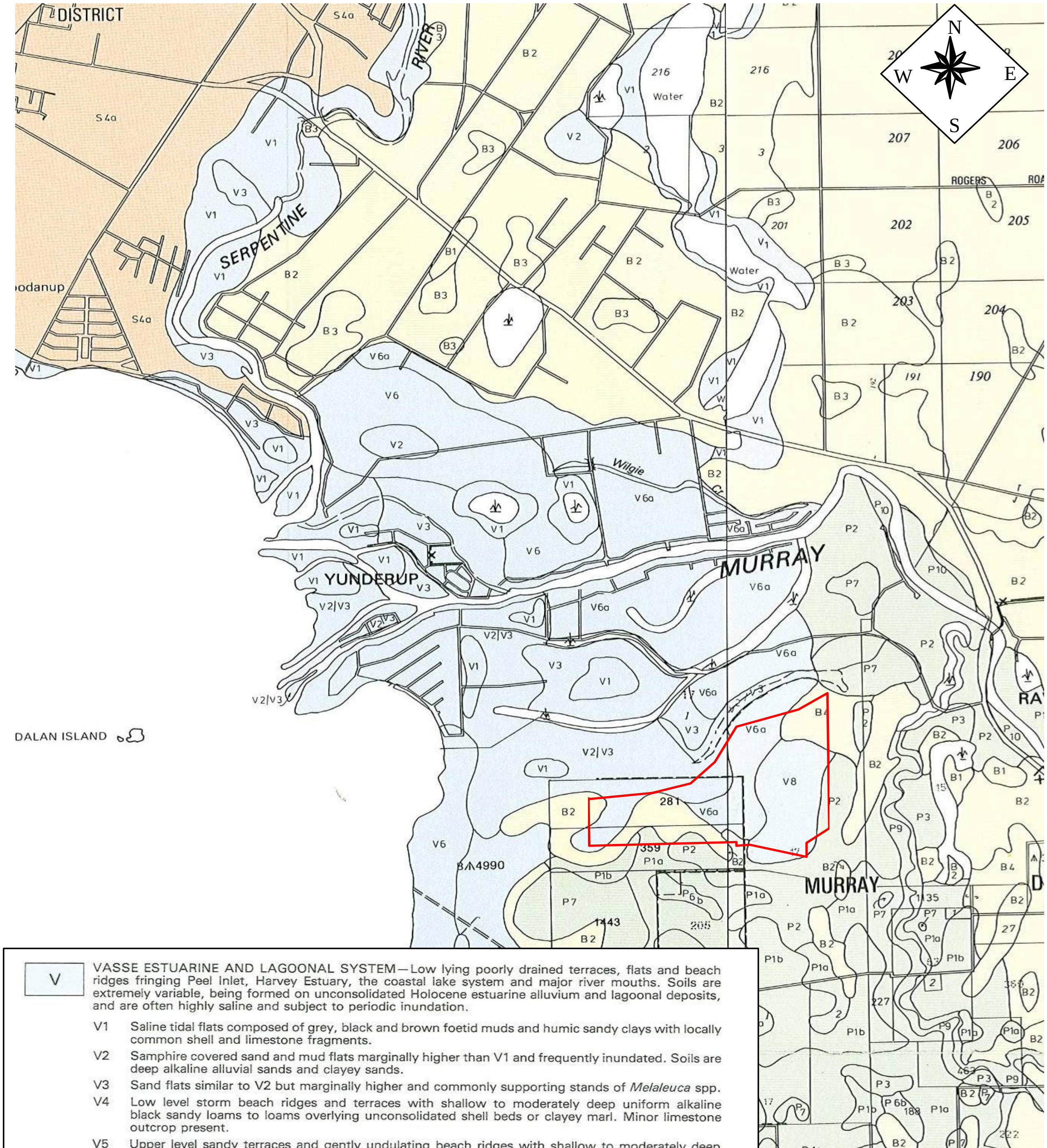
Satterley Property Group
Austin Cove Phase Two UWMS
Figure 4: Geology



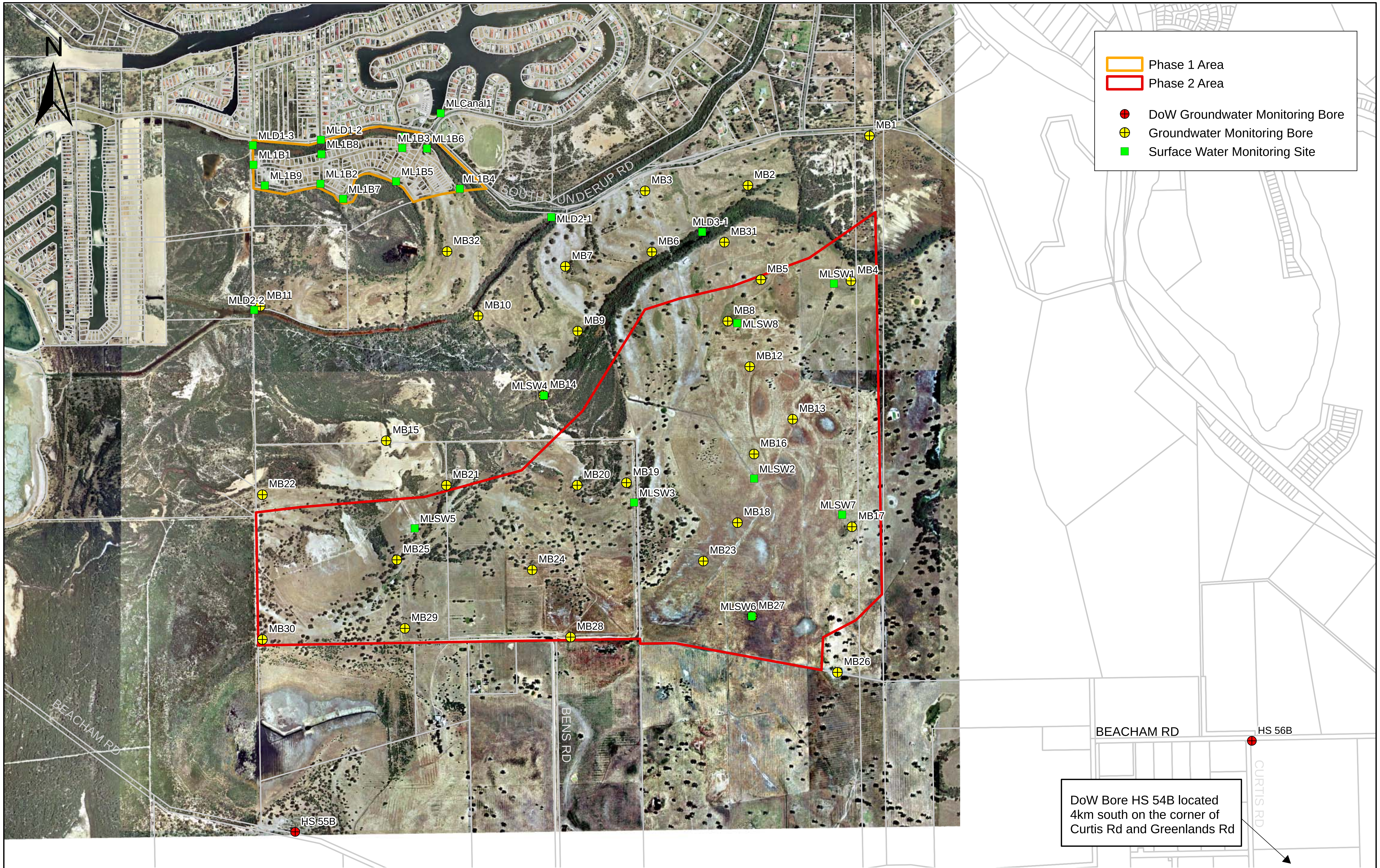
V	VASSE ESTUARINE AND LAGOONAL SYSTEM—Low lying poorly drained terraces, flats and beach ridges fringing Peel Inlet, Harvey Estuary, the coastal lake system and major river mouths. Soils are extremely variable, being formed on unconsolidated Holocene estuarine alluvium and lagoonal deposits, and are often highly saline and subject to periodic inundation.
V1	Saline tidal flats composed of grey, black and brown foetid muds and humic sandy clays with locally common shell and limestone fragments.
V2	Samphire covered sand and mud flats marginally higher than V1 and frequently inundated. Soils are deep alkaline alluvial sands and clayey sands.
V3	Sand flats similar to V2 but marginally higher and commonly supporting stands of *Melaleuca* spp.
V4	Low level storm beach ridges and terraces with shallow to moderately deep uniform alkaline black sandy loams to loams overlying unconsolidated shell beds or clayey marl. Minor limestone outcrop present.
V5	Upper level sandy terraces and gently undulating beach ridges with shallow to moderately deep grey siliceous sand overlying soft shelly limestone or shell beds.
V6	Upper level sandy terraces and gently undulating beach ridges with deep grey or bleached pale brown siliceous sands overlying soft shelly limestone.
V6a	Gently undulating beach ridges similar to V6 but formed from reworked Pleistocene Bassendean sands; deep bleached grey acid siliceous sands with iron-organic hardpan.
V7	Very broad shallow depression with deep, poorly drained, fine textured alkaline estuarine alluvium.
V8	Flat poorly drained plains forming the margins of the estuarine deposits which border and partially overlie the Pinjarra Plain. Variable, moderately deep to deep saline soils, commonly mottled yellow duplex soils over calcareous sediments or prior soils of the Pinjarra Plain.

Data Source: Wells & Hesp (1978)

JDA Consultant Hydrologists

Job No. J3770

Satterley Property Group
Austin Cove PhaseTwo UWMS
Figure 5: Soils



Data Source:

JDA Consultant Hydrologists

Job No. J3770
Scale: 1:15,000
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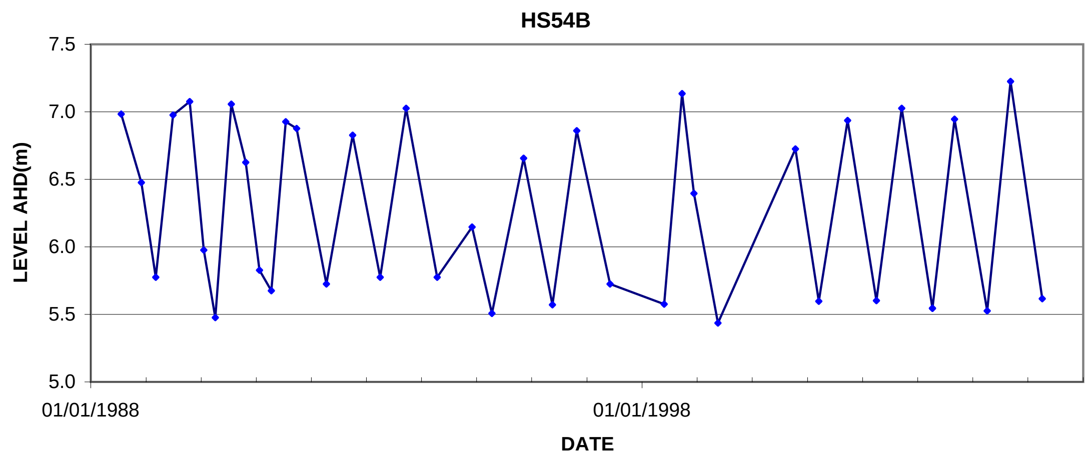
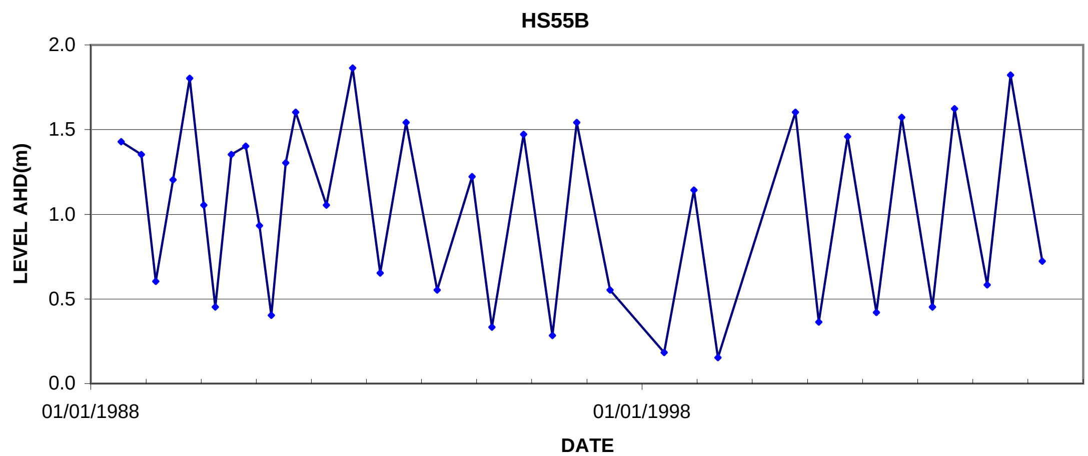
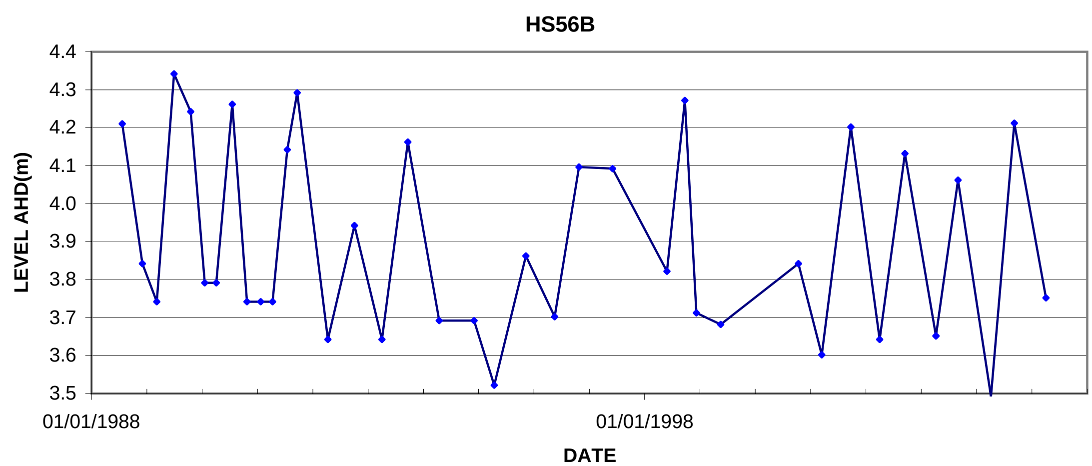
Satterly Property Group
Austin Cove Phase Two UWMS
Figure 6: Water Monitoring Locations

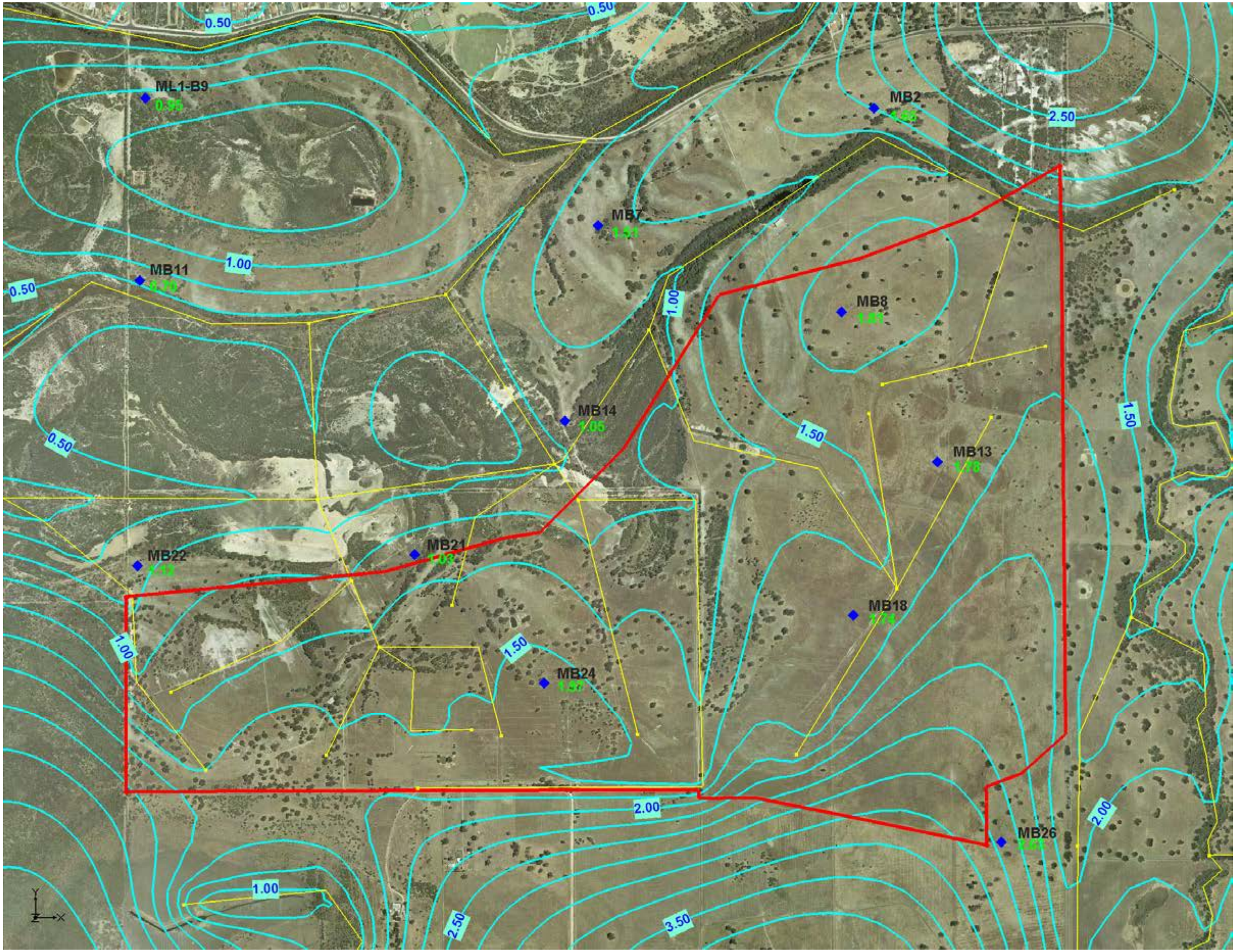






Data Source: Department of Environment

JDA Consultant Hydrologists	Job No. J3770	Satterley Property Group Austin Cove Phase Two UWMS **Figure 7: DoW Bore Hydrographs**



Observed vs. Modelled GWLs (mAHD)

Bore ID	Sep-07	Model	Error
MB2	1.65	1.77	-0.12
MB7	1.51	1.18	0.33
MB8	1.81	1.84	-0.03
MB11	0.70	0.56	0.13
MB13	1.78	1.62	0.16
MB14	1.05	0.81	0.24
MB18	1.74	1.62	0.11
MB21	1.03	1.17	-0.14
MB22	1.12	0.67	0.44
MB24	1.97	1.69	0.28
MB26	2.63	2.68	-0.05
ML1-B9	0.95	1.06	-0.11

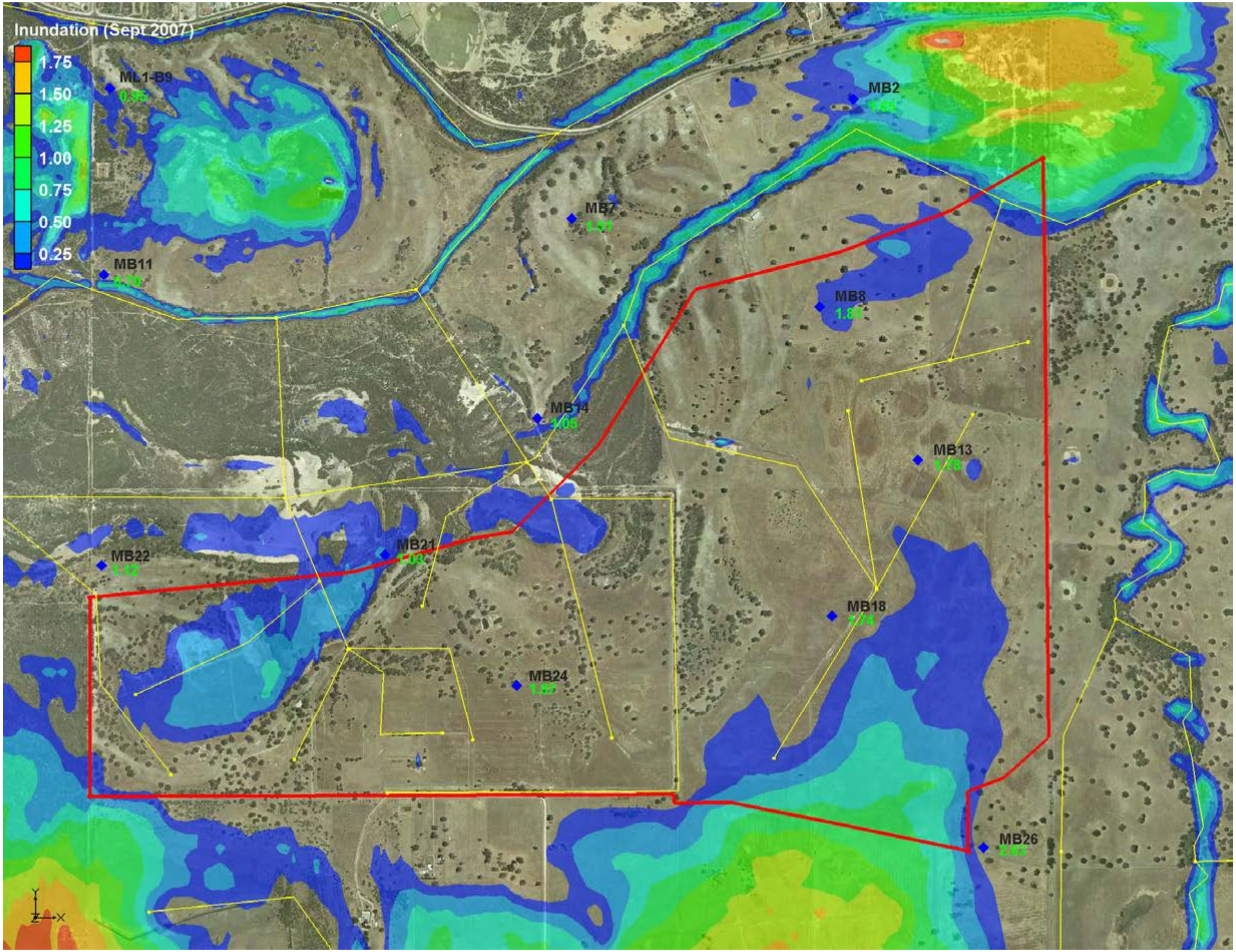
1.65 Observed GWLs (mAHD) (Sept 2007)

Functioning Drains

Site Boundary

Figure 8
Adopted Pre Development Average Annual Maximum Groundwater Level (Modelled Groundwater Levels September 2007 (AAMaxGL))

Job No. Date



1.65 **Observed GWLs (mAHD) (Sept 2007)**

Functioning Drains

Site Boundary

Note: The modelling may over predict areas of inundation, particularly to the south of the site. It is likely that there is more drainage than what has been incorporated into the model.

Figure 9

Predicted Inundated Areas
Max. Winter Watertable (m)
September 2007 (AAMaxGL)

RPS

Job No. Date

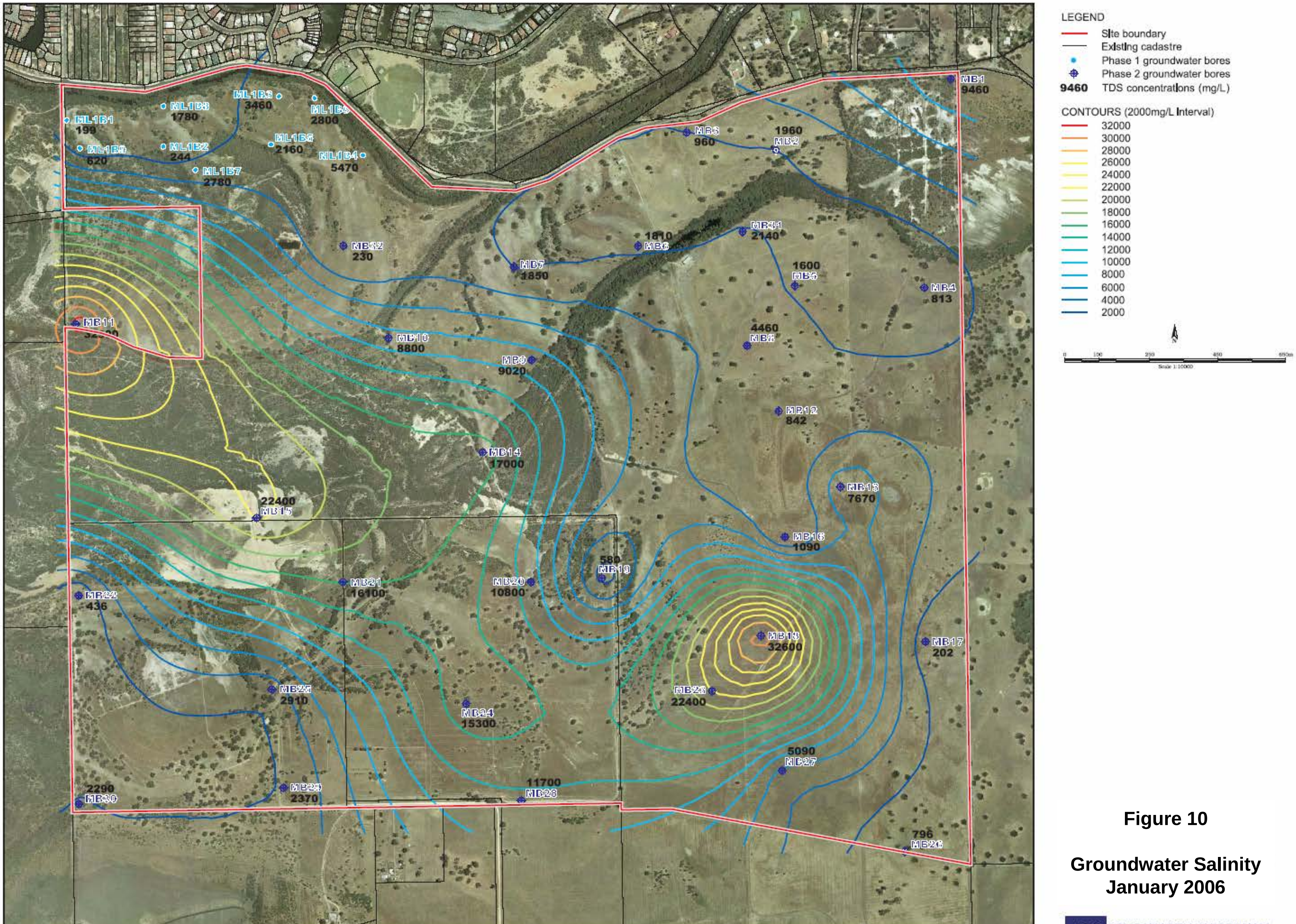


Figure 10

Groundwater Salinity January 2006

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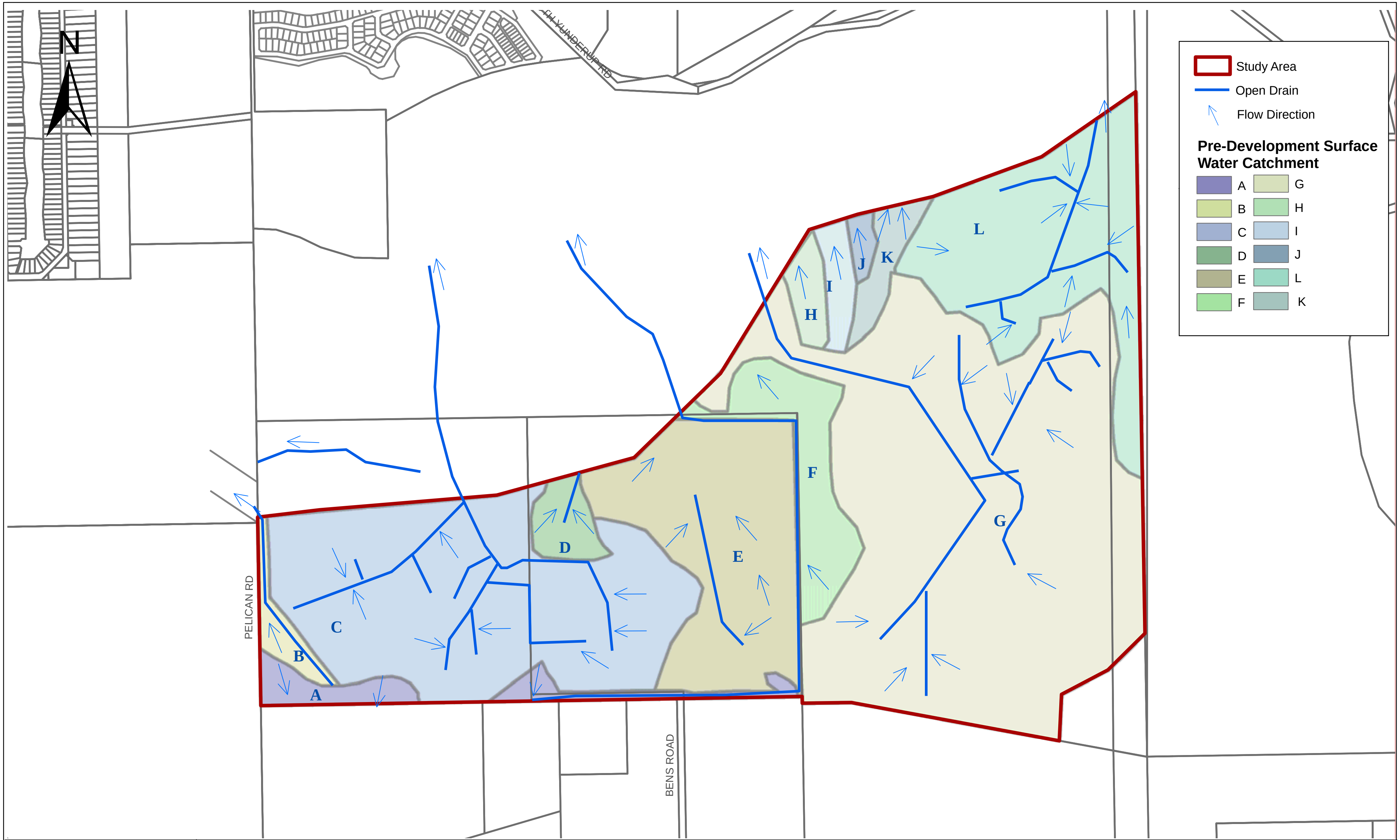
ENVIRONMENTAL MANAGEMENT CONSULTANTS



JDA Consultant Hydrologists

Job No: J3770

Scale: 1:15,000

0 200 400 600 800 Metres

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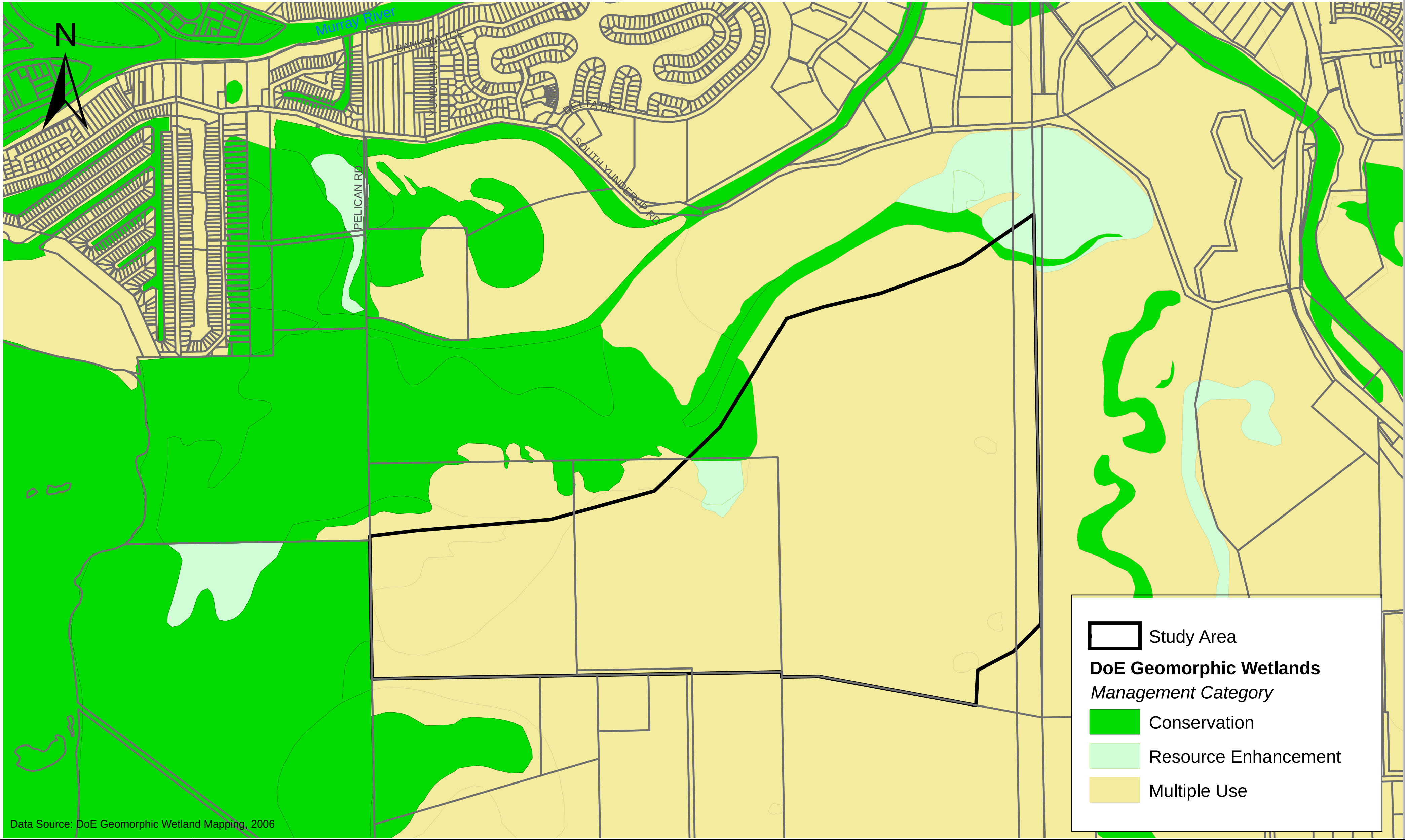
Austin Cove Stage 2- UWMS

Figure 11: Pre-development Catchments



JDA Consultant Hydrologists

Job No: J3770

Scale: 1:20,000

0 200 400 600 800 Metres

Satterley Property Group

Austin Cove Phase Two: UWMS

Figure 12: DoE Wetland Mapping

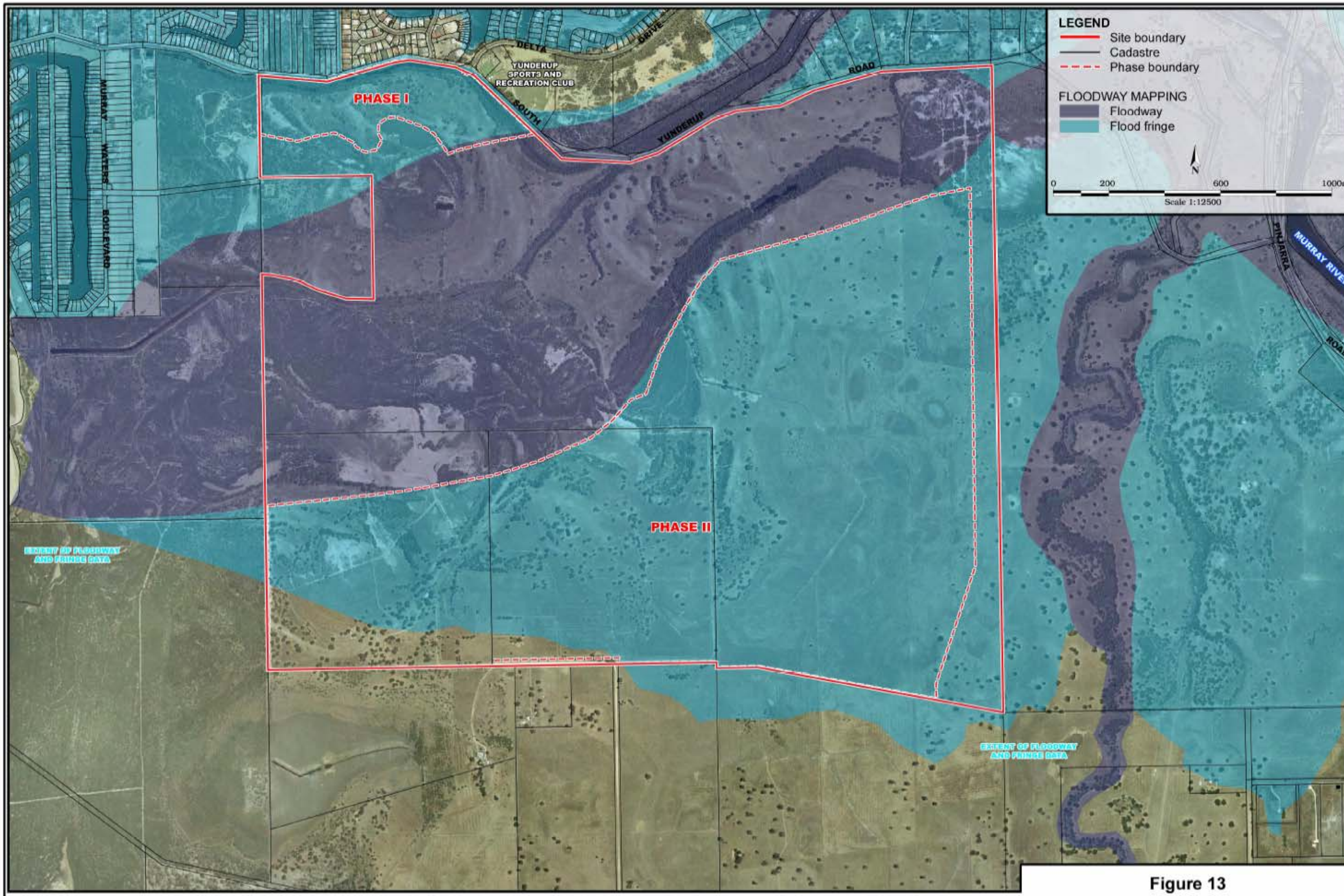


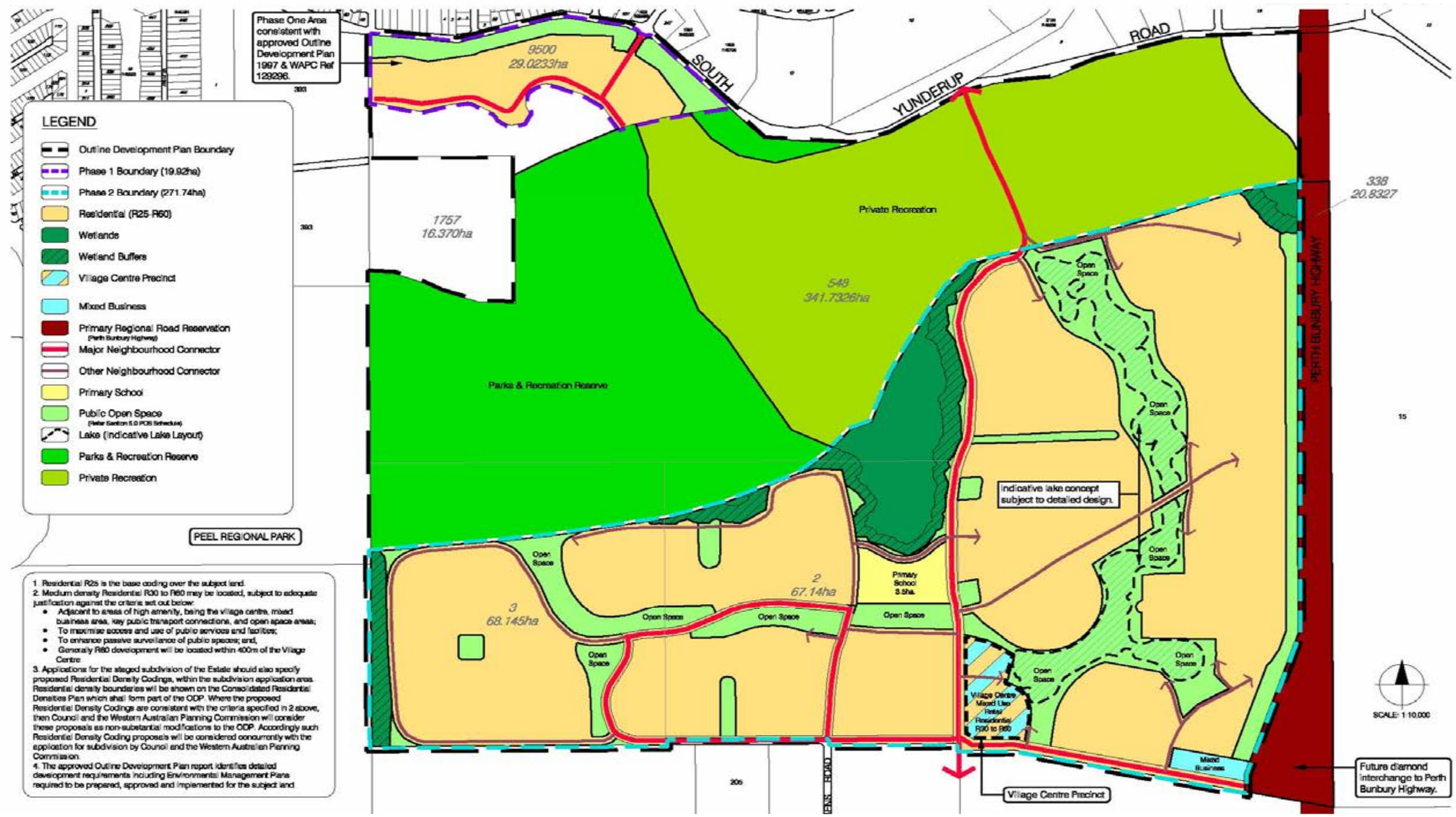
Figure 13

Murray River Floodplain Mapping

Source: Floodway Mapping - Water and Rivers Commission, 1983.

Date of Photography: 2003

RPS BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS



Data Source: Chappell Lambert Everett 2008

JDA Consultant Hydrologists

J3770

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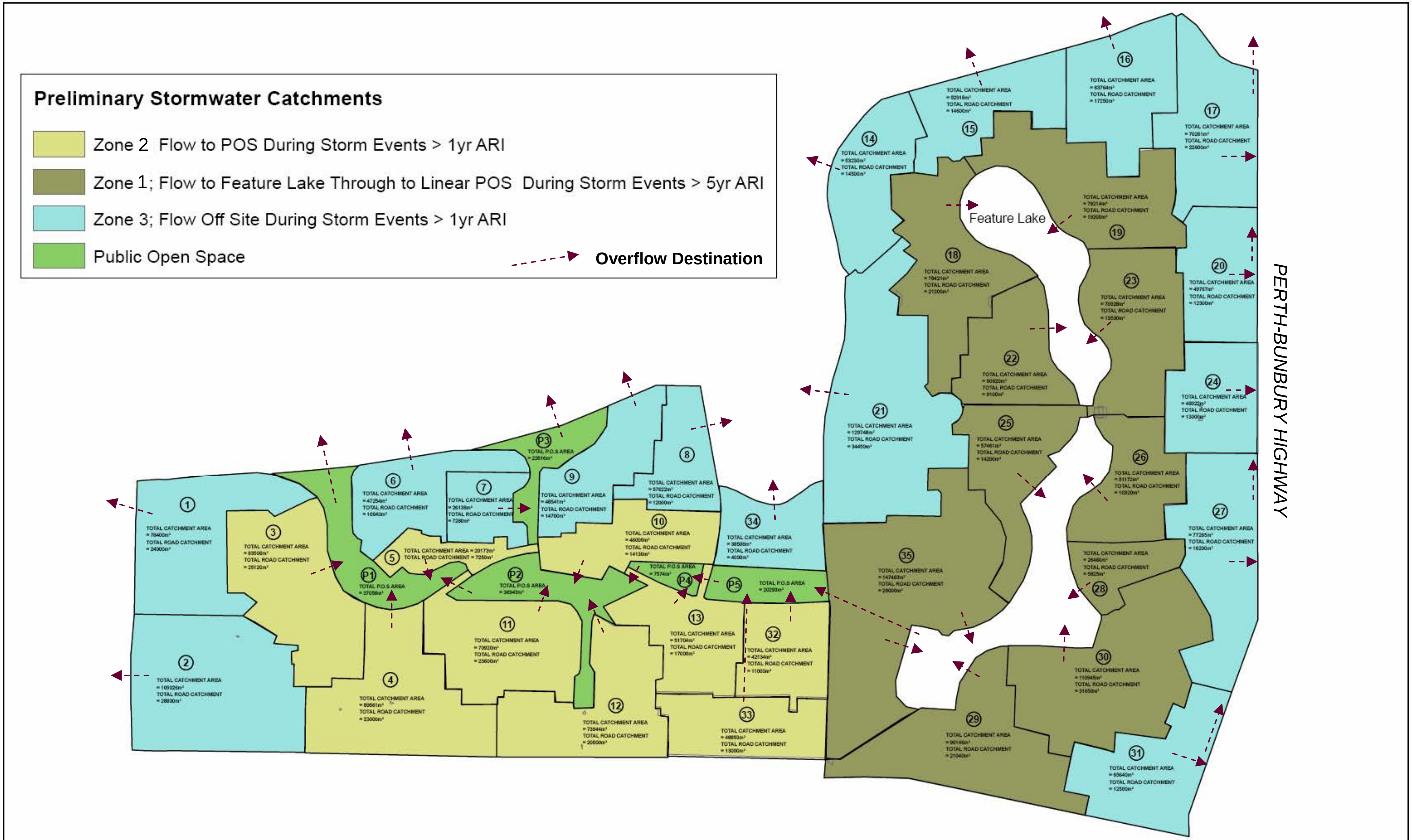
Austin Cove Phase Two UWMS

Figure 14: Austin Cove Phase Two Outline Development Plan



JDA Consultant Hydrologists

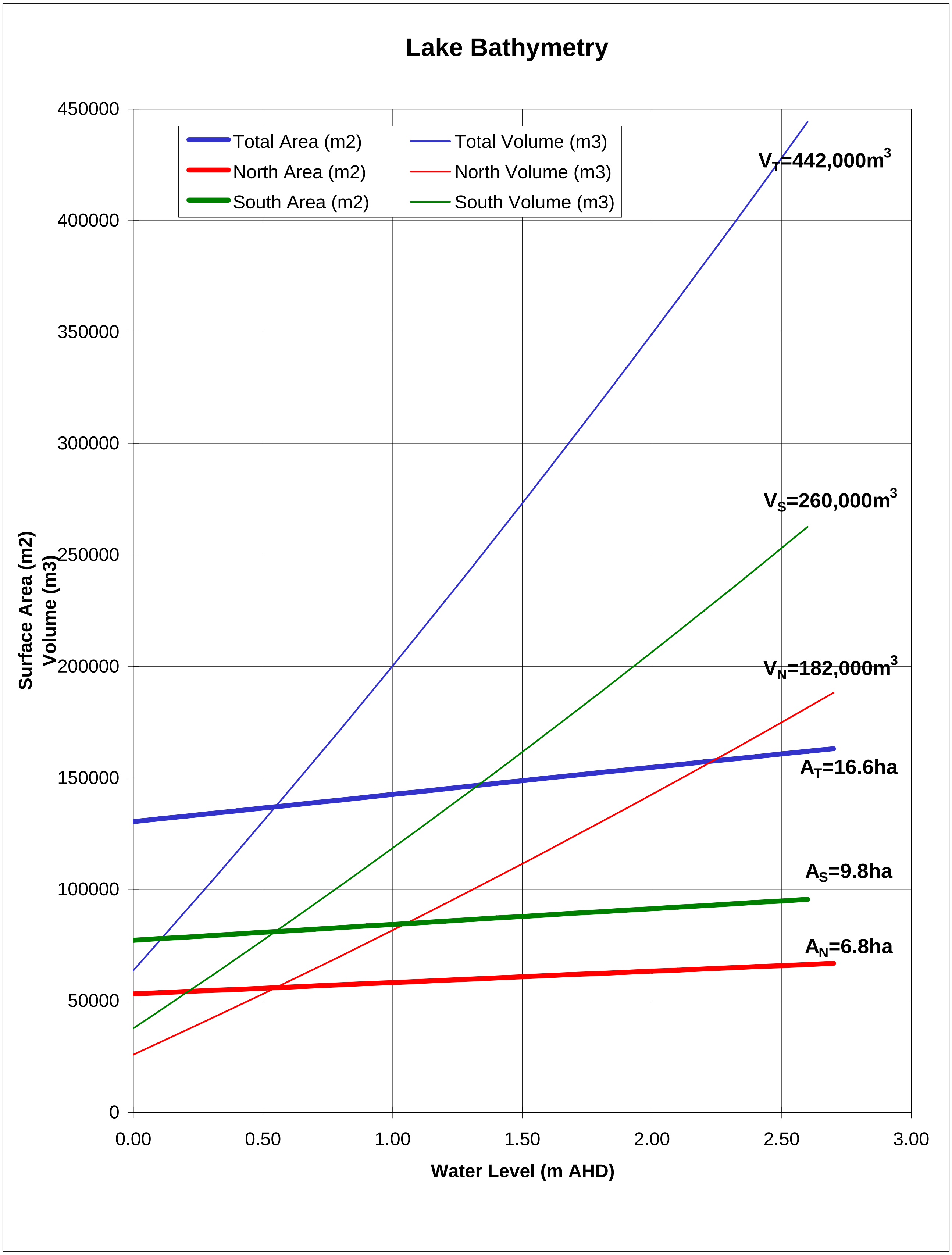
J3770

Scale: 1:8000

Satterley Property Group

Austin Cove Phase Two UWMS

Figure 15: Austin Cove Phase Two Post Development Drainage Catchments

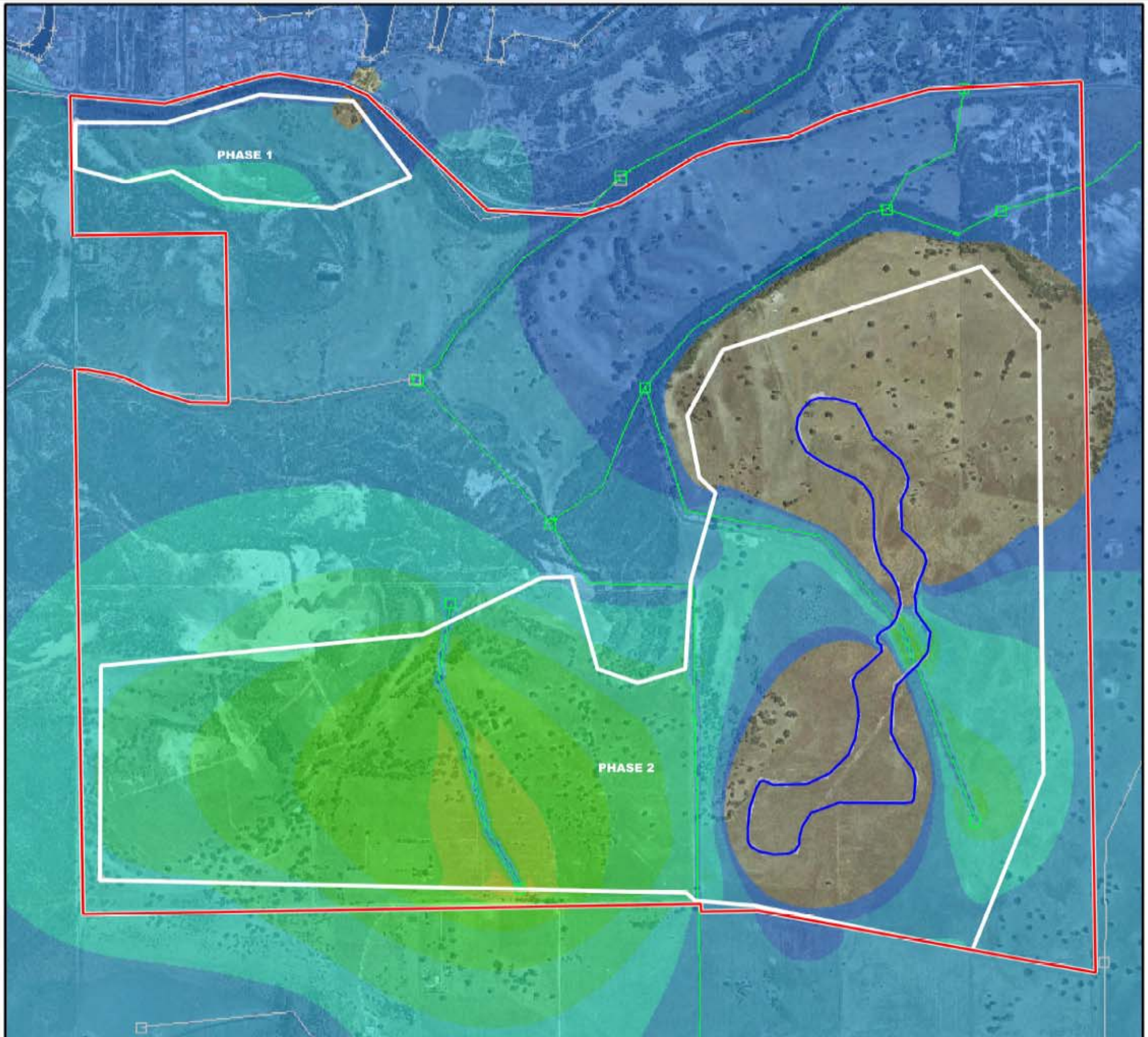


JDA Consultant Hydrologists

Job No. J3770
No Scale

Satterley Property Group Pty Ltd
Austin Cove Phase 2 - UWMS
Figure 16: Lake Bathymetry

Figures 17 to 30 are located in Section 5.4 of the UWMS



LEGEND

- Site boundary
- Existing cadastre
- Perimeter of proposed lake (approx.)
- Compaction area

PREDICTED GROUNDWATER LEVEL INCREASE (m)
POST-CONSTRUCTION

- 0.07
- 0.06
- 0.05
- 0.04
- 0.03
- 0.02
- 0.01
- 0.00

Figure 31

Predicted Groundwater Level Increase Due to Lake and Compaction Areas

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ENVIRONMENTAL MANAGEMENT CONSULTANTS

Appendix A

Department of Environment Endorsement on Detailed Site Assessment for Acid Sulphate Soils (12 Sept 2006)

Department of Environment

COPY

TRIM ☑ SRS ☐

SCANNED ☑

P1002 WRD 3003

Your ref: C05458

Our ref:

Enquiries: James Mackintosh

Direct tel: 9550 4230

RPS BOWMAN BISHAW GORHAM
PO Box 465
Subiaco WA 6904

Attention: David Sim

Dear David,

AUSTIN COVE DEVELOPMENT PHASE 2, SOUTH YUNDERUP – DETAILED SITE ASSESSMENT FOR ACID SULPHATE SOILS

Thank you for your submission of the above document dated April 2006. The Department of Environment and Conservation (DEC) has assessed the document and would like to provide the following advice:

Based on the information provided, the DEC supports the findings and recommendations of the Acid Sulphate Soil (ASS) investigation for the Austin Cove development.

The DEC considers that the investigation will provide a good basis upon which to develop an appropriate ASS management plan for the site. It is understood that the development plan for the site has been extensively modified, based on findings of the ASS investigation, to incorporate a design which largely avoids the disturbance of ASS.

We look forward to the opportunity to review the ASS management plan for the site when it is submitted in the future.

If you wish to discuss this issue further, please contact James Mackintosh on 9550 4230.

Yours sincerely,

for Adrian Parker
A / Program Manager – Catchment and Waterways
Kwinana Peel Region

12 SEPTEMBER 2006

S:\NRM & Waterways\Files 2006\Files 2006\letters\Austin Cove Phase 2 DSA for ASS - Letter to RPSBBG.doc

Kwinana Peel Region
Suite 8 21 Sholl Street
Mandurah Western Australia 6210
P.O. Box 332 Mandurah Western Australia 6210
Telephone (08) 9550 4222 Facsimile (08) 9581 4560
www.environment.wa.gov.au

Appendix B

WA Stormwater Management Objectives, Principles and Delivery Approach (DoE, 2004) and Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

Western Australian Stormwater Management Objectives

Water Quality
To maintain or improve the surface and groundwater quality within the development areas relative to pre development conditions.

Water Quantity
To maintain the total water cycle balance within development areas relative to the pre development conditions.

Water Conservation
To maximise the reuse of stormwater.

Ecosystem Health
To retain natural drainage systems and protect ecosystem health.

Economic Viability
To implement stormwater management systems that are economically viable in the long term.

Public Health
To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property
To protect the built environment from flooding and waterlogging.

Social Values
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Stormwater Delivery Approach for WA

Protect water quality
Stormwater remains clean and retains its high value

Implement best management practice on-site.
Implement non-structural controls, including education and awareness programs.
Install structural controls at source or near source.
Use in-system management measures.
Undertake regular and timely maintenance of infrastructure and streetscapes.

Protect infrastructure from flooding and inundation
Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed

Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.
Store and detain excess runoff from large rainfall events in parks and multiple use corridors.
Safely convey excessive groundwater to the nearest watercourse.

Minimise runoff
Slow the migration of rainwater from the catchment and reduce peak flows

Retain and infiltrate rainfall within property boundaries.
Use rainfall on-site or as high in the catchment as possible.
Maximise the amount of permeable surfaces in the catchment.
Use non-kerbed roads and carparks.
Plant trees with large canopies over sealed surfaces such as roads and carparks.

Maximise local infiltration
Fewer water quality and flooding problems

Minimise impervious areas.
Use vegetated swales.
Use soakwells and minimise use of piped drainage systems.
Create vegetated buffer and filter strips.
Recharge the groundwater table for local bore water use.

Make the most of nature's drainage
Cost effective, safe and attractive alternatives to pipes and drains

Retain natural channels and incorporate into public open space.
Retain and restore riparian vegetation to improve water quality through bio-filtration.
Create riffles and pools to improve water quality and provide refuge for local flora and fauna.
Protect valuable natural ecosystems.
Minimise the use of artificial drainage systems.

Minimise changes to the natural water balance
Avoid summer algal blooms and midge problems and protect our groundwater resources

Retain seasonal wetlands and vegetation.
Maintain the natural water balance of wetlands.
No direct drainage to Conservation Category Wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.
Recharge groundwater by stormwater infiltration.

Integrate stormwater treatment into the landscape
Add value while minimising development costs

Public open space systems incorporating natural drainage systems.
Water sensitive urban design approach to road layout, lot layout and streetscape.
Maximise environmental, cultural and recreational opportunities.

Convert drains into natural streams
Lower flow velocities, benefit from natural flood water storage and improve waterway ecology

Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.
Accommodate large and infrequent storm events within the floodplain.
Create habitat diversity to support a healthy, ecologically functioning waterway.

Note: Selection of appropriate methods should be determined by site conditions.

Decision Process for Stormwater Management in WA
(Department of Environment and Swan River Trust, 2005)

Preamble

The *Decision Process for Stormwater Management in WA* provides a decision framework for the planning and design of stormwater management systems. The methodology outlined in the decision process will result in minimising potential changes in the volume of surface water flows and peak flows which, if not managed, would lead to adverse impacts on water regime, water quality, habitat diversity and biodiversity in receiving water bodies[1] resulting from land development (i.e. residential, rural-residential, commercial and industrial). The process also addresses the management of flood events for the protection of properties. The decision process sits within the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

A significant stormwater management measure is to minimise the 'effective imperviousness' of a development area. Effective imperviousness is defined as the combined effect of the proportion of constructed impervious surfaces in the catchment, and the 'connectivity' of these impervious surfaces to receiving water bodies. The purpose of minimising effective imperviousness is to reduce the transportation of pollutants to receiving water bodies and to retain the post development hydrology as close as possible to the pre-development hydrology. This is achieved by 'disconnecting' constructed impervious areas from receiving water bodies and by reducing the amount of constructed impervious areas.

To retain the pre-development hydrology of a site, the order of management priorities is: the magnitude of peak flows; the volume of catchment run-off; and the seasonality of catchment run-off.

Rainfall, for the majority of events occurring each year, should be retained[2] or detained[3] on-site (i.e. as high in the catchment and as close to the source as possible, subject to adequate site conditions). Runoff from constructed impervious areas (e.g. roofs and paved areas) should be retained or detained through the use of soakwells, pervious paving, vegetated swales or gardens. For detention systems, the peak 1 year Average Recurrence Interval (ARI[4]) discharge from constructed impervious areas should be attenuated to the pre-development discharge rate. Events larger than 1 year ARI can overflow 'off-site'.

For larger rainfall events (i.e. greater than 1 year ARI events), runoff from constructed impervious areas should be retained or detained to the required design storm event in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands should be by overland flow paths across vegetated surfaces. Further detention may be required to ensure that the pre-development hydrologic regime of the receiving water bodies is largely unaltered, particularly in relation to peak flow rates and, where practical, discharge volume.

---

[1] Water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

[2] Retention is defined as the process of preventing rainfall runoff from being discharged into receiving water bodies by holding it in a storage area. The water may then infiltrate into groundwater, evaporate or be removed by evapotranspiration of vegetation. Retention systems are designed to prevent off-site discharges of surface water runoff, up to the design ARI event.

[3] Detention is defined as the process of reducing the rate of off-site stormwater discharge by temporarily holding rainfall runoff (up to the design ARI event) and then releasing it slowly, to reduce the impact on downstream water bodies and to attenuate urban runoff peaks for flood protection of downstream areas.

[4] ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For further information, refer to *Australian Rainfall & Runoff* (IEA, 2001) and the Bureau of Meteorology website via <www.bom.gov.au/hydro/has/ari_aep.shtml>.

Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of contaminants such as nutrients and metals with increasing storm sizes. Figure 1 shows that most hydraulic structures can be expected to treat over 99% of the expected annual runoff volume when designed for a 1 year ARI peak discharge. Unlike flood mitigation measures, stormwater quality treatment devices do not need to be designed for rainfall events of high ARI to achieve high hydrologic effectiveness (i.e. the percentage of mean annual runoff volume subjected to treatment) and therefore a high level of beneficial environmental outcomes.

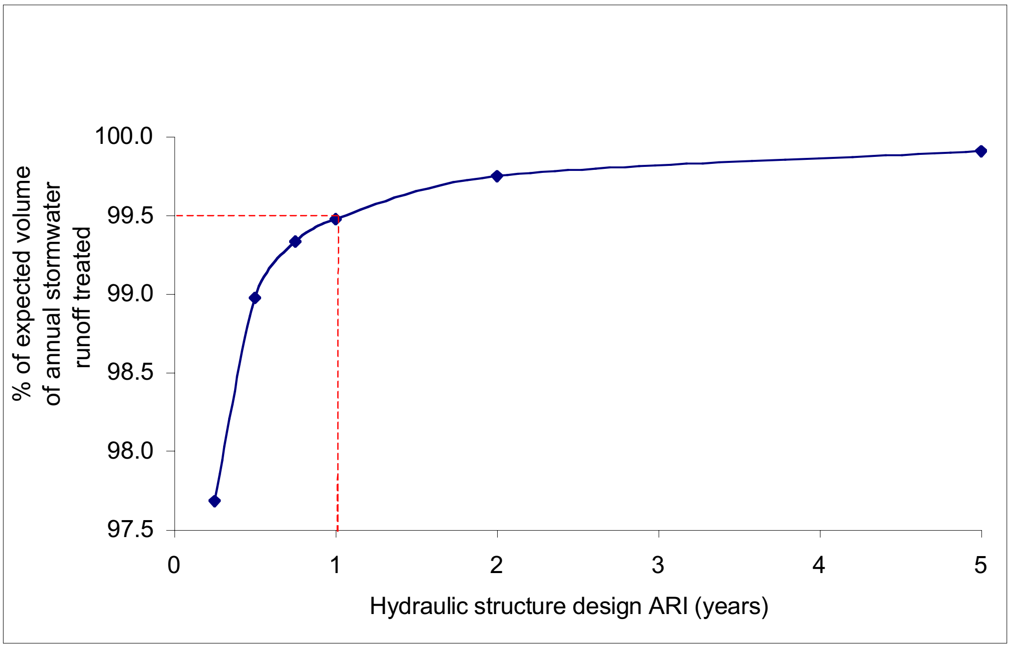

Figure 1. Treatment efficiency of stormwater hydraulic structures for Perth, Western Australia (adapted from Wong, 1999)

Stormwater management systems should be based on adequate field investigations and the conditions of the site. Prior to design, developers should consult with the Department of Environment, local government authority and other relevant stakeholders. For further information, refer to the *Decision Process for Stormwater Management in WA* flow chart.

References and further reading

Bureau of Meteorology (undated), *ARI and AEP*. Retrieved 27 January 2005 from <www.bom.gov.au/hydro/has/ari_aep.shtml>.

Center for Watershed Protection (undated), Chapter 2: 'The Importance of Imperviousness', *Site Planning for Urban Stream Protection*, Center for Watershed Protection, United States of America. Available via <www.cwp.org/SPSP/TOC.htm> or <www.cwp.org/SPSP/CHAPTER_TWO.PDF>.

Center for Watershed Protection (undated), *The Impacts of Urbanisation*, Center for Watershed Protection, United States of America. Retrieved 18 January 2005 from <www.stormwatercenter.net/Slideshows/impacts%20for%20smrc/sld001.htm>.

Cottingham, P. 2004, 'World Experience Focuses on Streams Suffering Urban Syndrome', *WaterShed*, October 2004, pp. 4-5. Available via <enterprise.canberra.edu.au>.

Cottingham, P., Walsh, C., Rooney, G. and Fletcher, T. 2004, *Urbanization Impacts on Stream Ecology – From Syndrome to Cure?* Available via <freshwater.canberra.edu.au> (see Publications / Technical Reports).

Department of Environment 2004, *Stormwater Management Manual for Western Australia*, Department of Environment, Western Australia.

Ladson, T., Walsh, C., Fletcher, T. and Cornish, S. 2003, 'Beyond the 10% Rule: Improving streams by retro-fitting in suburbs to decrease the connections between impervious surfaces and waterways', *Catchword – Newsletter of the Cooperative Research Centre for Catchment Hydrology*, No. 123, December 2003, pp 9-10. Available via <www.catchment.crc.org.au/products/catchword>.

Ladson, T., Walsh, C. and Fletcher, T. 2004, 'Is reducing runoff frequency the key to restoring urban streams?', *Catchword – Newsletter of the Cooperative Research Centre for Catchment Hydrology*, No. 129, July 2004, pp 9-10. Available via <catchment.crc.org.au/products/catchword>.

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United States Environmental Protection Agency 2004, *Protecting Water Resources with Smart Growth*, USEPA. Available via <www.epa.gov/smartgrowth>.

Walsh, C. J. 2004, *Protection of In-Stream Biota From Urban Impacts: Minimise catchment imperviousness or improve drainage design*?, Cooperative Research Centre for Freshwater Ecology, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. Available via <www.publish.csiro.au/paper/MF03206.htm> (select 'full text' or 'pdf').

Wong, T. H. F., Wootton, R. M., Argue, J. and Pezzaniti, D. 1999, 'Bringing Order to the Pollution Control Industry – Issues in Assessing the Performance of Gross Pollutant Traps', *Proceedings of the International Congress on Local Government Engineering and Public Works*, Sydney, 22-26 August 1999.

Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

1. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.
2. Prior to design, developers shall consult with the Department of Environment (DoE), local government authorities and other relevant stakeholders. Maintenance requirements should be considered at this stage.
3. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.
4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to) conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitat and vegetation identified in *Bush Forever* (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or high acid sulfate soil risk area?
2. Does the soil or groundwater contain *highly elevated* nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxyhydroxide content) and local wetting and drying cycles.

Yes (to either question)

Avoid mobilisation or disturbance of the in-situ contaminants

If yes to question 1 - seek further advice from the DoE.

If yes to question 2 - consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

No (most situations)

1. Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment.
2. Hydraulic requirements shall be determined by ecosystem requirements and the hydrologic form of the local and downstream environment. Physical survey measurements and a biological survey should be undertaken.
3. Hydrologic and hydraulic analyses, modelling and design shall incorporate the recommendations and methodology of *Australian Rainfall and Runoff, A Guide to Flood Estimation* (IEA, 2001).
4. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

Less than and up to 1 year ARI events

Generally, rainfall from 1 year average recurrence interval (ARI) events should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible), unless it can be clearly demonstrated that achievement of this objective is impractical due to site conditions.

Generally, for detention systems, preserve the pre-development 1 year ARI peak discharge rate. Use best management practices (structural and non-structural) to treat water quality.

Greater than 1 year and up to 100 year ARI events

Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

Design for greater than 1 year and less than 10 year ARI events

Minor system conveyance (i.e. swales and pipes).

Design for 10 year to 100 year ARI events

Major system conveyance (i.e. via overland flow).

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of nutrients towards receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.
2. The components of the water quality treatment train must be designed so that their combined effect meets the water quality management objectives as specified in the relevant regional water quality management targets (e.g. local government stormwater management plans, the Regional Natural Resource Management Strategy, *Swan-Canning Cleanup Program Action Plan* (SRT, 1999) and the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (EPA, 1992)). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of DoE.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach should be consistent with the *River Restoration Manual* (WRC, 1999-2003), *Draft Waterways WA - A Policy for Statewide Management of Waterways in Western Australia* (WRC, 2000), *Foreshore Policy 1 - Identifying the Foreshore Area* (WRC, 2002) and, in the Swan and Canning Catchments, the *Environmental Protection (Swan and Canning Rivers) Policy 1998* (EPA, 1998). For wetlands, the approach should be consistent with the *Environmental Protection of Wetlands Position Statement No. 4* (EPA, 2004) and the *Wetlands Conservation Policy for WA* (Government of WA, 1997). On the Swan Coastal Plain, the approach to managing wetlands should also be consistent with the *Environmental Protection (Swan Coastal Plain Lakes) Policy, 1992* (EPA, 1992) and the *Position Statement: Wetlands* (WRC, 2001).
2. There shall be no new constructed stormwater infrastructure within Conservation category wetlands and their buffers, or other conservation value wetlands and their buffers, or within a waterway foreshore area (e.g. no pipes or constructed channels within these wetlands and their buffers, or within waterway foreshore areas), unless authorised by the DoE or the Environmental Protection Authority. For Resource Enhancement and Multiple Use category wetlands, stormwater management shall be consistent with the objectives outlined in the *Position Statement:Wetlands* (WRC, 2001).
3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined lakes that require groundwater to maintain water levels in summer) or the modification of a wetland type (e.g. converting a dampland into a lake). Where water conservation (e.g. summer water supply) and environmental and health concerns (e.g. hydrology, water quality, mosquitoes, midges, algal blooms, acid sulfate soils and iron monosulfide minerals) can be adequately demonstrated to be addressed through design and maintenance, consideration may be given to the creation of artificial lakes/ponds. Seasonal wet infiltration areas or approved constructed waterways (i.e. ephemeral 'Living Streams') are preferred options.

Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through a Controlled Groundwater Level (CGL) approach shall demonstrate through adequate field investigations, to the satisfaction of the Department of Environment, that local and regional environmental impacts are adequately managed.
2. The CGL may be defined as the controlled (i.e. modified) groundwater level (measured in metres Australian Height Datum) at which the DoE will permit drainage inverts to be set. The CGL must be based on local and regional environmental water requirements, determined in accordance with the *Environmental Water Provisions Policy for Western Australia* (WRC, 2000) and the *Urban Development and Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems* (DoE, in preparation).
3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater level should not expose ASS to the air, as this may cause groundwater contamination. Refer to the ASS Guideline Series, including *Identification and Investigation of Acid Sulfate Soils* (DoE, 2004). If field investigations identify ASS, seek further advice from DoE.

References and further reading

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

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Department of Environment

SWAN RIVER TRUST

Swan-Canning Cleanup Program

Appendix C

Pre-Development Water Quality Data

Surface-water Results 2006 - Wetland Location MLD1-1

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91[f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MLD1-1	24/01/2006		0.11	<0.001	<0.001	<0.0001	2.79	0.058	0.001	0.005	<0.01	7.75	8340	10	201	5240	12	<0.1	346	2410	0.05	0.14	0.58	0.04	<0.01	2.0	1.9	0.016	-
MLD1-1	2/03/2006		0.10	<0.001	<0.001	<0.0001	2.21	0.076	0.002	0.006	<0.01	8.35	9470	20	284	6170	6	<0.1	226	3270	0.07	0.07	1.26	0.11	<0.01	2.6	2.6	0.032	-
MLD1-1	23/03/2006		0.59	0.001	0.001	<0.0001	9.37	0.399	0.002	0.006	<0.01	8.02	12590	17	427	7830	22	0.2	240	4540	0.04	0.05	1.78	0.19	<0.01	3.8	3.8	<0.01	-
MLD1-1	1/05/2006		<0.1	<0.001	<0.001	<0.0001	3.70	0.653	0.001	0.008	<0.01	7.80	6540	11	351	4330	20	0.1	116	2420	0.03	0.05	3.03	0.07	<0.01	3.8	3.8	0.040	-
MLD1-1	22/05/2006		0.16	0.001	<0.001	<0.0001	5.12	0.408	0.001	0.007	<0.01	7.59	8060	10	259	4010	42	<0.1	196	1680	0.04	0.12	1.32	0.12	<0.01	4.0	3.9	0.047	-
MLD1-1	22/06/2006		0.12	0.002	<0.001	<0.0001	6.99	0.590	<0.001	0.010	<0.01	8.16	7000	187	8	3210	8	<0.1	265	1580	23.38	0.17	0.03	0.11	<0.01	3.3	3.3	0.016	-
MLD1-1	25/07/2006		0.26	<0.001	<0.001	<0.0001	3.21	0.222	<0.001	0.053	<0.01	7.22	2790	10	86	1520	8	<0.1	159	676	0.12	0.24	0.54	<0.01	<0.01	1.9	1.9	0.026	-
MLD1-1	24/08/2006		0.22	<0.001	<0.001	<0.0001	2.41	0.251	0.002	0.010	<0.01	7.23	2710	15	60	1520	4	<0.1	242	721	0.25	0.34	0.25	0.05	<0.01	1.3	1.2	0.033	-
MLD1-1	27/09/2006		0.07	<0.001	<0.001	<0.0001	2.83	0.200	0.002	<0.005	<0.01	6.56	4380	14	106	3080	1	<0.1	405	1270	0.13	0.32	0.26	<0.01	<0.01	1.0	1.0	0.045	-
MLD1-1	30/10/2006		0.11	<0.001	<0.001	<0.0001	3.56	0.280	0.001	<0.005	<0.01	7.12	5762	90	148	3370	8	<0.1	398	1830	0.61	0.22	0.37	<0.01	<0.01	2.1	2.0	0.065	0.274
MLD1-1	23/11/2006		0.05	<0.001	<0.001	<0.0001	2.68	0.301	0.001	<0.005	<0.01	7.23	7052	6	194	4120	14	<0.1	440	2000	0.03	0.22	0.44	0.09	<0.01	1.8	1.8	0.044	0.184
MLD1-1	15/12/2006		0.02	0.001	<0.001	<0.0001	0.14	0.010	<0.001	<0.005	0.001	7.80	9441	14	210	5300	35	0.1	560	2700	0.07	0.21	0.38	0.13	0.08	2.3	2.3	<0.01	0.6
Summary Statistics		Min	0.02	0.001	0.001	0.0001	0.14	0.010	0.001	0.005	0.001	6.56	2710	6	8	1520	1	0.1	116	676	0.03	0.05	0.03	0.01	0.01	1.0	1.0	0.010	0.184
		Median	0.11	0.001	0.001	0.0001	3.02	0.266	0.001	0.006	0.010	7.67	7026	14	198	4065	10	0.1	254	1915	0.07	0.19	0.49	0.08	0.01	2.2	2.2	0.033	0.274
		Mean	0.16	0.001	0.001	0.0001	3.75	0.287	0.001	0.010	0.009	7.57	7011	34	195	4142	15	0.1	299	2091	2.07	0.18	0.85	0.08	0.02	2.5	2.5	0.032	0.353
		Max	0.59	0.002	0.001	0.0001	9.37	0.653	0.002	0.053	0.010	8.35	12590	187	427	7830	42	0.2	560	4540	23.38	0.34	3.03	0.19	0.08	4.0	3.9	0.065	0.600

Surface-water Results 2006 - Wetland Location MLD1-3

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91[f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MLD1-3	24/01/2006		0.09	<0.001	<0.001	<0.0001	2.07	0.054	0.002	0.009	<0.01	7.84	9350	4	184	6030	12	<0.1	390	2640	0.02	0.15	0.47	0.05	<0.01	2.4	2.4	<0.01	-
MLD1-3	2/03/2006		0.30	<0.001	0.001	<0.0001	14.10	0.616	0.002	0.014	<0.01	7.97	16840	15	586	11900	64	<0.1	354	6940	0.03	0.05	1.66	<0.01	<0.01	4.3	4.3	0.039	-
MLD1-3	25/07/2006		0.49	<0.001	<0.001	0.0001	1.89	1.570	0.004	0.063	<0.01	6.50	4890	9	25	2830	14	<0.1	582	1110	0.36	0.52	0.04	<0.01	<0.01	1.6	1.6	0.027	-
MLD1-3	24/08/2006		0.11	<0.001	<0.001	<0.0001	2.55	0.512	0.002	0.006	<0.01	6.94	3690	13	56	2290	4	<0.1	408	997	0.23	0.41	0.14	0.04	<0.01	1.7	1.7	<0.01	-
MLD1-3	27/09/2006		0.09	0.003	<0.001	<0.0001	2.10	0.104	0.001	0.017	<0.01	6.42	4700	11	73	8540	18	<0.1	489	1430	0.15	0.34	0.15	<0.01	<0.01	1.1	1.1	<0.01	-
MLD1-3	30/10/2006		0.02	<0.001	<0.001	<0.0001	2.42	0.190	0.002	0.012	<0.01	6.83	6860	22	83	4180	16	<0.1	588	220	0.27	2.67	0.14	<0.01	<0.01	1.3	1.3	0.050	0.471
MLD1-3	23/11/2006		0.06	<0.001	<0.001	<0.0001	1.62	0.354	0.002	0.012	<0.01	7.60	9856	6	66	6330	52	<0.1	866	3200	0.09	0.27	0.08	0.21	<0.01	4.6	4.6	<0.01	0.053
Summary Statistics		Min	0.02	0.001	0.001	0.0001	1.62	0.054	0.001	0.006	0.010	6.42	3690	4	25	2290	4	0.1	354	220	0.02	0.05	0.04	0.01	0.01	1.1	1.1	0.010	0.053
		Median	0.09	0.001	0.001	0.0001	2.10	0.354	0.002	0.012	0.010	6.94	6860	11	73	6030	16	0.1	489	1430	0.15	0.34	0.14	0.01	0.01	1.7	1.7	0.010	0.262
		Mean	0.17	0.001	0.001	0.0001	3.82	0.486	0.002	0.019	0.010	7.16	8027	11	153	6014	26	0.1	525	2362	0.16	0.63	0.38	0.05	0.01	2.4	2.4	0.022	0.262
		Max	0.49	0.003	0.001	0.0001	14.10	1.570	0.004	0.063	0.010	7.97	16840	22	586	11900	64	0.1	866	6940	0.36	2.67	1.66	0.21	0.01	4.6	4.6	0.050	0.471

Surface-water Results 2006 - Floodway Location MLD2-2

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MLD2-2	22/06/2006		0.39	<0.01	<0.01	<0.001	7.15	0.853	0.010	<0.05	<0.1	6.77	53400	332	99	78200	72	<0.1	6360	29300	3.35	0.22	0.02	0.40	<0.01	5.4	5.4	0.088	-
MLD2-2	25/07/2006		1.52	0.002	<0.001	0.0002	1.61	0.423	0.010	0.041	<0.01	6.20	24330	10	5	18000	32	<0.1	1540	8710	2.00	0.18	0.00	0.01	<0.01	3.6	3.2	0.482	-
MLD2-2	24/08/2006		0.46	<0.001	<0.001	<0.0001	1.27	0.102	0.001	0.006	<0.01	6.71	2182	12	33	1330	2	<0.1	148	574	0.36	0.26	0.22	0.11	0.05	1.6	1.6	0.042	-
MLD2-2	27/09/2006		2.39	<0.001	<0.001	0.0008	1.09	0.416	0.009	0.008	0.017	5.06	11810	38	1	2230	28	<0.1	1010	4490	38.00	0.22	0.00	0.16	<0.01	1.2	1.2	<0.01	-
MLD2-2	30/10/2006		5.26	<0.01	<0.01	<0.0001	3.90	0.971	0.016	<0.05	<0.1	4.42	41090	78	1	29000	18	<0.1	2750	15600	78.00	0.18	0.00	0.21	<0.01	2.7	2.6	0.045	1.34
MLD2-2	23/11/2006		7.33	<0.01	<0.01	<0.001	8.55	1.980	0.023	0.024	<0.05	3.80	73400	93	1	57600	106	<0.1	5820	31800	93.00	0.18	0.00	0.03	<0.01	4.8	4.8	<0.01	4.21
MLD2-2	15/12/2006		6.40	0.002	0.001	<0.0001	38.00	2.700	0.002	0.013	0.001	3.30	132400	280	5	120000	550	<0.1	17000	64000	56.00	0.27	0.00	0.06	<0.01	16.0	16.0	<0.01	12.0
Summary Statistics		Min	0.39	0.001	0.001	0.0001	1.09	0.102	0.001	0.006	0.001	3.30	2182	10	1	1330	2	0.1	148	574	0.36	0.18	0.00	0.01	0.01	1.2	1.2	0.010	1.34
		Median	2.39	0.002	0.001	0.0002	3.90	0.853	0.010	0.024	0.017	5.06	41090	78	5	29000	32	0.1	2750	15600	38.00	0.22	0.00	0.11	0.01	3.6	3.2	0.042	4.21
		Mean	3.39	0.005	0.005	0.0005	8.80	1.064	0.010	0.027	0.041	5.18	48373	120	21	43766	115	0.1	4947	22068	38.67	0.21	0.03	0.14	0.02	5.0	5.0	0.098	5.85
		Max	7.33	0.010	0.010	0.0010	38.00	2.700	0.023	0.050	0.100	6.77	132400	332	99	120000	550	0.1	17000	64000	93.00	0.27	0.22	0.40	0.05	16.0	16.0	0.482	12.00

Surface-water Results 2006 - Floodway Location MLD3-1

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MLD3-1	24/01/2006		0.51	<0.001	0.001	<0.0001	3.71	0.228	0.002	0.007	<0.01	7.42	4330	10	192	2440	20	<0.1	20	1310	0.05	0.02	9.60	0.68	0.59	3.8	3.8	0.066	-
MLD3-1	2/03/2006		0.34	0.002	0.002	<0.0001	6.27	0.326	0.002	0.006	<0.01	8.46	5690	<1	240	21900	62	<0.1	22	1980	0.00	0.01	10.91	1.19	0.35	5.8	5.8	0.034	-
MLD3-1	23/03/2006		0.60	0.003	0.002	<0.0001	11.70	0.344	0.003	<0.005	<0.01	8.37	7810	7	281	5140	102	<0.1	41	2920	0.02	0.01	6.85	1.33	0.14	8.4	8.4	<0.01	-
MLD3-1	1/05/2006		0.60	0.003	<0.001	<0.0001	24.10	0.450	0.004	0.020	<0.01	8.55	8560	2	222	5950	403	0.1	191	3580	0.01	0.05	1.16	2.26	<0.01	12.0	12.0	0.025	-
MLD3-1	22/05/2006		0.31	0.003	0.001	<0.0001	6.35	0.403	0.003	0.009	<0.01	6.89	11110	8	198	5930	120	<0.1	371	2560	0.04	0.14	0.53	1.06	<0.01	9.0	9.0	0.019	-
MLD3-1	22/06/2006		0.24	0.004	0.001	<0.0001	3.89	0.328	0.003	0.008	<0.01	7.22	6940	177	3	5800	132	0.1	468	2120	59.00	0.22	0.01	0.01	<0.01	4.3	4.3	0.022	-
MLD3-1	25/07/2006		1.09	<0.001	<0.001	0.0001	3.05	0.485	0.007	0.051	<0.01	6.07	6480	10	62	3670	32	<0.1	518	1670	0.16	0.31	0.12	0.11	0.01	2.2	2.2	<0.01	-
MLD3-1	24/08/2006		1.04	<0.001	<0.001	<0.0001	0.88	0.169	0.002	0.006	<0.01	5.49	899	10	7	688	6	<0.1	63	207	1.43	0.30	0.11	0.08	<0.01	0.9	0.8	0.011	-
MLD3-1	27/09/2006		0.28	<0.001	<0.001	<0.0001	6.60	0.375	0.003	0.024	<0.01	5.49	3130	13	30	2040	8	<0.1	281	960	0.43	0.29	0.11	0.09	0.04	1.6	1.6	0.010	-
MLD3-1	30/10/2006		0.20	<0.001	<0.001	<0.0001	6.47	0.302	0.003	<0.005	<0.01	6.96	3994	56	84	2390	8	<0.1	230	1300	0.67	0.18	0.37	0.20	0.17	2.2	2.1	0.055	0.514
MLD3-1	23/11/2006		0.17	<0.001	<0.001	<0.0001	2.66	0.281	0.002	<0.005	<0.01	7.49	4619	12	155	2910	2	<0.1	205	1490	0.08	0.14	0.76	0.37	0.22	2.4	2.3	0.054	0.465
MLD3-1	15/12/2006		0.14	0.002	0.001	<0.0001	1.70	0.010	<0.001	<0.005	0.001	7.50	5786	18	220	3500	33	<0.1	250	1800	0.08	0.14	0.88	0.63	0.33	4.0	4.1	0.010	<0.2
Summary Statistics		Min	0.14	0.001	0.001	0.0001	0.88	0.010	0.001	0.005	0.001	5.49	899	1	3	688	2	0.1	20	207	0.00	0.01	0.01	0.01	0.01	0.9	0.8	0.010	0.200
		Median	0.33	0.002	0.001	0.0001	5.08	0.327	0.003	0.007	0.010	7.32	5738	10	174	3585	33	0.1	218	1735	0.08	0.14	0.64	0.50	0.09	3.9	4.0	0.021	0.465
		Mean	0.46	0.002	0.001	0.0001	6.45	0.308	0.003	0.013	0.009	7.16	5779	27	141	5197	77	0.1	222	1825	5.16	0.15	2.62	0.67	0.16	4.7	4.7	0.027	0.393
		Max	1.09	0.004	0.002	0.0001	24.10	0.485	0.007	0.051	0.010	8.55	11110	177	281	21900	403	0.1	518	3580	59.00	0.31	10.91	2.26	0.59	12.0	12.0	0.066	0.514

Surface-water Results 2006 - August Runoff Samples

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MLSW1	24/08/2006		0.50	<0.001	<0.001	0.0002	1.90	0.419	<0.001	0.016	<0.01	5.66	724	21	29	374	6	<0.1	71	154	0.72	0.46	0.41	0.22	0.11	2.0	2.0	0.069
MLSW2	24/08/2006		0.46	<0.001	<0.001	<0.0001	1.20	0.022	<0.001	0.006	<0.01	6.77	1409	7	52	890	14	<0.1	63	513	0.13	0.12	0.83	0.32	0.22	2.5	2.5	<0.01
MLSW3	24/08/2006		0.84	0.001	0.001	<0.0001	2.54	0.070	<0.001	0.006	<0.01	6.36	2122	9	83	1070	8	<0.1	69	350	0.11	0.20	1.20	0.22	0.22	2.1	2.0	0.081
MLSW4	24/08/2006		0.36	<0.001	<0.001	<0.0001	1.06	0.104	0.001	0.007	<0.01	6.71	1421	10	31	906	8	<0.1	84	397	0.32	0.21	0.37	0.17	0.10	1.6	1.6	<0.01
MLSW5	24/08/2006		2.16	<0.001	0.001	<0.0001	2.30	0.055	0.001	0.006	<0.01	6.53	694	7	23	484	18	<0.1	31	164	0.30	0.19	0.74	0.10	<0.01	2.0	2.0	0.016
MLSW6	24/08/2006		- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	6.64	834	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.10	<0.01	3.8	3.7	0.084
MLSW7	24/08/2006		- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	6.31	437	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.33	0.81	3.8	3.7	0.012
MLSW8	24/08/2006		- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	6.22	204	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.22	<0.01	3.0	3.0	<0.01
Summary Statistics		Min	0.36	0.001	0.001	0.0001	1.06	0.022	0.001	0.006	0.010	5.66	204	7	23	374	6	0.1	31	154	0.11	0.12	0.37	0.10	0.01	1.6	1.6	0.010
		Median	0.50	0.001	0.001	0.0001	1.90	0.070	0.001	0.006	0.010	6.45	779	9	31	890	8	0.1	69	350	0.30	0.20	0.74	0.22	0.10	2.3	2.3	0.014
		Mean	0.86	0.001	0.001	0.0001	1.80	0.134	0.001	0.008	0.010	6.40	981	11	44	745	11	0.1	64	316	0.32	0.24	0.71	0.21	0.18	2.6	2.6	0.037
		Max	2.16	0.001	0.001	0.0002	2.54	0.419	0.001	0.016	0.010	6.77	2122	21	83	1070	18	0.1	84	513	0.72	0.46	1.20	0.33	0.81	3.8	3.7	0.084

Groundwater Results - January 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Dissolved Metals									Total Metals		Field Parameters			
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG
MB1	18/01/2006		<0.01	<0.001	<0.001	0.0003	<0.05	0.387	0.004	0.744	<0.01	4.30	4.92	6.47	13200	225	0.20
MB2	18/01/2006		0.07	0.001	<0.001	0.0002	<0.05	0.314	0.002	0.231	<0.01	162.00	281.00	6.85	2820	181	0.70
MB3	18/01/2006		0.82	0.001	0.002	0.0001	1.22	0.008	<0.001	0.398	<0.01	71.90	79.60	6.13	206	156	0.40
MB4	18/01/2006		0.58	<0.001	<0.001	<0.0001	0.13	0.042	<0.001	0.214	<0.01	36.30	15.10	6.07	508	244	0.60
MB5	18/01/2006		2.47	0.008	0.002	<0.0001	1.72	0.054	0.002	0.774	<0.01	129.00	37.50	6.81	849	-12	0.50
MB6	17/01/2006		0.52	0.005	0.002	0.0002	9.12	0.092	0.002	1.220	<0.01	122.00	356.00	5.52	1626	4	0.80
MB7	17/01/2006		0.57	0.006	0.001	0.0002	19.20	1.100	0.011	1.030	<0.01	9.34	34.90	5.94	2710	-54	0.80
MB8	18/01/2006		12.20	0.002	0.006	0.0002	11.10	0.036	0.002	0.726	<0.01	316.00	179.00	6.94	276	-28	0.00
MB9	17/01/2006		0.01	0.002	<0.001	0.0001	2.12	0.207	0.001	0.392	<0.01	11.70	13.60	6.66	13620	-44	1.50
MB10	17/01/2006		<0.01	0.002	<0.001	0.0002	6.95	0.405	0.003	0.416	<0.01	22.80	40.80	6.78	13930	-90	0.20
MB11	17/01/2006		<0.1	<0.01	<0.01	<0.001	0.91	2.730	<0.01	0.628	<0.1	11.60	14.70	6.12	44200	30	0.20
MB12	18/01/2006		0.91	0.004	<0.001	0.0001	0.48	0.065	<0.001	0.102	<0.01	17.20	9.31	7.39	1177	-66	0.80
MB13	19/01/2006		<0.01	<0.001	<0.001	0.0001	3.32	1.250	0.006	0.633	<0.01	37.00	19.90	6.90	10980	-34	0.40
MB14	17/01/2006		<0.01	0.001	<0.001	0.0002	0.81	0.332	0.004	0.694	<0.01	71.20	51.90	6.27	23900	19	0.20
MB15	17/01/2006		<0.01	<0.001	<0.001	0.0002	<0.05	0.611	<0.01	0.496	<0.01	10.30	5.61	6.37	31200	144	0.20
MB16	19/01/2006		0.65	0.002	<0.001	<0.0001	0.29	0.274	0.001	0.267	<0.01	26.00	18.00	7.28	1419	60	0.20
MB17	19/01/2006		0.55	0.005	<0.001	<0.0001	0.89	0.325	0.003	0.660	<0.01	6.96	6.46	6.46	575	68	0.30
MB18	19/01/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.242	<0.01	0.364	<0.1	37.30	22.30	7.02	35900	173	0.40
MB19	19/01/2006		1.06	<0.001	0.001	0.0001	0.77	0.018	<0.001	0.433	<0.01	24.60	23.90	5.40	485	318	1.10
MB20	19/01/2006		<0.01	<0.001	<0.001	0.0003	1.19	0.154	0.004	1.140	<0.01	6.46	7.44	6.22	13980	57	0.10
MB21	20/01/2006		<0.01	0.001	<0.001	0.0002	1.48	0.444	0.004	0.700	<0.01	66.30	62.40	5.86	23530	87	0.40
MB22	20/01/2006		0.07	<0.001	<0.001	<0.0001	<0.05	0.066	0.005	0.411	<0.01	16.40	14.20	3.71	347	445	2.10
MB23	19/01/2006		<0.01	<0.001	<0.001	0.0002	<0.05	0.031	0.003	0.615	<0.01	11.90	7.90	6.67	26100	197	0.40
MB24	20/01/2006		<0.01	<0.001	<0.001	0.0005	<0.05	0.503	0.015	0.498	<0.01	53.20	35.70	5.74	20460	269	1.20
MB25	20/01/2006		0.02	<0.001	<0.001	0.0002	<0.05	0.050	<0.001	0.271	<0.01	31.30	31.00	6.71	5260	221	0.20
MB26	19/01/2006		0.35	<0.001	<0.001	0.0001	0.07	0.082	0.001	0.323	<0.01	12.00	7.28	6.40	1139	234	1.40
MB27	19/01/2006		<0.01	<0.001	<0.001	0.0002	<0.05	0.129	0.001	0.108	<0.01	9.76	4.46	7.56	7510	145	0.70
MB28	20/01/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.027	0.001	0.220	<0.01	6.09	2.93	6.88	15890	167	0.20
MB29	20/01/2006		0.01	<0.001	<0.001	0.0001	<0.05	0.020	<0.001	0.159	<0.01	2.86	2.11	6.98	4940	207	0.10
MB30	20/01/2006		0.29	0.003	<0.001	0.0002	4.82	0.826	0.010	1.780	<0.01	88.60	94.90	5.40	2422	105	0.10
MB31	18/01/2006		2.96	0.004	0.003	0.0002	3.75	0.019	0.002	0.913	<0.01	240.00	215.00	5.46	117	182	0.90
MB32	17/01/2006		0.45	0.002	0.003	<0.0001	4.08	0.091	0.002	0.352	<0.01	8.23	8.73	5.55	317	45	0.30
ML1B1	16/01/2006		1.17	0.003	0.002	<0.0001	0.49	0.022	<0.001	0.422	<0.01	3.53	1.44	6.01	282	68	4.70
ML1B2	16/01/2006		5.98	0.004	0.005	<0.0001	5.50	0.507	0.003	1.010	<0.01	48.60	55.40	6.47	565	-28	4.30
ML1B3	16/01/2006		2.55	0.002	0.002	<0.0001	1.99	0.060	0.002	0.095	<0.01	76.60	91.10	7.08	6040	-98	1.40
ML1B4	16/01/2006		0.45	0.002	<0.001	0.0002	0.42	0.327	0.004	0.645	<0.01	55.60	60.40	7.10	7690	18	3.10
ML1B5	16/01/2006		0.77	0.005	0.002	<0.0001	6.59	0.707	0.003	0.658	<0.01	10.90	15.00	6.39	3980	-16	2.70
ML1B6	16/01/2006		0.61	<0.001	<0.001	<0.0001	5.05	0.270	0.007	1.060	<0.01	6.86	10.30	5.01	4600	168	2.70
ML1B7	16/01/2006		0.39	0.006	0.002	<0.0001	22.00	0.252	0.002	0.402	<0.01	4.40	28.80	6.34	4410	-31	0.20
ML1B8	16/01/2006		1.23	0.001	<0.001	<0.0001	1.94	0.057	<0.001	0.270	<0.01	19.80	15.30	7.57	3090	-143	0.20
ML1B9	16/01/2006		0.16	<0.001	<0.001	<0.0001	0.22	0.051	0.001	0.176	<0.01	26.30	14.70	6.42	1003	62	1.20
MLWZ1	16/01/2006	(ML1B4)	0.32	0.002	0.001	0.0001	0.37	0.384	0.004	0.514	<0.01	52.90	58.30	---	---	---	---
MLWZ2	19/01/2006	(MB16)	0.57	0.002	<0.001	<0.0001	0.20	0.268	0.001	0.264	<0.01	17.70	10.20	---	---	---	---
MLWZ3	20/01/2006	(MB28)	0.03	<0.001	<0.001	<0.0001	0.05	0.027	0.001	0.185	<0.01	5.69	2.80	---	---	---	---

1	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
LOR	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
FWG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7
MEPG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]
LIWG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG
ASS	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	23	170	9460	74	<0.1	965	4780	0.14	0.20	0.18	0.10	0.01	0.1	<0.1	0.130
MB2	21	116	1960	4440	0.2	265	810	0.18	0.33	0.44	0.97	<0.01	1.7	1.3	0.365
MB3	22	47	960	1360	0.6	10	14	0.47	0.70	4.70	0.38	<0.01	11.2	2.3	8.920
MB4	11	38	813	280	0.2	74	86	0.29	0.86	0.51	0.28	<0.01	0.2	<0.1	0.155
MB5	23	156	1600	1480	0.4	54	150	0.15	0.36	2.89	0.58	0.01	3.1	2.8	0.285
MB6	90	13	1810	2420	<0.1	117	444	6.92	0.26	0.11	0.18	<0.01	3.0	2.5	0.450
MB7	66	45	1850	126	0.1	728	414	1.47	1.76	0.06	0.01	<0.01	0.7	0.5	0.150
MB8	23	47	4460	1740	0.4	23	38	0.49	0.60	2.04	0.93	<0.01	4.2	4.0	0.265
MB9	20	166	9020	192	<0.1	818	4580	0.12	0.18	0.20	<0.01	<0.01	0.5	0.5	0.025
MB10	20	129	8800	444	0.4	1570	4310	0.16	0.36	0.08	0.05	<0.01	0.5	0.5	0.070
MB11	44	176	32900	550	<0.1	3630	15300	0.25	0.24	0.05	0.05	<0.01	1.1	1.0	0.035
MB12	11	250	842	144	0.1	54	191	0.04	0.28	4.63	0.10	<0.01	0.6	0.2	0.420
MB13	8	201	7670	510	<0.1	766	3840	0.04	0.20	0.26	0.11	<0.01	1.0	0.8	0.175
MB14	47	157	17000	1440	<0.1	1630	7990	0.30	0.20	0.10	0.12	<0.01	1.0	1.0	0.045
MB15	20	174	22400	280	<0.1	2100	11400	0.11	0.18	0.08	<0.01	0.01	0.6	0.6	0.020
MB16	8	262	1090	74	<0.1	64	327	0.03	0.20	4.09	0.09	<0.01	0.8	0.7	0.020
MB17	12	107	202	38	<0.1	13	97	0.11	0.13	8.23	0.07	<0.01	1.4	1.3	0.120
MB18	61	261	32600	570	<0.1	2640	18600	0.23	0.14	0.10	0.09	0.02	0.9	0.8	0.125
MB19	16	13	580	74	<0.1	30	113	1.23	0.27	0.43	0.05	<0.01	1.8	0.2	1.630
MB20	24	94	10800	68	<0.1	732	5990	0.26	0.12	0.13	0.04	<0.01	0.2	0.2	0.035
MB21	43	73	16100	1340	<0.1	868	8370	0.59	0.10	0.08	0.84	<0.01	0.6	0.5	0.025
MB22	24	<1	436	154	<0.1	92	62	24.00	1.48	0.01	0.04	<0.01	4.5	0.9	3.640
MB23	34	143	22400	216	<0.1	1590	11500	0.24	0.14	0.09	0.04	<0.01	1.0	<0.1	0.955
MB24	17	12	15300	808	<0.1	1160	7170	1.42	0.16	0.01	0.08	<0.01	5.6	0.8	4.800
MB25	13	242	2910	486	<0.1	198	1430	0.05	0.14	1.22	0.10	<0.01	0.5	0.5	<0.01
MB26	10	55	796	298	<0.1	50	178	0.18	0.28	1.10	0.14	<0.01	48.2	2.2	46.000
MB27	10	254	5090	124	<0.1	417	2450	0.04	0.17	0.61	0.03	0.01	0.4	0.3	0.050
MB28	<1	224	11700	36	<0.1	574	5660	0.00	0.10	0.39	0.02	<0.01	1.9	0.4	1.480
MB29	2	230	2370	38	<0.1	210	1300	0.01	0.16	1.10	0.02	<0.01	0.4	0.4	<0.01
MB30	18	32	2290	667	<0.1	97	767	0.56	0.13	0.33	0.27	<0.01	2.4	2.4	<0.01
MB31	22	4	2140	1630	0.1	19	17	5.50	1.12	0.21	1.18	<0.01	4.1	3.5	0.530
MB32	12	50	230	168	<0.1	13	63	0.24	0.21	3.85	0.24	<0.01	1.2	1.2	0.055
ML1B1	19	37	192	17	<0.1	9	50	0.51	0.18	4.11	0.05	0.05	0.7	0.5	0.245
ML1B2	41	27	244	306	0.1	8	104	1.52	0.08	3.38	0.08	<0.01	1.0	0.9	0.080
ML1B3	42	139	3480	1150	1.0	480	1400	0.30	0.34	0.29	0.20	<0.01	2.5	2.4	0.165
ML1B4	38	353	5470	1370	<0.1	844	2580	0.11	0.33	0.42	0.07	<0.01	1.5	1.4	0.095
ML1B5	60	53	2160	74	<0.1	356	962	1.13	0.37	0.15	<0.01	<0.01	0.7	0.7	0.025
ML1B6	66	2	2800	56	<0.1	282	1470	33.00	0.19	0.01	<0.01	<0.01	0.5	0.3	0.195
ML1B7	86	78	2780	30	<0.1	407	1370	1.10	0.30	0.19	<0.01	<0.01	0.8	0.7	0.085
ML1B8	10	246	1780	222	<0.1	312	624	0.04	0.50	0.79	<0.01	<0.01	0.6	0.6	0.025
ML1B9	14	27	620	168	<0.1	81	327	0.52	0.25	0.33	0.02	<0.01	0.9	0.5	0.410
MLWZ1	41	355	5550	1010	<0.1	904	2470	0.12	0.37	0.39	0.04	<0.01	1.1	1.0	0.110
MLWZ2	9	262	1080	72	<0.1	60	328	0.03	0.18	4.37	0.08	<0.01	0.9	0.9	0.030
MLWZ3	19	224	11400	20	<0.1	524	5330	0.08	0.10	0.43	0.02	<0.01	1.9	0.3	1.560

Groundwater Results - February 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	24/02/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.302	0.002	0.158	<0.01	16.30	24.30	6.36	13740	147	0.30	2	160	8910	500	0.1	962	5180	0.01	0.19	0.17	0.12	<0.01	0.8	0.8	0.022
MB2	24/02/2006		0.01	0.004	<0.001	<0.0001	<0.05	0.603	0.002	0.301	<0.01	266.00	574.00	6.94	4460	217	0.40	16	179	3280	4740	<0.1	748	1450	0.09	0.52	0.24	0.78	<0.01	3.7	3.6	0.045
MB3	23/02/2006		0.67	0.002	0.001	<0.0001	0.75	0.006	0.001	0.422	<0.01	24.20	32.10	5.95	175	109	0.70	23	38	430	428	0.1	16	14	0.61	1.12	2.38	0.22	<0.01	5.6	1.4	4.160
MB4																																
MB5	23/02/2006		1.97	0.011	0.002	<0.0001	1.18	0.078	0.003	0.278	<0.01	40.60	17.60	6.45	786	-4	1.10	18	144	764	296	0.1	52	136	0.13	0.38	2.77	0.27	<0.01	1.4	1.3	0.100
MB6	24/02/2006		0.09	0.001	0.001	<0.0001	0.45	0.129	0.001	0.928	<0.01	111.00	297.00	5.58	1414	76	0.40	38	13	2330	1540	<0.1	113	332	2.92	0.34	0.12	1.08	<0.01	3.0	2.8	0.140
MB7	23/02/2006		0.08	0.012	<0.001	0.0001	24.70	0.711	0.008	1.060	<0.01	4.09	36.00	5.96	2810	3	0.30	92	40	1700	130	<0.1	778	479	2.30	1.62	0.05	0.09	<0.01	0.7	0.6	0.049
MB8	24/02/2006		8.22	0.002	0.004	<0.0001	4.17	0.036	0.002	0.623	<0.01	230.00	150.00	6.22	265	-41	0.10	16	56	3540	442	1.2	23	40	0.29	0.58	2.43	1.01	<0.01	2.7	2.6	0.061
MB9																																
MB10																																
MB11	24/02/2006		<0.1	<0.01	<0.01	<0.001	1.74	2.650	<0.01	0.304	<0.1	9.50	21.00	6.34	44500	52	0.20	52	60	33600	388	0.2	7730	15700	0.87	0.49	0.01	0.08	<0.01	1.8	1.8	0.014
MB12																																
MB13	28/02/2006		<0.01	<0.001	<0.001	<0.0001	0.68	1.430	0.005	0.323	<0.01	16.10	9.40	6.86	9650	-32	0.60	37	207	6450	142	0.2	683	3430	0.18	0.20	0.30	0.02	<0.01	1.4	1.2	0.184
MB14	28/02/2006		<0.01	0.001	<0.001	<0.0001	1.68	0.287	0.004	0.313	<0.01	44.50	44.60	6.57	24300	23	0.80	52	150	17400	1170	<0.1	1580	10800	0.35	0.15	0.09	<0.01	<0.01	0.6	0.6	0.021
MB15	28/02/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.549	<0.01	0.512	<0.1	6.64	5.36	6.62	32700	60	1.00	56	167	24400	182	<0.1	2080	15300	0.34	0.14	0.08	<0.01	<0.01	0.6	0.6	0.012
MB16																																
MB17																																
MB18	2/03/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.189	<0.01	0.057	<0.1	0.28	<0.05	7.12	42900	-2	0.60	53	270	57800	3400	<0.1	2630	21900	0.20	0.12	0.10	0.42	<0.01	1.3	1.1	0.177
MB19	28/02/2006		0.41	<0.001	0.002	<0.0001	0.34	0.020	0.001	0.638	<0.01	17.80	15.00	5.20	300	214	1.20	16	2	420	48	0.2	16	89	8.00	0.18	0.13	0.09	<0.01	2.4	0.7	1.690
MB20																																
MB21	28/02/2006		<0.01	<0.001	0.001	0.0001	1.61	0.265	0.003	0.469	<0.01	48.20	72.00	6.08	23100	101	0.50	60	69	15600	1510	0.2	880	10100	0.87	0.09	0.08	0.17	<0.01	0.4	0.4	0.037
MB22	28/02/2006		0.13	0.001	0.002	<0.0001	0.08	0.140	0.005	0.937	<0.01	23.20	35.40	3.74	286	417	1.50	28	<1	398	594	0.1	98	81	28.00	1.21	0.01	0.04	<0.01	3.2	0.2	3.020
MB23																																
MB24	23/02/2006		<0.01	<0.001	<0.001	0.0004	<0.05	0.494	0.019	0.683	<0.01	24.70	23.20	5.43	20560	261	1.00	40	4	15100	464	<0.1	2160	8810	10.00	0.25	0.00	0.96	<0.01	10.0	4.4	5.570
MB25																																
MB26	23/02/2006		0.02	<0.001	<0.001	0.0002	<0.05	0.056	<0.001	0.146	<0.01	28.00	22.70	6.15	992	203	0.70	<1	59	782	278	<0.1	366	168	0.02	2.18	0.16	0.29	<0.01	42.8	2.3	40.500
MB27	28/02/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.115	<0.001	0.088	<0.01	31.60	16.10	7.56	5520	-49	0.50	18	263	3790	174	<0.1	284	2180	0.07	0.13	0.93	0.10	<0.01	0.4	0.4	0.022
MB28	28/02/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.020	<0.001	0.222	<0.01	1.62	0.76	7.25	17000	159	0.30	28	227	11800	4	<0.1	567	7680	0.12	0.07	0.40	<0.01	<0.01	1.5	0.2	1.280
MB29																																
MB30	28/02/2006		0.02	0.008	<0.001	0.0002	16.40	0.820	0.007	0.823	<0.01	23.40	48.00	6.05	3960	28	0.20	45	39	2580	206	<0.1	145	1370	1.15	0.11	0.27	0.24	<0.01	0.6	0.6	0.029
MB31	24/02/2006		1.17	0.003	0.002	<0.0001	1.83	0.009	0.001	0.831	<0.01	103.00	107.00	4.97	131	194	1.20	22	2	946	1240	0.4	21	20	11.00	1.07	0.10	0.58	<0.01	2.2	1.7	0.475
MB32	24/02/2006		0.38	0.003	0.004	<0.0001	5.76	0.067	0.001	0.388	<0.01	14.80	17.60	6.40	486	-22	4.00	<1	54	644	276	0.2	27	97	0.02	0.28	2.00	0.30	<0.01	1.9	1.9	0.020
ML1B1	22/02/2006		1.14	0.002	0.002	<0.0001	0.37	0.014	0.001	0.647	<0.01	1.23	0.94	5.52	241	256	0.70	10	17	144	4	<0.1	10	51	0.59	0.20	1.70	0.10	0.03	1.6	1.2	0.375
ML1B2	22/02/2006		1.80	0.002	0.002	<0.0001	8.40	0.466	0.003	1.430	<0.01	572.00	779.00	6.76	1891	-122	0.50	104	85	470	24300	<1	27	290	1.22	0.09	3.15	1.22	<0.01	32.8	32.8	0.010
ML1B3	22/02/2006		0.11	<0.001	<0.001	<0.0001	0.46	0.066	0.004	0.709	<0.01	1.49	8.08	6.45	2870	-400	0.70	18	83	1340	30	<0.1	296	762	0.22	0.39	0.28	<0.01	<0.01	1.1	0.5	0.605
ML1B4	23/02/2006		0.10	<0.001	0.001	0.0002	0.42	0.745	0.006	0.099	<0.01	28.30	39.00	6.99	18390	-19	0.40	50	364	12600	516	<0.1	1280	7290	0.14	0.18	0.28	0.29	<0.01	1.6	1.4	0.145
ML1B5	23/02/2006		<0.01	0.008	<0.001	<0.0001	15.20	1.150	0.005	0.367	<0.01	5.77	26.80	6.30	14260	-54	0.40	54	72	7780	376	<0.1	1220	3810	0.75	0.32	0.06	0.10	<0.01	1.2	1.1	0.035
ML1B6	23/02/2006		0.02	<0.001	<0.001	0.0001	10.50	0.202	0.004	0.770	<0.01	2.40	15.00	5.31	7980	29	0.50	100	18	4250	58	0.1	388	2340	5.56	0.17	0.05	0.06	<0.01	0.7	0.7	0.028
ML1B7	23/02/2006		0.32	0.008	0.002	<0.0001	11.10	0.110	0.001	0.007	<0.01	0.12	10.70	6.74	4930	-45	0.20	12	111	2680	66	<0.1	338	1540	0.11	0.22	0.33	0.06	<0.01	0.7	0.7	0.020
ML1B8	22/02/2006		0.47	0.002	<0.001	<0.0001	0.54	0.040	<0.001	0.053	<0.01	1.73	3.35	7.25	3180	-171	1.00	11	257	1620	66	<0.1	365	650	0.04	0.56	0.70	<0.01	<0.01	0.5	0.5	<0.01
ML1B9	22/02/2006		0.08	<0.001	<0.001	0.0004	0.42	1.540	0.011	1.330	<0.01	1.27	4.12	5.78	14210	191	0.10	44	30	9920	8	<0.1	1050	5230	1.47	0.20	0.03	<0.01	<0.01	1.1	0.9	0.196
MLZ1	23/02/2006	(ML1B7)	0.07	0.005	0.002	<0.0001	9.52	0.118	<0.001	0.347	<0.01	2.55	16.30	---	---	---	---	20	108	2680	54	<0.1	384	1500	0.19	0.26	0.28	0.05	<0.01	0.7	0.7	0.027
MLZ2	28/02/2006	(MB19)	0.42	<0.001	0.002	<0.0001	0.33	0.020	0.001	0.514	<0.01	21.30	17.90	---	---	---	---	14	6	460	56	<0.1	17	86	2.33	0.20	0.35	0.08	<0.01	2.2	0.5	1.690

Groundwater Results - March 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	21/03/2006		<0.01	<0.001	<0.005	<0.0001	<0.05	0.244	0.014	0.368	<0.01	3.29	2.45	6.36	12460	131	0.30	8	154	9160	154	<0.1	871	4630	0.05	0.19	0.18	0.10	<0.01	0.9	0.9	0.031
MB2	21/03/2006		<0.01	0.009	<0.005	0.0001	0.43	0.594	0.014	0.858	<0.01	19.30	27.40	6.09	5230	55	0.90	20	190	3330	4000	<0.1	270	1620	0.11	0.17	0.70	0.39	<0.01	0.5	0.5	0.036
MB3	21/03/2006		0.28	<0.001	0.002	<0.0001	0.29	0.006	0.008	0.710	<0.01	21.30	7.92	5.86	156	149	1.60	7	41	234	168	0.2	14	15	0.17	0.97	2.93	0.18	<0.01	3.5	0.6	2.880
MB4																																
MB5	23/03/2006		1.08	0.009	<0.001	<0.0001	0.53	0.023	0.008	0.277	<0.01	56.10	20.10	6.61	664	-55	0.20	15	148	1270	202	0.1	40	101	0.10	0.40	3.70	0.15	<0.01	1.5	1.5	<0.01
MB6	21/03/2006		0.46	0.009	0.003	<0.0001	2.64	0.110	0.013	1.110	<0.01	31.80	27.70	4.98	258	190	0.40	16	6	1210	530	0.2	48	136	2.67	0.35	0.13	1.07	<0.01	1.9	1.5	0.366
MB7	20/03/2006		0.01	0.014	0.001	<0.0001	30.90	0.347	0.018	0.441	<0.01	1.43	39.30	5.96	3320	6	0.20	47	45	2100	40	<0.1	746	537	1.04	1.39	0.06	0.07	<0.01	0.4	0.3	0.051
MB8	23/03/2006		6.12	0.002	0.002	<0.0001	4.22	0.027	0.009	1.400	<0.01	191.00	106.00	6.45	275	-90	0.20	20	68	3180	92	<0.1	19	38	0.29	0.50	3.58	0.25	<0.01	2.6	2.6	<0.01
MB9																																
MB10																																
MB11	21/03/2006		<0.1	<0.01	<0.01	<0.001	1.82	3.030	<0.01	0.184	<0.05	21.80	20.10	6.59	47900	45	0.60	26	178	31400	942	<0.1	3090	16000	0.15	0.19	0.06	0.18	<0.01	1.1	1.0	0.032
MB12																																
MB13	23/03/2006		<0.01	0.001	<0.001	<0.0001	1.32	1.710	0.019	0.480	<0.01	8.62	8.65	6.74	8620	-45	0.30	49	220	6740	96	<0.1	666	3290	0.22	0.20	0.33	0.04	<0.01	0.8	0.7	0.021
MB14	21/03/2006		<0.01	0.001	<0.001	0.0001	1.12	0.291	0.015	0.369	<0.01	23.50	11.90	6.52	26500	37	0.40	26	150	16900	882	<0.1	1390	9360	0.17	0.15	0.11	0.15	<0.01	0.4	0.4	0.030
MB15																																
MB16																																
MB17																																
MB18	22/03/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.175	0.019	0.236	<0.05	4.08	3.12	6.91	42800	119	0.20	56	275	32800	106	<0.1	2670	17100	0.20	0.16	0.10	0.05	<0.01	0.2	<0.1	0.165
MB19	22/03/2006		0.08	<0.001	<0.001	<0.0001	0.55	0.028	0.019	1.000	<0.01	6.20	9.39	5.78	3840	156	1.40	15	18	2230	50	0.1	174	1170	0.83	0.15	0.10	0.07	<0.01	1.7	0.2	1.540
MB20																																
MB21	22/03/2006		<0.01	0.004	<0.001	<0.0001	2.65	0.229	0.018	0.377	<0.01	7.69	13.40	6.11	22700	94	0.30	41	71	14600	520	<0.1	835	8860	0.58	0.09	0.09	0.08	<0.01	0.4	0.4	0.037
MB22	22/03/2006		0.16	<0.001	<0.001	0.0001	0.49	0.761	0.029	0.198	<0.01	3.95	4.65	5.13	14760	295	0.20	28	8	10600	88	<0.1	1110	5480	3.50	0.20	0.01	0.04	<0.01	0.3	0.3	0.044
MB23																																
MB24	22/03/2006		0.18	0.003	<0.001	0.0003	<0.05	0.476	0.041	1.240	0.012	3.82	2.86	5.24	21540	243	1.00	25	3	14500	142	<0.1	1120	8400	8.33	0.13	0.00	0.04	<0.01	6.3	0.5	5.790
MB25																																
MB26	23/03/2006		0.01	<0.001	<0.001	<0.0001	<0.05	0.029	0.009	0.285	<0.01	20.10	13.00	6.61	996	86	0.60	10	72	880	150	<0.1	54	148	0.14	0.36	1.33	0.11	<0.01	43.4	2.0	41.300
MB27	22/03/2006		<0.01	0.002	<0.001	<0.0001	<0.05	0.033	0.003	0.035	<0.01	3.05	2.14	7.63	5310	12	0.40	10	271	3140	40	<0.1	197	1680	0.04	0.12	1.38	0.04	<0.01	0.5	0.4	0.041
MB28	22/03/2006		<0.01	<0.001	<0.005	<0.0001	<0.05	0.025	0.012	0.171	<0.01	0.38	0.26	7.19	24600	135	0.10	16	224	14000	15	<0.1	734	8180	0.07	0.09	0.31	0.03	<0.01	2.4	0.4	1.980
MB29																																
MB30	22/03/2006		0.01	0.012	<0.001	<0.0001	18.60	0.710	0.013	0.128	<0.01	4.91	32.30	6.11	4100	14	0.20	62	52	2460	58	<0.1	160	1410	1.19	0.11	0.33	0.06	<0.01	0.4	0.3	0.080
MB31	21/03/2006		1.02	0.004	0.002	<0.0001	1.01	0.006	0.006	0.919	<0.01	28.70	16.80	4.98	205	203	0.90	14	3	532	694	<0.1	21	17	4.67	1.24	0.14	0.30	<0.01	1.3	0.7	0.570
MB32	20/03/2006		0.26	0.002	0.003	<0.0001	3.87	0.049	0.012	0.807	<0.01	3.10	8.42	6.20	391	-47	0.20	6	48	110	40	<0.1	9	68	0.13	0.13	5.33	0.11	<0.01	1.0	1.0	<0.01
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	20/03/2006		<0.01	0.002	0.002	0.0003	0.16	0.515	0.004	0.116	<0.01	17.10	24.60	7.17	26600	2	0.30	21	327	16100	180	<0.1	1390	8360	0.06	0.17	0.24	0.12	<0.01	1.1	1.1	<0.01
ML1B5	20/03/2006		<0.01	0.010	0.001	0.0003	14.60	0.733	0.033	0.436	<0.01	1.67	23.50	6.22	20330	-10	1.60	32	87	12700	128	<0.1	2050	5810	0.37	0.35	0.04	0.04	<0.01	1.3	1.2	0.020
ML1B6	20/03/2006		0.01	0.002	0.001	<0.0001	15.30	0.297	0.027	0.329	<0.01	0.41	17.90	5.91	18000	6	1.00	51	59	11300	40	<0.1	1050	5860	0.86	0.18	0.06	0.03	<0.01	1.3	1.3	0.017
ML1B7	20/03/2006		0.11	0.005	0.002	<0.0001	9.74	0.098	0.012	0.278	<0.01	4.08	16.40	6.84	4770	-65	0.10	7	113	2610	76	<0.1	345	1270	0.06	0.27	0.33	0.07	<0.01	0.7	0.7	<0.01
ML1B8	20/03/2006		<0.01	0.001	0.002	<0.0001	0.17	0.026	0.003	0.026	<0.01	0.25	1.71	7.35	3150	-138	0.20	5	258	1650	30	<0.1	309	609	0.02	0.51	0.83	0.02	<0.01	0.4	0.4	<0.01
ML1B9	20/03/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.770	0.012	1.070	<0.1	<0.1	0.09	6.56	34600	121	0.20	8	211	23100	56	<0.1	2330	11300	0.04	0.21	0.09	0.05	<0.01	0.9	0.9	0.020
MLWZ1	20/03/2006	(ML1B8)	<0.01	0.002	0.001	<0.0001	0.14	0.024	0.003	0.024	<0.01	0.28	1.69	---	---	---	---	<1	257	1520	10	<0.1	303	618	0.00	0.49	0.85	0.02	<0.01	0.4	0.4	<0.01
MLWZ2	22/03/2006	(MB22)	0.16	0.003	<0.001	0.0001	0.46	0.747	0.028	0.188	<0.01	4.66	5.37	---	---	---	---	56	9	10700	84	<0.1	1120	5570	6.22	0.20	0.01	0.03	<0.01	0.4	0.4	0.041

Groundwater Results - April 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	1/05/2006		<0.01	0.001	<0.001	<0.0001	0.19	0.476	0.022	0.346	<0.01	6.26	7.49	6.47	12890	-38	0.15	31	158	8970	180	<0.1	896	5460	0.20	0.16	0.18	0.35	<0.01	0.5	0.5	0.018
MB2	27/04/2006		<0.01	0.012	<0.001	<0.0001	<0.05	0.300	0.007	0.091	<0.01	33.70	61.60	6.48	6230	76	0.27	63	197	4520	1330	<0.1	449	1910	0.32	0.24	0.44	0.22	<0.01	0.6	0.6	0.012
MB3	27/04/2006		0.22	<0.001	<0.001	<0.0001	0.27	0.005	0.005	0.774	<0.01	22.50	27.30	5.94	171	114	0.40	8	48	367	537	<0.1	16	17	0.17	0.97	3.00	0.21	<0.01	2.0	0.6	1.350
MB4																																
MB5	27/04/2006		1.83	0.008	0.002	<0.0001	1.28	0.028	0.005	0.266	<0.01	69.20	32.10	6.32	674	-5	0.28	43	143	1250	457	<0.1	41	118	0.30	0.35	3.49	0.80	<0.01	1.8	1.7	0.148
MB6	27/04/2006		0.08	0.005	0.002	<0.0001	3.75	0.064	0.004	1.090	<0.01	19.10	36.00	5.60	1669	72	0.34	24	26	1440	97	<0.1	138	477	0.92	0.29	0.19	0.26	<0.01	1.1	0.9	0.193
MB7	26/04/2006		0.03	0.014	<0.001	0.0001	27.60	0.327	0.018	0.753	<0.01	0.45	38.00	5.97	2860	18	0.23	134	43	2130	43	<0.1	781	543	3.12	1.44	0.06	<0.01	<0.01	0.4	0.4	<0.01
MB8	27/04/2006		1.64	<0.001	0.001	<0.0001	0.56	0.011	0.002	0.225	<0.01	17.30	8.25	6.28	275	17	0.19	7	58	570	37	<0.1	24	46	0.12	0.52	2.42	0.20	<0.01	0.5	0.4	0.079
MB9																																
MB10																																
MB11	1/05/2006		<0.1	<0.01	<0.01	<0.001	2.17	2.520	0.020	0.553	<0.1	4.73	9.57	6.44	40500	35	0.29	63	143	33000	300	0.2	3200	17700	0.44	0.18	0.04	0.46	<0.01	0.4	0.4	0.018
MB12																																
MB13	27/04/2006		<0.01	<0.001	<0.001	0.0001	2.68	2.380	0.007	0.600	<0.01	9.78	9.70	6.59	5670	-45	0.76	80	191	4500	140	<0.1	464	2290	0.42	0.20	0.41	0.21	<0.01	1.0	0.7	0.294
MB14	28/04/2006		<0.01	0.001	<0.001	0.0001	1.12	0.273	0.004	0.401	<0.01	26.00	24.50	6.38	22600	65	0.19	17	147	17400	897	<0.1	1560	9930	0.12	0.16	0.09	0.42	<0.01	0.6	0.6	<0.01
MB15																																
MB16																																
MB17																																
MB18	28/04/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.135	<0.01	0.195	<0.1	2.05	1.26	6.99	39100	168	0.31	58	284	33400	143	<0.1	2480	18800	0.20	0.13	0.11	0.01	<0.01	0.3	0.2	0.147
MB19	28/04/2006		0.02	<0.001	<0.001	0.0001	0.87	0.024	0.037	0.609	<0.01	3.72	4.47	5.30	6740	157	0.86	57	36	3740	57	<0.1	274	1880	1.58	0.15	0.13	0.06	<0.01	1.4	0.3	1.130
MB20																																
MB21	26/04/2006		<0.01	0.003	0.001	0.0002	2.22	0.224	0.023	0.478	<0.01	17.90	25.20	5.90	20950	100	0.15	62	71	14600	667	<0.1	806	9320	0.87	0.09	0.09	0.30	<0.01	0.9	0.9	<0.01
MB22	26/04/2006		<0.01	0.001	0.001	0.0003	2.73	0.978	0.022	0.671	<0.01	21.50	36.80	6.01	25400	77	0.23	97	104	18600	1120	<0.1	1740	11000	0.93	0.16	0.06	0.31	<0.01	0.7	0.7	<0.01
MB23																																
MB24	26/04/2006		0.70	0.001	<0.001	0.0003	<0.05	0.486	0.032	0.443	<0.01	5.28	3.64	5.08	20450	213	0.67	33	2	15300	213	<0.1	807	8900	16.50	0.09	0.00	0.12	0.02	2.6	0.3	2.280
MB25																																
MB26	28/04/2006		<0.01	<0.001	<0.001	0.0001	<0.05	0.025	0.013	0.228	<0.01	22.70	15.00	5.91	975	200	0.61	14	76	880	717	<0.1	61	173	0.18	0.35	1.25	0.32	<0.01	38.7	0.7	37.900
MB27	28/04/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.142	0.009	0.144	<0.01	4.44	2.68	6.29	4940	175	0.33	49	278	3220	137	0.2	210	1620	0.18	0.13	1.32	0.18	<0.01	0.3	0.2	0.084
MB28	26/04/2006		<0.01	<0.001	0.002	0.0001	<0.05	0.017	0.023	0.206	<0.01	3.34	2.63	7.07	18370	81	0.29	37	279	12800	170	0.2	493	7590	0.13	0.06	0.57	0.08	<0.01	4.9	0.2	4.670
MB29																																
MB30	26/04/2006		<0.01	0.011	<0.001	0.0002	16.40	0.825	0.018	2.170	<0.01	20.10	50.40	6.05	4150	-64	0.20	31	52	2790	453	0.1	160	1380	0.60	0.12	0.33	0.41	<0.01	0.9	0.9	<0.01
MB31	27/04/2006		0.20	0.002	<0.001	0.0002	0.46	0.006	0.004	0.596	<0.01	54.00	55.80	4.71	126	201	0.65	39	<1	673	883	<0.1	26	23	39.00	1.14	0.04	0.42	<0.01	1.3	0.9	0.363
MB32	26/04/2006		0.31	0.003	0.003	<0.0001	8.65	0.042	0.007	0.429	<0.01	0.87	11.70	6.15	479	-71	0.26	36	58	257	157	0.1	9	94	0.62	0.10	6.44	0.36	<0.01	4.0	4.0	0.010
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	24/04/2006		<0.01	0.004	<0.005	0.0007	1.90	0.851	0.013	1.480	<0.01	1.85	4.58	6.01	23900	93	0.05	202	366	15800	860	<0.1	1540	8570	0.55	0.18	0.24	0.63	<0.01	1.0	1.0	0.019
ML1B5	24/04/2006		<0.01	0.011	<0.001	0.0006	10.50	0.603	0.067	0.656	<0.01	0.34	16.40	6.21	19380	19	0.72	67	87	13500	102	<0.1	2160	6260	0.77	0.35	0.04	0.27	<0.01	1.1	1.1	<0.01
ML1B6	24/04/2006		0.02	0.006	0.005	0.0005	19.40	0.422	0.058	0.608	<0.01	1.02	23.40	5.15	29700	151	0.08	446	117	19600	96	<0.1	1780	10400	3.81	0.17	0.07	0.03	<0.01	1.7	1.7	0.018
ML1B7	24/04/2006		<0.01	0.004	0.001	<0.0001	10.40	0.098	0.013	0.266	<0.01	0.40	13.20	6.74	4430	-84	0.03	33	113	2770	54	<0.1	377	1270	0.29	0.30	0.30	<0.01	<0.01	0.4	0.4	0.017
ML1B8	24/04/2006		<0.01	0.002	<0.005	<0.0001	1.05	0.051	0.023	0.806	<0.01	0.56	2.68	5.93	2050	88	0.12	109	266	1780	222	<0.1	332	614	0.41	0.54	0.80	0.12	<0.01	0.5	0.5	0.020
ML1B9	24/04/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.780	0.018	0.443	<0.1	1.11	0.57	6.65	33900	131	0.08	36	238	25600	148	<0.1	2740	13500	0.15	0.20	0.09	0.02	<0.01	1.2	1.2	<0.01
MLWZ1	24/04/2006	(ML1B4)	<0.01	0.004	<0.005	0.0008	1.63	0.852	0.011	1.470	<0.01	5.24	8.65	---	---	---	---	56	378	14500	2360	0.2	1600	8420	0.15	0.19	0.24	0.28	<0.01	2.9	2.9	<0.01
MLWZ2	27/04/2006	(MB6)	0.07	0.005	0.001	<0.0001	3.45	0.061	0.004	1.100	<0.01	20.00	37.80	---	---	---	---	113	24	1440	73	<0.1	128	469	4.71	0.27	0.19	0.29	<0.01	1.0	0.8	0.229

Groundwater Results - May 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	25/05/2006		<0.01	<0.001	<0.001	<0.0001	0.29	0.459	0.014	0.123	<0.01	9.45	9.50	6.27	14040	-79	0.17	75	156	8820	180	0.1	904	3610	0.48	0.25	0.17	0.04	<0.01	0.6	0.6	0.035
MB2	25/05/2006		<0.01	0.002	<0.001	0.0001	0.33	1.370	0.020	0.994	<0.01	36.00	45.20	6.53	7730	56	0.39	48	192	5080	880	<0.1	598	2140	0.25	0.28	0.32	0.08	<0.01	0.6	0.6	0.030
MB3	25/05/2006		0.50	0.001	0.001	<0.0001	0.61	0.004	0.004	0.666	<0.01	13.50	13.40	5.91	218	135	0.47	24	45	78	130	0.2	19	13	0.53	1.51	2.37	0.04	<0.01	1.6	1.0	0.665
MB4																																
MB5	30/05/2006		3.98	0.012	0.003	0.0012	1.63	0.050	0.007	0.084	<0.01	24.10	9.04	6.71	811	38	0.20	31	170	749	66	<0.1	38	107	0.18	0.36	4.47	0.06	<0.01	1.7	1.0	0.730
MB6	25/05/2006		0.08	0.004	0.002	<0.0001	2.60	0.050	0.007	1.190	<0.01	15.60	28.00	5.50	1539	58	0.43	27	22	710	140	<0.1	118	323	1.23	0.37	0.19	0.05	0.03	2.1	2.0	0.080
MB7	24/05/2006		0.04	0.007	<0.001	<0.0001	19.90	0.560	0.017	1.310	<0.01	0.70	27.10	5.57	3080	78	0.20	81	24	2470	34	<0.1	746	520	3.38	1.43	0.03	0.02	<0.01	0.6	0.6	0.070
MB8	30/05/2006		1.84	0.001	<0.001	0.0010	0.68	0.009	0.002	0.254	<0.01	18.40	7.44	6.51	331	17	0.70	10	57	248	28	<0.1	22	40	0.18	0.56	2.59	0.07	<0.01	0.5	0.5	0.045
MB9																																
MB10																																
MB11	25/05/2006		<0.1	<0.01	<0.01	<0.001	0.97	1.830	0.014	0.728	<0.1	1.17	4.18	6.10	4200	50	1.65	36	143	35300	116	<0.1	3250	15800	0.25	0.21	0.04	<0.01	<0.01	1.5	1.5	0.010
MB12																																
MB13	30/05/2006		<0.01	<0.001	<0.001	0.0003	3.21	1.940	0.008	0.543	<0.01	6.74	7.25	6.96	7490	-33	0.99	45	192	4890	76	<0.1	517	2410	0.23	0.21	0.37	0.05	0.01	1.0	0.9	0.094
MB14	25/05/2006		<0.01	<0.001	<0.001	<0.0001	1.02	0.283	0.022	0.530	<0.01	8.94	18.60	6.36	25300	55	0.51	25	151	18100	285	<0.1	1540	7560	0.17	0.20	0.10	0.02	<0.01	0.7	0.7	0.010
MB15																																
MB16																																
MB17																																
MB18	30/05/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.084	<0.01	0.097	<0.1	6.40	4.11	7.30	35400	95	0.81	67	293	30300	210	<0.1	2180	14900	0.23	0.15	0.13	0.04	0.01	0.2	0.2	0.065
MB19	26/05/2006		<0.01	<0.001	<0.001	<0.0001	1.28	0.029	0.016	1.040	<0.01	1.44	2.68	5.88	8190	92	1.04	33	48	4990	24	<0.1	363	2280	0.69	0.16	0.13	0.02	<0.01	1.2	0.2	0.995
MB20																																
MB21	26/05/2006		<0.01	<0.001	<0.001	<0.0001	2.18	0.181	0.017	0.273	<0.01	19.60	29.40	5.86	21000	106	0.23	68	73	14700	430	<0.1	879	5780	0.93	0.15	0.08	0.06	<0.01	0.4	0.4	0.010
MB22	26/05/2006		<0.01	<0.001	<0.001	<0.0001	4.21	1.150	0.016	0.198	<0.01	15.10	25.20	6.08	26500	60	0.17	37	120	21400	430	0.1	2160	13600	0.31	0.16	0.06	0.05	<0.01	0.8	0.8	<0.01
MB23																																
MB24	26/05/2006		0.72	<0.001	<0.001	0.0002	<0.05	0.489	0.036	0.558	0.013	5.45	2.72	4.89	21650	310	1.19	31	2	16600	100	<0.1	1240	5400	15.50	0.23	0.00	0.02	<0.01	5.6	0.3	5.320
MB25																																
MB26	30/05/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.007	0.001	0.164	<0.01	12.10	5.10	7.11	1154	196	1.56	7	74	1160	98	<0.1	66	155	0.09	0.43	1.12	0.08	<0.01	9.4	2.9	6.500
MB27	30/05/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.018	0.002	0.167	<0.01	1.76	0.86	7.60	5810	98	0.39	18	294	3440	32	<0.1	227	1520	0.06	0.15	1.30	0.02	0.01	<0.1	<0.1	0.042
MB28	26/05/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.013	<0.01	0.120	<0.01	7.18	5.15	7.07	19260	135	0.36	35	284	12700	96	<0.1	688	4210	0.12	0.16	0.41	0.05	<0.01	9.2	0.2	9.000
MB29																																
MB30	26/05/2006		<0.01	0.008	<0.001	0.0001	12.60	1.420	0.014	1.440	<0.01	4.09	22.50	5.92	5150	-2	0.21	73	56	3200	74	<0.1	185	1380	1.30	0.13	0.30	0.03	<0.01	0.6	0.5	0.090
MB31	25/05/2006		0.36	0.001	0.001	<0.0001	0.42	0.004	0.002	0.555	<0.01	23.10	22.70	4.46	171	229	1.16	8	2	123	216	0.1	24	19	4.00	1.25	0.08	0.10	<0.01	1.0	0.6	0.360
MB32	24/05/2006		0.21	0.002	0.003	<0.0001	6.30	0.030	0.008	0.325	<0.01	2.10	9.11	5.99	457	-48	1.35	26	55	298	14	<0.1	13	83	0.47	0.16	4.23	0.04	0.02	1.5	1.5	<0.01
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	24/05/2006		<0.01	<0.001	<0.001	0.0001	0.15	0.501	<0.01	0.132	<0.01	12.90	19.80	7.11	31590	12	0.29	43	314	15100	514	<0.1	1660	8160	0.14	0.20	0.19	0.06	<0.01	1.3	1.3	<0.01
ML1B5	24/05/2006		<0.01	0.006	<0.001	0.0001	12.50	0.411	0.044	0.238	<0.01	3.18	19.10	5.90	19830	51	0.90	82	86	14300	132	<0.1	2130	6120	0.95	0.35	0.04	<0.01	<0.01	1.3	1.3	<0.01
ML1B6	24/05/2006		<0.01	<0.001	<0.001	<0.0001	13.80	0.392	0.014	0.159	<0.01	0.12	16.70	6.01	23500	48	5.04	120	109	19900	98	<0.1	1840	8980	1.10	0.20	0.06	<0.01	<0.01	1.8	1.8	<0.01
ML1B7	24/05/2006		<0.01	0.002	<0.001	<0.0001	10.70	0.091	0.005	0.455	<0.01	2.23	15.80	6.67	4600	-84	0.06	33	122	2920	42	<0.1	362	1230	0.27	0.29	0.34	0.02	<0.01	0.5	0.4	0.105
ML1B8	24/05/2006		<0.01	0.002	<0.001	<0.0001	0.11	0.015	0.002	0.025	<0.01	1.94	3.26	7.27	31600	-119	0.09	11	262	2150	40	<0.1	309	550	0.04	0.56	0.85	<0.01	<0.01	0.3	0.3	<0.01
ML1B9	24/05/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.820	0.015	0.636	<0.1	<0.1	0.13	6.45	33400	132	0.15	69	234	26200	106	<0.1	2780	12700	0.29	0.22	0.08	0.03	<0.01	0.8	0.8	<0.01
MLWZ2	24/05/2006	(ML1B6)	<0.01	<0.001	<0.001	<0.0001	13.30	0.391	0.015	0.173	<0.01	0.13	17.10	-	-	-	-	118	111	20000	82	<0.1	1900	9970	1.06	0.19	0.06	0.01	<0.01	1.9	1.9	<0.01
MLWZ3	30/05/2006	(MB8)	3.99	0.001	0.002	0.0007	1.17	0.010	0.002	0.250	<0.01	16.80	6.72	-	-	-	-	12	64	526	36	<0.1	22	41	0.19	0.54	2.91	0.08	<0.01	0.5	0.5	0.049

Groundwater Results - June 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	29/06/2006		<0.01	<0.001	<0.001	<0.0001	0.47	0.436	0.014	0.539	<0.01	13.00	18.90	7.00	12810	-64	0.23	67	165	10100	32	<0.1	933	3820	0.41	0.24	0.18	0.12	<0.01	0.7	0.6	0.020
MB2	26/06/2006		<0.01	0.006	<0.001	0.0007	<0.05	0.692	0.012	0.316	<0.01	12.40	23.00	6.69	7280	99	0.43	55	215	4690	18	<0.1	670	2260	0.26	0.30	0.32	36.20	<0.01	3.8	3.8	0.010
MB3	26/06/2006		3.24	0.001	0.003	0.0012	1.64	0.009	0.003	0.636	<0.01	9.81	11.40	6.00	182	162	0.44	16	46	244	46	0.1	18	18	0.35	0.98	2.56	33.50	<0.01	2.2	1.9	0.325
MB4																																
MB5	29/06/2006		1.04	0.010	0.002	0.0002	0.94	0.041	0.002	0.297	<0.01	17.80	8.11	7.12	780	-6	0.26	18	172	552	88	<0.1	38	106	0.10	0.36	4.53	<0.01	<0.01	0.9	0.8	0.135
MB6	26/06/2006		0.08	0.005	0.002	<0.0001	1.66	0.048	0.006	1.100	<0.01	14.20	31.70	5.78	1834	42	0.98	41	25	1250	70	<0.1	152	489	1.64	0.31	0.16	0.01	<0.01	1.1	1.0	0.025
MB7	26/06/2006		0.04	0.009	<0.001	0.0001	19.10	0.535	0.019	1.300	<0.01	1.16	25.30	5.33	2530	75	0.32	82	2	1740	20	<0.1	724	418	41.00	1.73	0.00	<0.01	<0.01	0.6	0.5	0.095
MB8	29/06/2006		2.32	<0.001	0.002	<0.0001	1.48	0.010	0.001	0.342	<0.01	18.40	8.95	7.27	331	34	1.51	13	59	220	40	<0.1	20	39	0.22	0.51	2.95	0.03	0.02	0.5	0.3	0.195
MB9																																
MB10																																
MB11	26/06/2006		<0.1	<0.01	<0.01	<0.001	1.92	2.350	0.025	1.150	<0.1	0.72	5.55	6.20	35400	53	0.16	102	137	31300	122	<0.1	3070	18000	0.74	0.17	0.04	<0.01	<0.01	1.4	1.4	<0.01
MB12																																
MB13	29/06/2006		<0.01	<0.001	<0.001	0.0002	1.44	1.270	0.004	0.564	<0.01	4.30	8.15	7.50	4920	-36	2.27	36	162	4040	24	<0.1	286	1560	0.22	0.18	0.57	<0.01	<0.01	1.7	0.8	0.875
MB14	26/06/2006		<0.01	0.001	<0.001	<0.0001	1.17	0.254	0.017	0.497	<0.01	19.10	37.60	6.33	21190	57	0.20	84	149	17100	430	<0.1	1530	5080	0.56	0.30	0.10	0.05	<0.01	0.9	0.9	<0.01
MB15																																
MB16																																
MB17																																
MB18	29/06/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.043	<0.01	0.188	<0.1	13.60	21.60	7.31	32	148	1.96	80	305	30000	80	<0.1	2600	15600	0.26	0.17	0.12	0.04	0.03	0.4	<0.1	0.425
MB19	28/06/2006		0.21	<0.001	<0.001	<0.0001	2.93	0.028	0.015	<0.005	<0.01	11.00	6.90	6.22	9680	63	0.30	35	64	6550	45	<0.1	492	3350	0.55	0.15	0.13	0.10	0.05	0.2	0.2	0.051
MB20																																
MB21	28/06/2006		0.48	0.004	0.001	<0.0001	8.62	0.175	0.010	0.008	<0.01	27.80	27.40	7.30	3160	-119	0.10	23	70	13700	260	<0.1	858	7670	0.33	0.11	0.08	0.06	<0.01	0.4	0.4	<0.01
MB22	28/06/2006		0.28	<0.001	0.001	<0.0001	6.36	0.983	0.013	0.006	<0.01	8.68	12.10	6.24	23000	60	0.21	29	118	19900	140	<0.1	2090	10100	0.25	0.21	0.06	0.07	0.01	0.6	0.6	<0.01
MB23																																
MB24	28/06/2006		1.41	<0.001	0.001	0.0002	0.11	0.465	0.028	0.010	<0.01	19.00	6.50	5.26	17470	326	0.91	23	<1	14800	136	<0.1	1250	7980	23.00	0.16	0.00	0.09	<0.01	0.6	<0.1	0.629
MB25																																
MB26	29/06/2006		<0.01	<0.001	<0.001	0.0001	<0.05	0.005	0.002	0.185	<0.01	7.91	5.32	7.41	1204	163	1.73	14	102	876	50	<0.1	68	170	0.14	0.40	1.50	<0.01	<0.01	24.8	1.0	23.800
MB27	29/06/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.010	0.001	0.177	<0.01	5.88	3.98	7.81	5660	156	0.71	<1	278	4080	52	<0.1	197	1450	0.00	0.14	1.41	0.03	0.03	0.2	0.1	0.140
MB28	28/06/2006		0.29	<0.001	<0.001	<0.0001	0.08	0.012	0.004	0.006	<0.01	5.64	2.60	7.30	14270	147	0.29	17	289	12800	32	<0.1	643	6740	0.06	0.10	0.45	0.01	<0.01	1.1	<0.1	1.110
MB29																																
MB30	28/06/2006		0.44	0.007	0.001	<0.0001	15.60	1.460	0.017	0.007	<0.01	7.21	23.60	6.46	5250	-101	0.21	39	64	3510	96	<0.1	281	1760	0.61	0.16	0.23	1.36	0.02	1.9	1.8	0.031
MB31	28/06/2006		2.28	0.004	0.003	<0.0001	5.49	0.004	0.011	0.017	<0.01	101.00	82.10	4.87	152	208	1.26	23	2	372	1430	<0.1	30	23	11.50	1.28	0.07	0.28	<0.01	1.6	1.5	0.077
MB32	26/06/2006		0.45	0.002	0.003	0.0001	8.50	0.035	0.016	0.367	<0.01	2.47	13.10	5.88	532	-68	0.32	25	63	386	34	<0.1	254	99	0.40	2.56	0.25	0.07	<0.01	1.4	1.4	0.025
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	23/06/2006		<0.01	0.002	<0.001	0.0001	<0.05	0.350	0.007	0.080	<0.01	18.00	21.60	7.19	21200	6	0.26	50	302	15800	586	0.3	1760	5750	0.17	0.31	0.17	0.06	<0.01	1.2	1.2	0.033
ML1B5	23/06/2006		<0.01	0.003	<0.001	0.0001	3.08	0.345	0.034	0.442	<0.01	2.41	16.00	6.08	18290	38	0.71	68	77	13700	100	<0.1	2540	4450	0.88	0.57	0.03	0.04	<0.01	1.3	1.3	<0.01
ML1B6	23/06/2006		0.01	<0.001	0.001	<0.0001	9.86	0.436	0.017	0.235	<0.01	0.52	15.80	6.42	26600	7	2.87	76	98	17900	102	<0.1	2220	6960	0.78	0.32	0.04	0.01	<0.01	2.0	2.0	<0.01
ML1B7	23/06/2006		0.01	0.002	<0.001	<0.0001	9.77	0.098	0.003	0.301	<0.01	1.41	15.70	6.76	4280	-106	0.07	38	116	2650	34	<0.1	394	1160	0.33	0.34	0.29	0.05	<0.01	0.7	0.7	0.013
ML1B8	23/06/2006		0.05	0.002	<0.001	<0.0001	0.19	0.022	0.002	0.057	<0.01	0.65	2.39	7.25	2770	-101	0.16	17	256	1660	28	0.1	320	537	0.07	0.60	0.80	<0.01	<0.01	0.4	0.4	<0.01
ML1B9	23/06/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.710	<0.01	0.600	<0.1	<0.1	0.16	6.64	2900	122	0.21	54	226	25000	154	<0.1	3350	8220	0.24	0.41	0.07	0.02	<0.01	1.1	1.1	<0.01
MLWZ2	26/06/2006	(MB7)	0.04	0.009	0.001	0.0001	18.30	0.468	0.019	1.210	<0.01	1.03	25.30	-	-	-	-	78	2	1800	50	<0.1	845	396	39.00	2.13	0.00	0.03	<0.01	0.5	0.4	0.125

Groundwater Results - July 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	27/07/2006		<0.01	<0.001	<0.001	<0.0001	0.38	0.465	0.014	0.561	<0.01	10.00	9.75	6.43	12110	-53	0.34	37	158	8900	38	0.9	720	4530	0.23	0.16	0.22	<0.01	<0.01	0.7	0.7	<0.01
MB2	27/07/2006		<0.01	0.003	<0.001	0.0001	0.23	1.100	0.026	0.471	<0.01	12.50	15.00	6.71	5260	-13	2.22	14	136	3940	318	0.7	485	1840	0.10	0.26	0.28	<0.01	<0.01	0.6	0.6	<0.01
MB3	28/07/2006		2.03	<0.001	0.002	<0.0001	1.02	0.024	0.008	0.842	<0.01	16.90	17.30	6.18	284	111	0.84	18	23	166	248	<0.1	54	29	0.78	1.88	0.43	0.06	<0.01	2.2	1.0	1.260
MB4																																
MB5	31/07/2006		2.52	0.007	<0.005	0.0006	2.32	0.040	0.011	0.530	<0.01	48.10	40.30	5.46	688	194	1.75	230	84	436	286	0.1	55	135	2.74	0.41	1.53	0.10	0.02	4.2	1.6	2.610
MB6	27/07/2006		0.11	0.004	0.002	0.0001	5.05	0.078	0.010	0.443	<0.01	22.40	34.90	5.95	1640	75	0.83	16	25	1140	136	<0.1	139	455	0.64	0.31	0.18	<0.01	<0.01	0.8	0.8	<0.01
MB7	27/07/2006		0.26	0.003	0.001	0.0001	9.59	0.264	0.020	0.951	<0.01	6.46	17.10	5.24	1991	184	0.30	54	<1	1220	610	<0.1	472	311	54.00	1.52	0.00	<0.01	<0.01	0.6	0.6	0.010
MB8	31/07/2006		3.12	<0.001	0.001	<0.0001	0.98	0.007	0.004	0.418	<0.01	26.50	11.60	6.69	441	75	5.96	10	41	324	36	<0.1	40	78	0.24	0.51	1.03	<0.01	<0.01	2.6	1.2	1.410
MB9																																
MB10																																
MB11	27/07/2006		<0.1	<0.01	<0.01	<0.001	2.43	2.390	0.024	0.185	<0.1	4.14	10.40	6.20	33700	47	0.22	46	143	33900	460	<0.1	3180	18500	0.32	0.17	0.04	<0.01	<0.01	5.5	5.5	<0.01
MB12																																
MB13	31/07/2006		0.02	<0.001	<0.001	<0.0001	1.92	1.100	0.008	1.040	<0.01	13.80	8.26	7.09	3800	-48	0.75	36	123	2470	94	<0.1	239	134	0.29	1.78	0.51	<0.01	<0.01	2.6	0.9	1.700
MB14	27/07/2006		<0.01	<0.001	0.001	0.0001	1.75	0.263	0.017	0.299	<0.01	11.50	17.10	6.39	19760	-37	0.63	30	152	18500	390	<0.1	1450	9360	0.20	0.15	0.10	<0.01	<0.01	1.4	1.4	0.075
MB15																																
MB16																																
MB17																																
MB18	31/07/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.020	<0.01	0.250	<0.1	4.57	1.92	7.15	21730	96	2.01	40	229	20700	140	<0.1	1800	14800	0.17	0.12	0.13	<0.01	<0.01	2.5	0.8	1.690
MB19	28/07/2006		<0.01	<0.001	<0.001	0.0001	1.38	0.026	0.019	1.460	<0.01	9.69	10.50	6.17	9000	51	1.58	30	61	5850	52	<0.1	409	2720	0.49	0.15	0.15	0.13	<0.01	1.2	0.4	0.840
MB20																																
MB21	28/07/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.220	0.027	0.338	<0.1	14.00	10.60	5.28	36000	201	5.49	19	5	38000	2900	0.4	2730	25900	3.80	0.11	0.00	0.11	<0.01	10.5	2.1	8.420
MB22	28/07/2006		0.01	<0.001	<0.001	0.0002	3.45	1.190	0.022	0.158	<0.01	5.10	8.96	5.93	21570	90	0.32	64	107	18700	580	<0.1	2310	12500	0.60	0.18	0.05	0.04	<0.01	1.0	1.0	0.070
MB23																																
MB24	28/07/2006		0.52	<0.01	<0.01	<0.001	<0.5	0.568	0.033	1.170	<0.1	5.20	2.62	4.84	15	191	0.50	37	2	14800	180	<0.1	1290	8830	18.50	0.15	0.00	0.10	<0.01	6.4	0.2	6.260
MB25																																
MB26	31/07/2006		0.03	<0.001	<0.005	0.0001	<0.05	0.016	0.010	1.780	<0.01	11.30	4.45	5.86	1234	146	0.27	84	134	744	64	<0.1	91	240	0.63	0.38	1.47	<0.01	<0.01	13.4	1.4	12.000
MB27	31/07/2006		0.04	<0.001	<0.001	<0.0001	<0.05	0.010	0.001	0.109	<0.01	0.31	0.15	7.61	4990	108	0.16	8	254	2690	8	2.5	196	1640	0.03	0.12	1.30	<0.01	<0.01	0.8	0.6	0.223
MB28	28/07/2006		<0.01	<0.001	<0.001	0.0001	<0.05	0.008	0.007	0.250	<0.01	1.33	0.78	6.92	6310	88	4.59	18	130	5410	40	<0.1	324	2440	0.14	0.13	0.40	0.01	<0.01	83.8	2.1	81.700
MB29																																
MB30	28/07/2006		<0.01	0.004	<0.001	0.0001	4.80	0.736	0.016	1.010	<0.01	123.00	132.00	6.16	4	35	0.90	37	50	3660	1070	<0.1	212	1400	0.74	0.15	0.24	0.42	<0.01	4.0	4.0	0.090
MB31	31/07/2006		0.09	0.001	<0.005	<0.0001	0.86	0.003	0.020	0.569	<0.01	59.60	47.80	4.41	182	267	1.05	176	8	122	636	0.8	25	30	22.00	0.84	0.32	0.05	0.03	1.5	1.4	0.103
MB32	26/07/2006		0.31	<0.001	0.002	<0.0001	1.38	0.032	0.007	0.539	<0.01	3.42	6.39	6.23	506	2	1.74	1	37	355	26	<0.1	17	80	0.03	0.21	2.18	0.08	0.06	1.6	0.9	0.702
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	26/07/2006		<0.01	0.004	<0.001	0.0002	<0.05	0.433	0.007	0.115	0.010	5.23	8.79	7.13	21860	-6	0.21	33	300	18300	34	<0.1	1560	9250	0.11	0.17	0.19	0.05	0.02	0.7	0.6	0.045
ML1B5	26/07/2006		<0.01	0.006	<0.001	<0.0001	7.64	0.264	0.045	0.343	<0.01	1.20	13.90	5.74	16760	71	0.90	64	61	13500	78	<0.1	1870	5780	1.05	0.32	0.03	<0.01	<0.01	1.1	1.0	0.062
ML1B6	26/07/2006		0.04	0.005	0.001	<0.0001	6.05	0.313	0.026	0.215	<0.01	1.73	7.83	5.72	19200	66	0.63	37	48	14000	10	<0.1	1260	7560	0.77	0.17	0.04	<0.01	<0.01	1.1	1.1	<0.01
ML1B7	26/07/2006		<0.01	0.002	0.001	<0.0001	10.60	0.098	0.003	0.310	<0.01	0.95	15.60	6.76	5220	-96	0.03	32	126	3830	6	<0.1	369	1400	0.25	0.26	0.34	<0.01	<0.01	1.2	1.1	0.014
ML1B8	26/07/2006		<0.01	0.002	<0.001	<0.0001	0.36	0.031	0.002	0.134	<0.01	0.32	1.99	7.30	3450	-133	0.05	15	267	1610	12	<0.1	314	660	0.06	0.48	0.85	<0.01	<0.01	0.2	0.2	<0.01
ML1B9	26/07/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.650	0.013	0.496	<0.1	0.18	0.32	6.42	31500	86	0.09	46	239	27800	130	<0.1	2670	14100	0.19	0.19	0.09	<0.01	<0.01	0.3	0.3	<0.01
MLWZ2	26/07/2006	(ML1B8)	<0.01	0.001	<0.001	<0.0001	0.33	0.030	0.002	0.136	<0.01	0.35	1.93	-	-	-	-	8	267	1940	16	<0.1	314	789	0.03	0.40	0.85	0.04	<0.01	0.6	0.6	0.011
MLWZ3	31/07/2006	(MB8)	2.76	<0.001	<0.001	0.0001	0.84	0.006	0.004	0.416	<0.01	29.10	12.20	-	-	-	-	6	39	150	<1	<0.1	39	76	0.15	0.51	1.00	0.02	<0.01	3.4	2.1	1.260

Groundwater Results - August 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Dissolved Metals									Total Metals		Field Parameters			
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG
MB1	31/08/2006		0.07	0.001	<0.001	0.0001	<0.05	0.071	0.019	1.170	<0.01	6.19	3.23	3.93	6060	329	6.22
MB2	31/08/2006		<0.01	0.002	<0.001	<0.0001	0.30	0.354	0.009	0.480	<0.01	1.25	2.17	5.70	2000	74	2.37
MB3	31/08/2006		0.72	<0.001	0.001	<0.0001	0.13	0.084	0.019	1.090	<0.01	10.20	5.83	4.36	339	346	2.47
MB4																	
MB5	30/08/2006		3.29	0.007	0.003	0.0001	1.78	0.108	0.006	0.634	<0.01	6.49	4.23	5.77	623	97	0.10
MB6	31/08/2006		0.13	0.001	0.002	<0.0001	0.58	0.181	0.017	0.802	<0.01	7.53	11.00	4.75	502	308	1.78
MB7	31/08/2006		0.14	0.001	<0.001	<0.0001	2.71	0.108	0.018	1.600	<0.01	3.54	6.79	4.52	688	248	1.92
MB8	30/08/2006		3.53	<0.001	0.001	<0.0001	1.07	0.005	0.003	0.153	<0.01	8.34	2.96	6.50	562	108	1.43
MB9																	
MB10																	
MB11	31/08/2006		<0.1	<0.01	<0.01	<0.001	2.65	2.380	0.012	0.174	<0.1	0.91	5.33	6.29	44300	86	0.22
MB12																	
MB13	30/08/2006		0.11	<0.001	<0.001	<0.0001	0.76	1.000	0.008	1.860	<0.01	0.10	0.77	6.43	2730	16	0.65
MB14	31/08/2006		<0.01	0.003	<0.001	<0.0001	1.88	0.242	0.009	0.225	<0.01	4.23	7.29	6.50	24200	53	0.18
MB15																	
MB16																	
MB17																	
MB18	30/08/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.093	<0.01	0.143	<0.1	0.22	0.44	6.87	30700	153	0.74
MB19	1/09/2006		0.05	<0.001	<0.001	<0.0001	0.54	0.016	0.004	0.793	<0.01	18.30	15.00	5.89	2464	172	5.54
MB20																	
MB21	1/09/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.537	0.020	1.020	<0.1	0.52	0.58	5.80	25500	219	0.23
MB22	1/09/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.099	0.003	0.032	<0.01	4.31	4.61	5.57	506	241	8.92
MB23																	
MB24	1/09/2006		0.05	0.001	<0.001	0.0003	<0.05	0.338	0.022	1.170	<0.01	1.27	0.65	5.01	18370	235	4.93
MB25																	
MB26	30/08/2006		0.70	<0.001	<0.001	<0.0001	0.18	0.037	0.004	0.880	<0.01	3.29	1.60	6.07	785	221	0.89
MB27	30/08/2006													7.81	6	156	0.71
MB28	1/09/2006		0.02	<0.001	<0.001	<0.0001	<0.05	0.018	0.012	0.592	<0.01	2.94	1.44	6.37	3060	170	3.40
MB29																	
MB30	1/09/2006		0.04	0.002	<0.001	<0.0001	0.21	0.149	0.006	0.221	<0.01	408.00	432.00	5.76	547	186	1.28
MB31	30/08/2006		0.07	<0.001	<0.001	<0.0001	0.10	0.093	0.007	0.355	<0.01	<0.1	0.15	4.14	169	335	2.18
MB32	29/08/2006		1.45	<0.001	0.002	<0.0001	0.69	0.016	0.003	0.319	<0.01	6.52	4.07	5.71	310	117	1.16
ML1B1																	
ML1B2																	
ML1B3																	
ML1B4	29/08/2006		<0.01	0.002	<0.001	<0.0001	<0.05	0.098	0.002	0.052	<0.01	1.02	1.85	6.10	6260	137	3.58
ML1B5	29/08/2006		0.12	0.001	<0.001	<0.0001	0.68	0.100	0.010	0.379	<0.01	3.54	4.33	5.00	1069	318	4.62
ML1B6	29/08/2006		10.50	0.001	0.001	<0.0001	5.26	0.172	0.021	0.416	<0.01	12.50	6.75	4.16	7160	318	3.05
ML1B7	29/08/2006		0.08	0.002	<0.001	<0.0001	10.80	0.111	0.006	0.318	<0.01	0.62	15.70	6.40	4	-31	1.43
ML1B8	29/08/2006		<0.01	<0.001	<0.005	<0.0001	0.13	0.033	0.001	0.120	<0.01	1.28	6.14	7.29	3370	-31	1.77
ML1B9	29/08/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.360	<0.01	0.218	<0.1	0.12	0.26	6.64	2900	122	0.21
MLWZ2	30/08/2006	(MB18)	<0.1	<0.01	<0.01	<0.001	<0.5	0.095	<0.01	0.161	<0.1	<0.1	0.16	-	-	-	-
MLWZ3	31/08/2006	(MB14)	<0.01	0.005	<0.001	<0.0001	1.92	0.240	0.008	0.186	<0.01	4.62	7.70	-	-	-	-
MLWZ4	1/09/2006	(MB28)	0.04	<0.001	<0.001	<0.0001	<0.05	0.018	0.012	0.569	<0.01	3.00	1.55	-	-	-	-

1	3	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Trigger	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
	LOR	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
	FWG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
	MEPG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
	LIWG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
	ASS	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1		34	<1	4730	40	<0.1	954	2020	34.00	0.47	0.00	0.03	<0.01	0.2	<0.1	0.170
MB2		17	37	1090	5	<0.1	272	492	0.46	0.55	0.14	<0.01	<0.01	3.1	<0.1	3.080
MB3		36	<1	256	52	<0.1	93	23	36.00	4.12	0.01	<0.01	<0.01	6.2	<0.1	6.240
MB4																
MB5		38	42	568	268	<0.1	118	98	0.90	1.20	0.36	0.22	<0.01	1.3	1.3	<0.01
MB6		21	<1	446	16	<0.1	122	51	21.00	2.40	0.01	<0.01	<0.01	0.8	<0.1	0.765
MB7		26	<1	406	38	<0.1	147	116	26.00	1.27	0.01	<0.01	<0.01	<0.1	<0.1	0.085
MB8		10	43	882	92	<0.1	62	109	0.23	0.57	0.69	0.48	0.03	5.4	4.0	1.360
MB9																
MB10																
MB11		34	133	32100	68	0.4	3740	19400	0.26	0.19	0.04	0.03	<0.01	0.3	0.2	0.090
MB12																
MB13		31	105	1990	20	<0.1	160	830	0.30	0.19	0.66	0.07	<0.01	2.2	1.7	0.495
MB14		30	138	17700	34	<0.1	1740	9220	0.22	0.19	0.08	<0.01	<0.01	<0.1	<0.1	0.080
MB15																
MB16																
MB17																
MB18		54	263	29800	220	<0.1	2500	14300	0.21	0.17	0.11	0.01	0.02	1.7	1.1	0.615
MB19		15	24	2600	6	<0.1	246	972	0.63	0.25	0.10	0.02	0.02	0.7	0.5	0.252
MB20																
MB21		36	68	23300	<1	<0.1	1200	11100	0.53	0.11	0.06	0.09	0.05	0.7	0.4	0.293
MB22		2	3	408	40	<0.1	27	136	0.67	0.20	0.11	<0.01	<0.01	1.2	0.3	0.830
MB23																
MB24		24	3	14700	<1	<0.1	1080	7550	8.00	0.14	0.00	0.02	<0.01	1.6	0.4	1.210
MB25																
MB26		15	31	728	8	<0.1	52	107	0.48	0.49	0.60	0.05	<0.01	29.3	0.8	28.400
MB27																
MB28		16	166	6840	<1	<0.1	390	3110	0.10	0.13	0.43	0.11	0.01	6.4	2.6	3.840
MB29																
MB30		44	12	620	3890	1.2	39	149	3.67	0.26	0.31	0.76	<0.01	6.7	6.6	0.084
MB31		25	<1	448	70	<0.1	40	23	25.00	1.77	0.03	0.95	<0.01	6.3	5.8	0.455
MB32		8	24	222	416	0.1	17	54	0.33	0.31	1.41	0.12	0.02	1.5	0.6	0.945
ML1B1																
ML1B2																
ML1B3																
ML1B4		21	50	4490	56	<0.1	471	1780	0.42	0.26	0.11	<0.01	<0.01	1.0	0.4	0.535
ML1B5		26	2	970	38	<0.1	91	312	13.00	0.29	0.02	0.09	<0.01	1.5	0.6	0.905
ML1B6		115	<1	5820	16	<0.1	428	2470	115.00	0.17	0.00	<0.01	<0.01	0.7	0.4	0.285
ML1B7		18	90	3290	8	<0.1	353	1260	0.20	0.28	0.25	<0.01	<0.01	0.9	0.7	0.225
ML1B8		10	259	2620	12	<0.1	344	755	0.04	0.46	0.75	0.02	<0.01	0.6	0.3	0.265
ML1B9		65	263	28700	40	<0.1	2820	13100	0.25	0.22	0.09	0.46	<0.01	0.6	0.6	<0.01
MLWZ2	(MB18)	48	261	39300	80	<0.1	2450	14800	0.18	0.17	0.11	0.01	0.01	1.1	0.5	0.615
MLWZ3	(MB14)	20	137	17400	38	<0.1	1700	9460	0.15	0.18	0.08	<0.01	<0.01	0.4	0.3	0.110
MLWZ4	(MB28)	16	164	6910	<1	<0.1	364	3090	0.10	0.12	0.45	0.04	<0.01	5.7	2.9	2.800

Groundwater Results - September 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MB1	27/09/2006		<0.01	0.002	<0.001	<0.0001	1.24	0.859	0.020	1.200	<0.01	5.35	6.95	5.45	10280	28	2.80	46	29	7050	98	<0.1	1280	3010	1.59	0.43	0.02	0.02	<0.01	0.4	0.4	0.030
MB2	27/09/2006		<0.01	<0.001	<0.001	<0.0001	0.84	0.479	0.010	0.919	<0.01	2.98	4.68	5.81	2540	28	2.75	21	49	1280	48	<0.1	258	674	0.43	0.38	0.19	0.04	<0.01	4.0	0.8	3.160
MB3	27/09/2006		0.11	<0.001	<0.001	<0.0001	0.11	0.068	0.005	0.209	<0.01	9.82	9.20	5.31	226	134	3.78	18	15	130	68	<0.1	24	22	1.20	1.07	0.63	0.04	<0.01	7.0	2.0	4.970
MB4																																
MB5	29/09/2006		1.11	0.005	0.002	0.0002	0.86	0.044	0.012	0.862	<0.01	10.40	7.38	5.83	620	81	0.77	37	50	622	294	0.1	56	113	0.74	0.50	0.89	0.13	<0.01	1.8	1.8	0.057
MB6	27/09/2006		0.10	0.003	0.002	<0.0001	4.19	0.074	0.010	0.281	<0.01	38.20	61.70	4.73	621	171	3.68	27	7	920	184	<0.1	103	317	3.86	0.32	0.07	0.11	<0.01	1.6	1.3	0.255
MB7	27/09/2006		0.27	0.003	0.001	<0.0001	3.26	0.092	0.010	1.780	<0.01	3.98	10.30	4.61	372	64	2.10	25	<1	240	90	<0.1	50	81	25.00	0.62	0.02	0.03	<0.01	0.6	0.5	0.045
MB8	29/09/2006		0.82	<0.001	<0.001	<0.0001	0.23	0.003	0.002	0.385	<0.01	4.50	2.08	5.75	305	93	3.12	10	24	354	68	<0.1	30	57	0.42	0.53	0.80	0.06	<0.01	0.3	0.3	0.010
MB9																																
MB10																																
MB11	27/09/2006		<0.1	<0.01	<0.01	<0.001	2.72	2.200	0.015	0.190	<0.1	1.58	7.31	6.26	31400	61	1.87	86	131	32900	68	<0.1	2450	18400	0.66	0.13	0.05	<0.01	<0.01	1.3	1.3	<0.01
MB12																																
MB13	29/09/2006		<0.01	<0.001	<0.001	0.0003	1.75	0.970	0.006	1.480	<0.01	2.82	2.68	6.52	4850	-43	1.11	31	102	4110	32	<0.1	309	1760	0.30	0.18	0.33	0.03	<0.01	4.0	1.1	2.940
MB14	27/09/2006		<0.01	0.004	0.001	<0.0001	2.58	0.250	0.010	0.088	0.011	1.48	4.60	6.42	20890	4	3.49	23	146	16400	50	<0.1	1800	9760	0.16	0.18	0.08	0.04	<0.01	0.8	0.8	0.075
MB15																																
MB16																																
MB17																																
MB18	29/09/2006		<0.01	0.005	0.001	<0.0001	<0.05	0.061	0.012	0.464	0.018	4.54	2.74	6.89	35500	137	0.87	122	280	33400	80	<0.1	2580	16800	0.44	0.15	0.11	0.08	0.03	0.6	0.3	0.305
MB19	28/09/2006		0.05	<0.001	<0.001	<0.0001	0.60	0.020	0.003	1.340	<0.01	23.30	20.20	5.60	2560	154	2.98	25	22	1840	154	<0.1	109	809	1.14	0.13	0.20	0.09	<0.01	1.2	0.8	0.434
MB20																																
MB21	28/09/2006		<0.01	0.004	<0.001	0.0001	1.32	0.244	0.023	0.342	<0.01	7.81	13.60	5.82	19290	126	1.20	86	71	14900	150	<0.1	854	6130	1.21	0.14	0.08	0.08	<0.01	0.4	0.4	<0.01
MB22	28/09/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.070	0.004	0.332	<0.01	3.47	3.91	4.23	503	317	7.57	25	<1	598	40	<0.1	30	174	25.00	0.17	0.03	0.02	<0.01	4.7	0.6	4.080
MB23																																
MB24	28/09/2006		0.51	0.001	0.001	0.0002	<0.05	0.509	0.034	0.993	0.015	2.58	1.11	4.94	18000	278	3.04	38	3	15300	80	<0.1	1130	6040	12.67	0.19	0.00	0.06	<0.01	7.5	0.7	6.770
MB25																																
MB26	29/09/2006		0.24	<0.001	<0.001	<0.0001	0.06	0.039	0.006	1.200	<0.01	3.52	1.81	5.76	721	143	4.15	22	26	604	32	<0.1	48	101	0.85	0.48	0.54	0.04	0.02	32.3	3.4	28.800
MB27	29/09/2006		<0.01	<0.001	<0.001	0.0001	<0.05	0.010	0.005	0.231	<0.01	1.35	0.89	7.32	5660	107	4.89	16	162	3570	28	<0.1	231	1700	0.10	0.14	0.70	0.06	0.02	0.4	0.3	0.159
MB28	28/09/2006		<0.01	0.005	<0.001	<0.0001	<0.05	0.010	0.015	0.415	0.019	1.15	0.69	6.87	13460	185	1.66	59	213	11000	11	<0.1	465	4230	0.28	0.11	0.46	0.04	<0.01	2.1	0.9	1.200
MB29																																
MB30	28/09/2006		0.84	0.002	0.001	0.0002	4.30	0.927	0.014	0.797	<0.01	35.90	42.00	5.45	2240	71	1.19	69	11	1730	550	<0.1	72	610	6.27	0.12	0.15	0.19	<0.01	1.4	1.4	<0.01
MB31	27/09/2006		0.04	0.003	<0.001	<0.0001	0.11	0.024	0.004	0.318	<0.01	19.00	18.80	4.03	138	273	1.10	15	2	140	12	<0.1	24	27	7.50	0.89	0.08	<0.01	<0.01	0.2	0.2	0.070
MB32	26/09/2006		0.19	0.003	<0.001	<0.0001	0.75	0.086	0.004	0.125	<0.01	3.13	3.63	5.52	178	17	1.52	11	22	210	146	0.1	10	40	0.50	0.25	2.20	0.11	0.01	1.5	0.6	0.885
ML1B1																																
ML1B2																																
ML1B3																																
ML1B4	26/09/2006		0.04	0.004	0.001	<0.0001	0.75	0.297	0.010	0.024	0.018	2.42	3.31	6.28	4830	37	1.41	28	53	2840	44	<0.1	300	1494	0.53	0.20	0.18	<0.01	<0.01	0.6	0.5	0.115
ML1B5	26/09/2006		0.59	0.002	<0.001	<0.0001	3.15	0.089	0.006	0.026	<0.01	1.17	3.60	4.61	320	106	2.25	15	1	262	10	<0.1	24	80	15.00	0.30	0.04	0.01	<0.01	0.9	0.6	0.355
ML1B6	26/09/2006		7.20	0.003	0.002	<0.0001	19.42	0.623	0.027	0.082	0.012	5.26	9.92	4.56	4590	174	1.66	128	<1	3930	38	<0.1	309	2077	128.00	0.15	0.00	<0.01	<0.01	0.7	0.6	0.135
ML1B7	26/09/2006		0.32	0.004	0.002	<0.0001	8.14	0.099	0.005	0.009	<0.01	1.04	9.26	6.54	2250	-67	4.21	13	65	1620	16	<0.1	187	691	0.20	0.27	0.35	0.02	<0.01	1.4	1.2	0.185
ML1B8	26/09/2006		0.10	0.002	<0.001	<0.0001	1.27	0.058	0.005	0.012	<0.01	0.63	3.78	7.05	2480	-77	2.42	13	237	1680	16	<0.1	303	637	0.05	0.48	0.78	0.01	<0.01	0.3	0.3	0.030
ML1B9	26/09/2006		0.04	0.003	<0.001	<0.0001	0.06	0.969	0.012	0.016	0.022	0.25	0.30	6.67	16910	98	2.07	40	148	18000	28	<0.1	2119	9935	0.27	0.21	0.07	0.05	0.05	1.0	0.6	0.455
MLWZ1	27/09/2006	(MB31)	0.04	0.001	<0.001	<0.0001	0.11	0.028	0.004	0.355	<0.01	17.20	18.00	-	-	-	-	15	<1	130	78	<0.1	22	22	15.00	0.99	0.05	0.02	<0.01	0.4	0.3	0.075
MLWZ3	28/09/2006	(MB24)	0.66	0.005	<0.001	0.0003	<0.05	0.463	0.032	0.948	0.011	2.38	0.97	-	-	-	-	49	2	16100	66	<0.1	1130	8770	24.50	0.13	0.00	0.01	0.01	7.6	0.6	7.060

Groundwater Results - October 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7	2.18[f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]	0.91[f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1	1/11/2006		<0.01	<0.001	<0.001	<0.0001	3.25	1.180	0.013	0.671	<0.01	1.61	5.79	6.08	12810	-64	0.31	54	79	9420	76	<0.1	1040	3880	0.68	0.27	0.08	<0.01	<0.01	0.4	0.4	0.015	0.112
MB2	1/11/2006		<0.01	0.001	<0.001	<0.0001	0.32	0.443	0.009	1.110	<0.01	1.46	2.51	6.36	3863	-7	0.65	<1	70	2290	42	<0.1	391	950	0.01	0.41	0.18	<0.01	<0.01	0.6	0.4	0.235	0.01
MB3	1/11/2006		0.06	0.001	<0.001	<0.0001	0.08	0.004	0.005	0.291	<0.01	21.80	25.30	5.98	215	159	0.82	9	22	96	462	<0.1	14	16	0.41	0.86	1.57	0.05	0.01	6.8	1.5	5.290	0.067
MB4																																	
MB5	2/11/2006		5.99	0.012	0.004	<0.0001	2.06	0.052	0.012	0.517	<0.01	19.80	11.60	6.63	695	-23	0.35	4	122	620	234	<0.1	44	111	0.03	0.40	2.77	0.08	<0.01	1.6	1.5	0.063	0.152
MB6	1/11/2006		0.09	0.003	0.002	<0.0001	4.28	0.064	0.010	0.700	<0.01	39.90	70.80	5.32	475	161	0.38	24	13	1400	112	<0.1	98	239	1.85	0.41	0.13	0.07	<0.01	2.0	1.6	0.450	0.128
MB7	1/11/2006		0.04	0.004	<0.001	<0.0001	15.00	0.428	0.016	1.760	<0.01	2.58	25.00	5.93	2282	8	0.38	35	22	1630	40	<0.1	488	328	1.59	1.49	0.05	<0.01	<0.01	0.2	0.1	0.100	0.084
MB8	2/11/2006		3.50	0.002	0.002	<0.0001	1.24	0.009	0.008	0.590	<0.01	3.58	2.17	5.95	265	95	0.37	22	37	150	256	<0.1	12	43	0.59	0.28	3.08	0.02	<0.01	0.9	0.8	0.029	0.07
MB9																																	
MB10																																	
MB11	1/11/2006		<0.1	<0.01	<0.01	<0.0001	2.24	2.330	0.020	0.520	<0.1	2.17	7.77	5.53	48650	126	0.44	29	125	35600	106	<0.1	3170	17800	0.23	0.18	0.04	0.01	0.03	0.6	0.5	0.035	1.67
MB12																																	
MB13	2/11/2006		<0.01	<0.001	<0.001	0.0001	4.60	1.280	0.020	2.550	<0.01	13.70	13.20	6.52	7887	-8	0.71	20	213	6060	26	<0.1	644	3190	0.09	0.20	0.33	0.09	<0.01	2.0	1.5	0.558	0.377
MB14	1/11/2006		<0.01	0.002	0.001	<0.0001	5.20	0.390	0.016	0.165	<0.01	12.70	21.70	6.35	26250	-36	0.81	28	142	17600	274	<0.1	1580	8730	0.20	0.18	0.09	0.22	0.03	0.9	0.9	0.030	0.488
MB15																																	
MB16																																	
MB17																																	
MB18	2/11/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.088	<0.01	0.475	<0.1	18.20	12.00	6.62	48190	80	0.33	33	288	36500	596	<0.1	3660	18300	0.11	0.20	0.08	0.02	0.01	0.9	0.8	0.086	0.374
MB19	2/11/2006		1.31	<0.001	0.001	0.0002	1.03	0.026	0.010	1.730	<0.01	6.55	4.92	5.45	500	199	1.37	6	9	994	48	<0.1	27	601	0.67	0.04	0.33	<0.01	<0.01	1.2	0.7	0.540	0.034
MB20																																	
MB21	3/11/2006		<0.01	0.002	0.001	0.0001	1.62	0.206	0.019	0.434	<0.01	3.78	12.80	5.82	24070	112	0.48	4	80	14900	70	<0.1	806	7940	0.05	0.10	0.10	0.02	<0.01	0.7	0.6	0.063	0.182
MB22	3/11/2006		0.06	<0.001	<0.001	<0.0001	<0.05	0.053	0.041	1.820	<0.01	19.10	30.30	4.25	364	365	5.72	25	<1	910	280	<0.1	60	405	25.00	0.15	0.02	0.06	<0.01	6.5	2.9	3.580	0.01
MB23																																	
MB24	3/11/2006		0.39	0.001	0.001	0.0002	<0.05	0.455	0.040	0.577	0.011	6.92	3.97	4.66	23600	273	1.53	34	1	16700	100	<0.1	1090	8370	34.00	0.13	0.00	<0.01	<0.01	6.4	0.5	5.870	0.082
MB25																																	
MB26	2/11/2006		0.02	<0.001	<0.001	<0.0001	<0.05	0.028	0.010	1.760	<0.01	2.78	1.63	6.03	960	135	0.84	12	43	852	32	<0.1	39	136	0.28	0.29	1.10	0.50	<0.01	44.5	2.5	42.000	0.065
MB27	2/11/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.077	0.006	0.672	<0.01	5.28	3.30	7.21	7708	-10	0.31	14	281	4400	58	<0.1	314	2300	0.05	0.14	0.89	<0.01	0.02	0.6	0.5	0.045	0.147
MB28	3/11/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.008	0.005	0.329	<0.01	2.96	1.82	7.01	14960	47	0.24	11	238	9950	56	<0.1	420	3850	0.05	0.11	0.57	0.01	<0.01	2.1	1.1	0.943	<0.010
MB29																																	
MB30	3/11/2006		<0.01	0.004	<0.001	<0.0001	13.40	1.090	0.020	0.996	<0.01	10.40	28.00	6.02	4897	-11	0.34	64	45	2790	196	<0.1	169	1360	1.42	0.12	0.27	0.06	<0.01	1.7	1.6	0.098	0.119
MB31	2/11/2006		7.36	0.001	0.004	<0.0001	4.07	0.006	0.012	0.744	<0.01	19.80	21.80	4.94	138	232	3.26	20	2	182	6	<0.1	1	25	10.00	0.04	2.00	0.09	<0.01	2.2	0.9	1.260	0.065
MB32	1/11/2006		0.22	<0.001	<0.005	<0.0001	1.73	0.077	0.013	1.350	<0.01	7.81	11.30	5.41	287	31	0.80	24	26	124	272	0.2	10	44	0.92	0.23	2.60	0.10	<0.01	1.8	1.2	0.615	0.155
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4	31/10/2006		0.02	<0.001	<0.005	<0.0001	1.50	0.401	0.025	0.619	<0.01	11.30	23.00	5.41	6350	114	0.85	111	97	3830	65	<0.1	335	1640	1.14	0.20	0.29	<0.01	<0.01	0.9	0.8	0.070	0.125
ML1B5	31/10/2006		0.88	0.005	0.002	<0.0001	6.99	0.280	0.005	0.854	<0.01	25.40	40.40	6.14	2565	-67	0.91	21	23	1000	704	<0.1	103	422	0.91	0.24	0.22	0.03	<0.01	1.6	1.4	0.155	0.089
ML1B6	31/10/2006		3.64	<0.001	<0.005	<0.0001	36.60	0.597	0.040	0.966	<0.01	8.67	46.90	4.57	6451	107	1.19	176	<1	4310	36	<0.1	349	2090	176.00	0.17	0.00	<0.01	<0.01	0.6	0.4	0.160	0.028
ML1B7	31/10/2006		0.32	0.004	<0.005	<0.0001	6.48	0.092	0.014	0.780	<0.01	1.04	7.77	5.70	2049	-2	0.38	139	53	1520	3	<0.1	140	594	2.62	0.24	0.38	<0.01	<0.01	0.9	0.8	0.040	0.13
ML1B8	31/10/2006		<0.01	<0.001	<0.005	0.0002	<0.05	1.200	0.014	0.697	<0.01	0.20	0.40	5.99	2117	65	0.64	124	180	1420	8	<0.1	190	421	0.69	0.45	0.95	<0.01	<0.01	0.7	0.7	<0.01	0.197
ML1B9	31/10/2006		0.10	0.002	<0.005	<0.0001	0.84	0.057	0.008	2.350	<0.01	1.15	4.20	6.07	25780	143	0.42	45	152	17600	6	<0.1	193	9570	0.30	0.02	0.79	<0.01	<0.01	0.4	0.3	0.065	0.33
MLWZ2	31/10/2006	(ML1B4)	0.03	<0.001	<0.005	0.0001	1.52	0.407	0.026	0.737	<0.01	12.20	24.60	-	-	-	-	158	102	3840	130	<0.1	346	1720	1.55	0.20	0.29	<0.01	<0.01	1.1	1.0	0.085	-
MLWZ3	3/11/2006	(MB1)	<0.01	<0.001	<0.005	<0.0001	<0.05	0.070	0.006	0.547	<0.01	4.46	2.65	-	-	-	-	9	282	5140	40	<0.1	316	51	0.03	6.20	0.89	0.02	0.02	0.7	0.7	0.023	-

Groundwater Results - November 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1	27/11/2006		<0.01	0.002	<0.001	<0.0001	3.55	1.060	0.014	0.215	<0.01	1.71	6.62	6.30	14220	-124	0.44	64	123	9220	40	0.1	941	5540	0.52	0.17	0.13	0.03	<0.01	0.3	0.2	0.115	0.253
MB2	27/11/2006		<0.01	<0.001	<0.001	<0.0001	2.08	0.720	0.011	0.528	<0.01	1.40	4.97	6.61	4853	-95	0.67	28	91	2860	30	<0.1	498	1390	0.31	0.36	0.18	0.03	<0.01	1.0	0.8	0.291	0.421
MB3	27/11/2006		0.05	<0.001	<0.001	<0.0001	0.08	0.003	0.005	0.493	<0.01	5.65	8.19	6.06	209	122	1.92	15	17	258	70	<0.1	16	21	0.88	0.77	1.06	0.05	<0.01	11.7	2.6	9.140	0.067
MB4																																	
MB5	28/11/2006		0.74	0.012	0.002	<0.0001	0.84	0.079	0.012	0.500	<0.01	17.40	12.00	6.70	746	-8	0.59	28	107	648	172	<0.1	53	129	0.26	0.41	2.02	0.08	<0.01	0.8	0.8	0.020	0.148
MB6	27/11/2006		0.66	0.002	0.002	<0.0001	1.79	0.057	0.007	1.260	<0.01	31.40	74.80	5.07	290	182	0.60	25	9	1160	178	<0.1	66	184	2.78	0.36	0.14	0.21	<0.01	5.5	4.3	1.210	0.12
MB7	27/11/2006		0.03	0.010	<0.001	<0.0001	27.70	0.353	0.028	0.590	<0.01	0.62	29.90	5.92	2831	-25	0.42	84	34	1920	18	<0.1	664	536	2.47	1.24	0.05	<0.01	<0.01	0.9	0.5	0.330	0.248
MB8	28/11/2006		2.94	0.001	0.002	<0.0001	1.06	0.010	0.006	0.917	<0.01	6.00	4.04	6.19	256	35	0.48	23	28	246	158	<0.1	21	44	0.82	0.48	1.33	0.03	<0.01	0.4	0.4	<0.01	0.1
MB9																																	
MB10																																	
MB11	27/11/2006		<0.1	<0.01	0.014	<0.001	2.56	2.920	0.023	0.339	<0.05	1.75	9.50	6.40	47790	21	0.39	27	140	35100	80	<0.1	3290	19000	0.19	0.17	0.04	0.03	0.02	2.2	2.0	0.198	1.88
MB12																																	
MB13	28/11/2006		<0.01	<0.001	<0.001	0.0001	6.08	1.280	0.012	1.420	<0.01	7.80	12.10	6.87	9709	-67	0.73	51	202	6310	174	0.1	567	3990	0.25	0.14	0.36	0.12	<0.01	1.5	1.1	0.375	0.538
MB14	27/11/2006		<0.1	<0.01	<0.01	<0.001	1.55	0.283	<0.01	0.281	<0.1	14.20	21.00	6.36	25880	-102	0.44	43	148	17600	272	<0.1	1460	9000	0.29	0.16	0.10	0.07	<0.01	1.1	0.8	0.234	0.692
MB15																																	
MB16																																	
MB17																																	
MB18	28/11/2006		<0.1	<0.01	<0.01	<0.001	<0.5	0.108	0.015	0.272	<0.1	8.85	8.10	6.75	46120	63	0.61	50	246	34200	134	<0.1	2470	17300	0.20	0.14	0.10	0.08	<0.01	1.2	<0.1	1.180	0.037
MB19	29/11/2006		0.01	<0.001	<0.001	0.0001	0.40	0.036	0.013	2.150	<0.01	7.27	6.82	5.99	3893	98	2.48	23	29	2510	73	<0.1	178	1200	0.79	0.15	0.16	0.03	<0.01	1.0	0.4	0.688	0.31
MB20																																	
MB21	29/11/2006		<0.01	<0.001	<0.001	<0.0001	1.84	0.200	0.020	0.476	<0.01	7.14	14.10	5.97	23300	81	0.68	68	72	15300	176	<0.1	862	9390	0.94	0.09	0.08	0.01	<0.01	0.2	0.1	0.082	0.6
MB22	29/11/2006		0.08	<0.001	<0.001	0.0001	<0.05	0.168	0.039	0.799	<0.01	5.58	9.85	4.06	1543	381	5.03	29	<1	2860	122	<0.1	307	1310	29.00	0.23	0.00	0.03	<0.01	4.2	0.6	3.580	0.285
MB23																																	
MB24	29/11/2006		0.04	<0.001	<0.001	0.0003	0.08	0.433	0.033	1.150	<0.01	3.97	2.54	4.72	23330	308	1.56	24	1	15900	68	<0.1	1130	9360	24.00	0.12	0.00	<0.01	<0.01	6.4	<0.1	6.430	0.16
MB25																																	
MB26	28/11/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.010	0.006	0.641	<0.01	9.27	6.45	6.57	1106	91	1.22	17	50	794	8	<0.1	57	165	0.34	0.35	0.88	0.09	<0.01	62.0	5.2	56.800	0.065
MB27	28/11/2006		<0.01	<0.001	0.001	<0.0001	<0.05	0.095	0.006	0.254	<0.01	1.64	1.40	7.40	7899	9	0.47	13	248	4030	<1	<0.1	332	3040	0.05	0.11	0.75	0.08	<0.01	0.3	0.3	<0.01	0.236
MB28	29/11/2006		<0.01	<0.001	<0.001	<0.0001	0.08	0.013	0.012	0.407	<0.01	2.23	1.52	7.03	18070	126	0.41	20	224	12600	24	<0.1	550	5290	0.09	0.10	0.41	0.04	<0.01	1.4	<0.1	1.430	0.135
MB29																																	
MB30	29/11/2006		<0.01	0.006	<0.001	0.0001	19.00	1.090	0.021	0.540	<0.01	27.60	52.50	6.37	5569	-91	0.66	79	46	3580	486	<0.1	236	1670	1.72	0.14	0.19	0.22	<0.01	1.3	1.2	0.143	0.61
MB31	28/11/2006		0.18	<0.001	<0.001	<0.0001	0.25	0.004	0.023	0.668	<0.01	20.50	26.00	4.81	127	252	3.91	23	8	466	120	<0.1	15	21	2.88	0.70	0.53	0.13	<0.01	2.1	0.8	1.290	<0.010
MB32	27/11/2006		0.18	0.002	0.001	<0.0001	4.38	0.053	0.011	0.178	<0.01	1.12	5.86	6.29	281	-99	0.48	9	<1	188	32	<0.1	9	57	9.00	0.16	0.11	0.05	0.04	1.7	1.3	0.363	0.278
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4	24/11/2006		<0.01	<0.001	<0.001	0.0003	<0.05	0.775	0.014	0.296	<0.01	7.68	15.30	6.64	21240	23	0.89	24	279	13900	122	<0.1	1230	6670	0.09	0.18	0.23	0.06	<0.01	1.6	1.6	0.055	0.677
ML1B5	24/11/2006		0.23	0.004	0.001	<0.0001	7.76	0.309	0.019	0.728	<0.01	1.76	12.60	6.24	3499	-114	0.59	38	41	1520	20	0.1	211	689	0.93	0.31	0.19	0.07	<0.01	0.7	0.6	0.085	0.104
ML1B6	24/11/2006		0.15	0.001	<0.001	<0.0001	51.80	0.503	0.031	0.364	<0.01	2.00	57.90	5.18	7160	-25	0.84	132	267	4410	34	<0.1	440	1610	0.49	0.27	0.61	0.01	0.01	0.8	0.5	0.265	0.07
ML1B7	24/11/2006		0.39	0.011	0.002	<0.0001	9.52	0.074	0.007	0.370	<0.01	1.89	18.60	6.67	2931	-126	0.47	26	79	1940	22	<0.1	240	856	0.33	0.28	0.33	0.02	0.01	0.9	0.8	0.100	0.11
ML1B8	24/11/2006		<0.01	0.002	<0.001	<0.0001	<0.05	0.044	0.004	0.040	<0.01	1.27	5.30	7.40	2751	-113	0.47	16	17	1680	32	<0.1	346	651	0.94	0.53	0.05	0.02	0.01	0.5	0.4	0.080	0.196
ML1B9	24/11/2006		<0.1	<0.01	<0.01	<0.001	<0.5	1.500	0.012	0.358	<0.1	0.50	1.06	6.45	33970	85	0.55	39	235	23300	36	<0.1	2250	11900	0.17	0.19	0.10	<0.01	<0.01	1.3	1.3	<0.01	1.13
MLWZ2	24/11/2006	(ML1B6)	0.16	<0.001	<0.001	<0.0001	51.20	0.516	0.031	0.473	<0.01	2.07	56.50	-	-	-	-	166	16	4130	24	<0.1	388	2380	10.38	0.16	0.04	<0.01	0.01	0.8	0.6	0.160	0.085
MLWZ3	29/11/2006	(MB28)	<0.01	<0.001	<0.001	<0.0001	0.09	0.014	0.012	0.434	<0.01	1.99	1.49	-	-	-	-	23	239	12400	22	<0.1	554	5340	0.10	0.10	0.43	<0.01	<0.01	1.4	<0.1	1.440	0.325

Groundwater Results - December 2006

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1	20/12/2006		<0.01	<0.001	<0.001	<0.0001	1.38	0.654	0.024	0.014	<0.010	<0.10	3.75	6.29	15580	-116	0.86	3	148	9520	80	0.1	1020	4270	0.02	0.24	0.15	0.01	<0.010	0.4	0.4	0.010	0.326
MB2	19/12/2006		<0.01	0.004	<0.001	<0.0001	1.22	1.600	0.008	0.308	<0.010	44.20	65.30	6.68	7	-115	1.05	16	157	3970	2220	<0.1	639	1740	0.10	0.37	0.25	0.22	<0.010	0.9	0.8	0.086	0.239
MB3	19/12/2006		0.05	<0.001	<0.001	<0.0001	0.07	0.004	0.006	1.220	<0.010	7.06	8.11	6.13	218	127	2.08	11	25	110	66	<0.1	18	19	0.44	0.95	1.39	0.04	<0.010	9.7	2.3	7.380	0.044
MB4																																	
MB5	20/12/2006		0.22	0.007	<0.001	<0.0001	0.20	0.082	0.007	0.502	<0.010	21.90	21.20	6.50	943	83	1.44	10	104	892	106	<0.1	69	191	0.10	0.36	1.51	0.17	<0.010	1.5	1.0	0.517	0.036
MB6	19/12/2006		0.08	0.002	0.001	<0.0001	1.00	0.051	0.006	1.140	<0.010	42.60	81.00	5.41	691	148	1.17	21	10	540	216	0.5	115	185	2.10	0.62	0.09	0.22	<0.010	1.9	1.4	0.499	0.123
MB7	19/12/2006		<0.01	0.010	<0.001	0.0002	25.30	0.268	0.016	1.480	<0.010	0.84	35.20	6.00	3326	-19	0.86	67	41	2450	40	<0.1	914	494	1.63	1.85	0.04	0.02	<0.010	0.5	0.4	0.089	0.192
MB8	20/12/2006		0.30	<0.001	<0.001	<0.0001	0.12	0.007	0.004	0.587	<0.010	16.00	10.00	6.28	282	-9	0.82	16	40	344	8	<0.1	24	42	0.40	0.57	1.67	0.06	<0.010	0.3	0.3	<0.010	0.137
MB9																																	
MB10																																	
MB11	19/12/2006		<0.10	<0.010	<0.010	<0.0010	1.90	2.430	0.021	0.190	<0.100	1.91	6.72	6.15	50150	36	0.71	31	148	33200	174	<0.1	3670	18800	0.21	0.20	0.04	0.05	<0.010	1.8	1.8	<0.010	1.75
MB12																																	
MB13	20/12/2006		<0.01	<0.001	<0.001	0.0001	1.16	1.700	0.013	1.560	<0.010	9.83	15.30	6.87	9709	-67	0.73	26	238	6260	142	<0.1	599	2650	0.11	0.23	0.40	0.05	<0.010	1.8	1.5	0.243	0.537
MB14	19/12/2006		<0.01	0.002	<0.001	<0.0001	1.39	0.273	0.020	0.377	<0.010	48.60	49.40	6.36	27270	-86	0.80	7	152	20400	1180	<0.1	1860	11000	0.05	0.17	0.08	0.11	<0.010	0.8	0.8	<0.010	0.81
MB15																																	
MB16																																	
MB17																																	
MB18	21/12/2006		<0.10	<0.010	<0.010	<0.0010	<0.50	0.107	0.014	0.357	<0.100	15.50	12.40	6.72	48950	64	0.86	68	252	35400	502	<0.1	642	19900	0.27	0.03	0.39	0.06	0.01	0.4	0.3	0.099	0.046
MB19	21/12/2006		<0.01	<0.001	<0.001	0.0002	0.74	0.032	0.014	2.700	<0.010	11.00	11.00	6.01	7006	66	3.12	16	40	4120	68	<0.1	266	2360	0.40	0.11	0.15	0.06	<0.010	1.8	0.7	1.060	0.125
MB20																																	
MB21	21/12/2006		<0.01	<0.001	<0.001	0.0001	2.42	0.207	0.023	0.305	<0.010	3.36	8.32	5.85	24340	73	0.79	25	68	13600	328	<0.1	197	8680	0.37	0.02	0.35	0.01	<0.010	0.3	0.2	0.093	0.295
MB22	21/12/2006		0.04	0.001	<0.001	<0.0001	<0.05	0.600	0.020	0.685	<0.010	7.90	7.19	4.83	17640	238	0.84	33	18	11800	208	<0.1	1090	6040	1.83	0.18	0.02	0.04	<0.010	1.6	0.4	1.230	0.084
MB23																																	
MB24	21/12/2006		0.02	0.002	<0.001	0.0003	<0.05	0.495	0.032	1.470	<0.010	4.27	3.16	4.66	24390	285	1.60	38	2	19000	116	<0.1	262	8200	19.00	0.03	0.01	0.02	<0.010	5.3	0.2	5.030	0.034
MB25																																	
MB26	20/12/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.007	0.003	0.200	<0.010	2.20	0.95	6.66	1152	65	1.00	5	66	744	18	<0.1	64	186	0.08	0.34	1.03	0.02	<0.010	38.8	4.2	34.600	0.113
MB27	20/12/2006		<0.01	<0.001	<0.001	<0.0001	<0.05	0.059	0.005	0.169	<0.010	4.38	3.49	7.35	6895	18	0.74	6	265	3910	60	<0.1	306	2020	0.02	0.15	0.87	<0.01	<0.010	1.4	0.8	0.679	0.283
MB28	21/12/2006		<0.01	0.001	<0.001	0.0002	<0.05	0.023	0.008	0.388	<0.010	2.29	1.80	6.93	21320	113	0.84	11	219	14000	60	<0.1	652	6020	0.05	0.11	0.34	0.04	<0.010	2.1	0.7	1.400	0.03
MB29																																	
MB30	21/12/2006		<0.01	0.006	<0.001	<0.0001	25.70	1.470	0.015	0.205	<0.010	8.10	42.00	6.29	7070	-109	0.64	71	54	7130	116	0.1	262	5430	1.31	0.05	0.21	0.08	<0.010	0.8	0.7	0.162	0.139
MB31	20/12/2006		0.10	<0.001	<0.001	<0.0001	0.06	0.003	0.008	0.615	<0.010	16.10	20.20	5.07	141	188	3.28	4	1	286	56	<0.1	16	23	4.00	0.71	0.06	0.09	<0.010	3.4	1.4	2.010	0.047
MB32	19/12/2006		0.20	0.002	0.002	<0.0001	4.54	0.053	0.010	0.218	<0.010	1.37	7.13	6.30	322	-109	1.07	18	42	224	42	0.1	10	63	0.43	0.16	4.20	0.08	0.02	0.8	0.7	0.067	0.315
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4	18/12/2006		<0.01	<0.001	<0.001	0.0003	<0.05	0.298	0.004	0.051	<0.010	7.36	11.40	6.97	28350	-25	0.76	35	315	18600	428	<0.1	2100	9490	0.11	0.22	0.15	0.10	<0.010	1.1	1.1	<0.010	1.15
ML1B5	18/12/2006		0.03	0.006	<0.001	<0.0001	12.60	0.425	0.019	1.210	<0.010	0.74	16.70	6.51	10140	-76	0.90	50	91	5220	56	<0.1	941	3180	0.55	0.30	0.10	0.01	<0.010	4.6	4.6	<0.010	0.387
ML1B6	18/12/2006		0.04	<0.001	<0.001	<0.0001	90.10	0.442	0.022	0.366	<0.010	2.78	82.70	5.18	7160	-25	0.84	218	72	6850	114	<0.1	722	3790	3.03	0.19	0.10	0.02	<0.010	1.0	1.0	<0.010	0.254
ML1B7	18/12/2006		0.48	0.016	0.002	<0.0001	15.20	0.073	0.008	0.398	<0.010	1.82	20.90	6.54	2999	-60	0.73	84	74	1740	44	<0.1	304	847	1.14	0.36	0.24	0.02	<0.010	1.2	1.2	0.031	0.164
ML1B8	18/12/2006		<0.01	0.001	<0.001	<0.0001	0.16	0.044	0.003	0.109	<0.010	0.24	1.28	7.44	3146	-128	0.71	20	269	1730	30	<0.1	373	597	0.07	0.62	0.72	<0.01	<0.010	4.7	4.7	<0.010	0.24
ML1B9	18/12/2006		<0.10	<0.010	<0.010	<0.0010	<0.50	1.700	0.018	0.384	<0.100	<0.10	<0.50	6.57	39110	85	0.63	82	244	21100	104	<0.1	3350	12700	0.34	0.26	0.07	<0.01	<0.010	1.2	1.2	<0.010	1.2
MLWZ1	18/12/2006	(ML1B7)	0.43	0.015	0.002	<0.0001	15.50	0.075	0.008	0.401	<0.010	1.50	17.80	-	-	-	-	69	72	1860	38	<0.1	267	852	0.96	0.31	0.27	0.14	<0.010	1.7	1.7	0.031	0.152
MLWZ3	20/12/2006	(MB1)	<0.01	<0.001	<0.001	<0.0001	2.24	0.751	0.021	0.220	<0.010	3.61	6.70	-	-	-	-	19	154	9860	72	0.1	1020	4560	0.12	0.22	0.15	<0.01	<0.010	0.3	0.3	0.058	0.293

Average Groundwater Quality in all Bores across 12 Sampling Occasions January 2006 – December 2006

Location	Guideline Value	pH	E.C µc/cm	Redox	DO	Total P mg/l	Reactive P mg/l	Total N mg/l	TKN mg/l	Nox mg/l	Al mg/l	As mg/l	Cr mg/l	Cd mg/l	Fe mg/l	Mn mg/l	Ni mg/l	Zn mg/l	Se mg/l	Total Al mg/l	Total Fe mg/l
	LOR	-	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05
	FWG	6.5-8.5	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	0.06	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG
	MEPG	7.5-8.5 [c]	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG
	LIWG	NG	2300 [e]	NG	NG	NG	NG	NG	NG	NG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG
MB1		6.12	12517	25	1.03	0.08	0.010	0.5	0.5	0.05	0.02	0.001	0.001	0.0001	0.91	0.55	0.01	0.51	0.01	6.46	8.64
MB2		6.45	6597	46	1.07	3.25	0.009	1.8	1.1	0.61	0.02	0.004	0.001	0.0002	0.18	0.71	0.01	0.55	0.01	49.43	92.24
MB3		5.82	217	141	1.33	2.90	0.010	5.8	1.4	4.38	0.73	0.001	0.001	0.0002	0.48	0.02	0.01	0.65	0.01	19.55	20.47
MB4		6.07	508	244	0.6	0.28	0.01	0.2	0.1	0.155	0.58	0.001	0.001	0.0001	0.13	0.04	0.00	0.21	0.01	36.3	15.1
MB5		6.41	740	25	0.63	0.22	0.011	0.0	0.0	0.01	2.19	0.009	0.002	0.0003	1.22	0.06	0.01	0.46	0.01	38.41	18.43
MB6		5.35	963	124	0.98	0.27	0.012	1.8	1.4	0.39	0.21	0.004	0.002	0.0001	8.43	0.08	0.01	0.94	0.01	41.31	92.55
MB7		5.58	2400	44	0.67	0.03	0.010	2.1	1.3	0.37	0.13	0.008	0.001	0.0001	19.26	0.42	0.02	1.17	0.01	2.93	27.07
MB8		6.42	991	26	1.24	0.26	0.012	0.5	0.4	0.09	3.88	0.001	0.002	0.0002	1.79	0.01	0.00	0.55	0.01	71.34	41.04
MB9		6.66	13620	-44	1.5	0.01	0.01	0.5	0.5	0.025	0.01	0.002	0.001	0.0001	2.12	0.21	0.00	0.39	0.01	11.7	13.6
MB10		6.78	13930	-90	0.2	0.05	0.01	0.5	0.5	0.07	0.01	0.002	0.001	0.0002	6.95	0.41	0.00	0.42	0.01	22.8	40.8
MB11		6.22	39391	49	0.58	0.08	0.001	1.7	1.4	0.29	0.10	0.010	0.010	0.0009	2.01	2.48	0.02	0.43	0.09	5.17	10.18
MB12		7.39	1177	-66	0.8	0.1	0.01	0.6	0.2	0.42	0.91	0.004	0.001	0.0001	0.48	0.07	0.00	0.10	0.01	17.2	9.31
MB13		6.82	7168	-33	0.83	0.07	0.001	0.0	0.0	0.00	0.02	0.001	0.001	0.0001	2.46	1.44	0.01	1.09	0.01	10.88	9.61
MB14		6.40	20216	4	0.72	0.10	0.012	0.0	0.0	0.01	0.02	0.002	0.002	0.0002	0.49	0.29	0.01	0.35	0.02	23.83	25.85
MB15		6.37	31200	144	0.2	0.01	0.01	0.6	0.6	0.02	0.01	0.001	0.001	0.0002	0.05	0.61	0.01	0.50	0.01	10.3	5.61
MB16		7.28	1419	60	0.2	0.09	0.01	0.8	0.7	0.02	0.65	0.002	0.001	0.0001	0.29	0.27	0.00	0.27	0.01	26	18
MB17		6.46	575	68	0.3	0.07	0.01	1.4	1.3	0.12	0.55	0.005	0.001	0.0001	0.89	0.33	0.00	0.66	0.01	6.96	6.46
MB18		6.97	25525	108	0.81	0.08	0.001	1.6	1.5	0.04	0.09	0.010	0.009	0.0009	0.60	0.11	0.01	0.26	0.09	9.63	7.50
MB19		5.74	4555	132	1.91	0.06	0.014	0.1	0.0	0.04	0.27	0.001	0.002	0.0001	0.97	0.03	0.01	1.16	0.02	11.74	10.90
MB20		6.22	13980	57	0.1	0.04	0.01	0.2	0.2	0.035	0.01	0.001	0.001	0.0003	1.19	0.15	0.00	1.14	0.01	6.46	7.44
MB21		5.97	22245	88	0.88	0.15	0.014	1.8	1.1	0.66	0.06	0.004	0.003	0.0003	2.33	0.34	0.02	0.44	0.03	18.68	24.15
MB22		4.98	15530	249	2.73	0.06	0.010	0.8	0.7	0.05	0.07	0.001	0.001	0.0001	0.81	0.52	0.02	0.52	0.01	11.19	16.10
MB23		6.67	26100	197	0.4	0.04	0.01	1	0.1	0.955	0.01	0.001	0.001	0.0002	0.05	0.03	0.00	0.62	0.01	11.9	7.9
MB24		5.74	20460	269	1.2	0.08	0.01	5.6	0.8	4.8	0.01	0.001	0.001	0.0005	0.05	0.50	0.02	0.50	0.01	53.2	35.7
MB25		6.71	5260	221	0.2	0.1	0.01	0.5	0.5	0.01	0.02	0.001	0.001	0.0002	0.05	0.05	0.00	0.27	0.01	31.3	31
MB26		6.38	1213	157	1.25	0.14	0.011	0.1	0.1	0.00	0.12	0.001	0.001	0.0001	0.04	0.03	0.01	0.65	0.01	11.26	7.11
MB27		7.43	5659	69	0.86	0.05	0.013	0.1	0.1	0.00	0.01	0.001	0.001	0.0001	0.05	0.06	0.00	0.18	0.01	5.79	3.29
MB28		6.99	12285	129	1.06	0.04	0.010	0.1	0.1	0.01	0.03	0.001	0.001	0.0001	0.02	0.02	0.01	0.28	0.01	3.10	1.87
MB29		6.98	4940	207	0.1	0.02	0.01	0.4	0.4	0.01	0.01	0.001	0.001	0.0001	0.05	0.02	0.00	0.16	0.01	2.86	2.11
MB30		6.00	3318	5	0.51	0.34	0.011	0.9	0.5	0.42	0.14	0.006	0.001	0.0001	6.44	0.96	0.01	0.84	0.01	63.44	83.35
MB31		4.74	150	208	1.74	0.35	0.011	1.3	0.4	0.90	1.32	0.002	0.002	0.0001	1.47	0.02	0.01	0.59	0.01	57.08	52.85
MB32		5.97	317	-21	1.10	0.14	0.020	0.0	0.0	0.00	0.38	0.002	0.003	0.0001	2.57	0.05	0.01	0.45	0.01	4.58	8.92

LOR Limit of Reporting, FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines

a) Aluminium trigger level relates to waters with pH >6.5; no guideline is provided for water pH< 6.5.
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for estuarine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
d) Values for wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species

Groundwater Results - April 2007

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm), Redox (mV)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Dissolved Metals									Total Metals		Field Parameters			
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-
		FWG	0.055[a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005[b]	NG	NG	6.5-8.5	NG	NG	NG
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5[c]	NG	NG	NG
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300[e]	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG
MB1																	
MB2	12/04/2007		<0.01	0.005	<0.001	0.0006	0.11	2.920	0.019	0.428	0.016	557.00	1010.00	6.15	23900	-38	3.07
MB3																	
MB4																	
MB5																	
MB6																	
MB7	12/04/2007		0.04	0.008	<0.001	<0.0001	20.30	0.314	0.022	1.580	<0.010	46.50	126.00	5.34	4073	-26	1.22
MB8	12/04/2007		2.89	<0.001	0.002	<0.0001	0.95	0.002	0.004	0.126	<0.010	23.00	11.90	6.11	363	-11	0.78
MB9																	
MB10																	
MB11	13/04/2007		<0.10	<0.010	<0.010	<0.0010	1.36	2.000	0.042	0.512	<0.100	12.20	22.30	5.95	48360	-43	0.98
MB12																	
MB13	12/04/2007		<0.01	0.003	<0.001	0.0003	7.29	1.100	0.015	1.520	<0.010	11.90	22.30	6.24	13760	-62	0.91
MB14	12/04/2007		<0.01	0.005	<0.001	0.0002	0.53	0.273	0.031	1.140	0.021	207.00	230.00	5.98	26930	-26	1.38
MB15														5.30	35520	-46	1.36
MB16																	
MB17																	
MB18	12/04/2007		<0.10	<0.010	<0.010	0.0014	<0.50	0.165	0.030	1.460	<0.100	38.10	27.50	6.41	49710	-66	0.85
MB19																	
MB20																	
MB21	13/04/2007		<0.01	<0.001	0.003	0.0003	1.57	0.181	0.020	1.380	<0.010	14.00	22.30	5.46	23910	-36	1.06
MB22	13/04/2007		<0.01	<0.001	0.003	0.0001	0.81	0.865	0.021	1.160	<0.010	35.60	50.60	5.60	30500	-38	1.01
MB23																	
MB24	13/04/2007		0.19	0.001	0.002	0.0002	<0.05	0.560	0.042	0.933	<0.010	14.40	10.50	4.31	24700	-39	1.18
MB25																	
MB26	12/04/2007		<0.01	<0.001	0.001	<0.0001	0.07	0.013	0.001	0.042	<0.010	3.27	1.59	6.79	1301	-23	0.89
MB27																	
MB28																	
MB29																	
MB30																	
MB31																	
MB32																	
ML1B1																	
ML1B2																	
ML1B3																	
ML1B4																	
ML1B5																	
ML1B6	12/04/2007		<0.10	0.013	<0.010	<0.0010	16.60	0.523	0.020	5.300	<0.100	12.30	45.50	5.90	38950	-58	1.49
ML1B7																	
ML1B8																	
ML1B9	13/04/2007		<0.10	<0.010	<0.010	<0.0010	<0.50	1.470	0.021	0.389	<0.100	0.86	2.05	6.17	38540	-43	0.99
MLWZ1	12/04/2007	(MB2)	<0.01	0.003	0.001	0.0006	0.14	3.030	0.020	0.454	0.014	459	978	-	-	-	-

1	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
LOR	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
FWG	NG	NG	NG	NG	0.001[b]	NG	NG	NG	NG	NG	0.06[d]	0.03[d]	1.5[d]	NG	0.7	2.18[f]
MEPG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03[c]	0.005[c,b]	0.75[c]	NG	0.045[c]	0.91[f]
LIWG	NG	NG	1500[e]	NG	NG	NG	710[e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
ASS	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1																
MB2	116	315	16800	29600	0.3	3550	7510	0.37	0.47	0.09	0.28	<0.010	4.8	4.8	<0.010	0.671
MB3																
MB4																
MB5																
MB6																
MB7	69	10	2940	2060	<0.1	876	692	6.90	1.27	0.01	0.15	<0.010	1.5	1.4	0.010	0.136
MB8	3	60	586	50	<0.1	24	61	0.05	0.39	2.50	0.10	<0.010	0.9	0.8	0.062	0.135
MB9																
MB10																
MB11	24	164	33900	1600	<0.1	3040	17400	0.15	0.17	0.05	0.04	<0.010	2.2	2.2	<0.010	1.92
MB12																
MB13	47	236	18000	210	<0.1	825	3750	0.20	0.22	0.29	0.06	<0.010	0.9	0.9	0.013	0.556
MB14	5	150	9260	4540	<0.1	1500	9190	0.03	0.16	0.10	0.18	<0.010	2.1	2.0	0.020	0.722
MB15																
MB16																
MB17																
MB18	47	292	36800	1140	<0.1	1300	18400	0.16	0.07	0.22	0.04	0.02	0.3	0.2	0.067	0.11
MB19																
MB20																
MB21	20	78	14800	510	<0.1	702	7520	0.26	0.09	0.11	0.05	<0.010	0.5	0.4	0.143	0.182
MB22	6	118	20300	1120	<0.1	2090	11000	0.05	0.19	0.06	0.06	<0.010	0.9	0.9	<0.010	0.716
MB23																
MB24	20	3	15600	720	<0.1	976	7620	6.67	0.13	0.00	0.04	<0.010	7.0	0.3	6.780	<0.010
MB25																
MB26	10	135	838	76	<0.1	84	212	0.07	0.40	1.61	0.04	0.013	14.3	1.3	13.000	0.018
MB27																
MB28																
MB29																
MB30																
MB31																
MB32																
ML1B1																
ML1B2																
ML1B3																
ML1B4																
ML1B5																
ML1B6	68	140	25800	320	<0.1	2190	13300	0.49	0.16	0.06	0.03	<0.010	2.1	2.1	0.012	1.47
ML1B7																
ML1B8																
ML1B9	15	260	26000	1340	<0.1	2760	13000	0.06	0.21	0.09	0.01	<0.010	1.1	1.0	0.038	0.969
MLWZ1	50	306	16400	27200	0.4	3510	7540				0.36	<0.010	6.4	6.4	<0.010	0.744

Groundwater Results - July 2007

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm), Redox (mV)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1																																	
MB2	11/07/2007		<0.01	0.002	<0.001	0.0008	<0.05	0.953	0.011	1.240	<0.010	37.80	25.90	5.74	4646	-46	0.83	20	67	3160	706	<0.1	480	1290	0.30	0.37	0.14	0.25	<0.010	0.8	0.7	0.109	-
MB3																																	
MB4																																	
MB5																																	
MB6																																	
MB7	11/07/2007		0.03	0.002	0.002	0.0001	4.07	0.177	0.015	2.390	<0.010	10.90	21.80	5.00	1339	-16	0.57	42	<1	967	158	<0.1	302	238	42.00	1.27	0.00	0.04	<0.010	0.6	0.5	0.121	-
MB8	11/07/2007		0.95	0.002	<0.001	<0.0001	0.42	<0.001	0.005	0.135	<0.010	30.50	15.80	6.05	447	-33	0.40	9	26	302	160	<0.1	54	91	0.35	0.60	0.48	0.11	<0.010	1.3	0.8	0.447	-
MB9																																	
MB10																																	
MB11	12/07/2007		<0.10	<0.010	<0.010	<0.0010	1.63	2.380	0.016	0.402	<0.100	4.81	15.10	5.63	50400	-54	0.33	59	2	38800	488	<0.1	3240	20300	29.50	0.16	0.00	0.02	<0.010	1.0	1.0	0.018	-
MB12																																	
MB13	11/07/2007		0.04	<0.001	<0.001	<0.0001	0.10	0.196	0.004	0.064	<0.010	8.00	5.37	6.16	4400	-43	2.15	24	112	2610	166	<0.1	253	1340	0.21	0.19	0.44	0.10	<0.010	28.3	1.6	26.700	-
MB14	11/07/2007		<0.01	0.003	<0.001	0.0002	1.08	0.247	0.020	0.877	<0.010	2.38	6.06	6.01	25630	-37	0.41	17	156	14400	70	<0.1	1500	8860	0.11	0.17	0.10	0.03	<0.010	0.5	0.5	0.010	-
MB15																																	
MB16																																	
MB17																																	
MB18	11/07/2007		<0.10	<0.010	<0.010	<0.0010	<0.50	0.027	<0.010	0.254	<0.100	4.30	2.05	6.57	30120	-43	1.18	22	234	24300	150	<0.1	1730	11500	0.09	0.15	0.14	0.06	0.03	2.2	0.5	1.620	-
MB19																																	
MB20																																	
MB21	12/07/2007		<0.10	<0.010	<0.010	<0.0010	<0.50	0.157	<0.010	0.613	<0.100	6.33	14.20	5.33	39460	-52	0.48	34	51	23400	248	<0.1	1280	15400	0.67	0.08	0.04	0.02	<0.010	2.4	0.2	2.140	-
MB22	12/07/2007		<0.01	0.002	<0.001	<0.0001	0.08	0.774	0.019	1.050	<0.010	4.93	11.10	5.32	29010	-36	0.67	67	88	23700	180	<0.1	1860	10900	0.76	0.17	0.05	0.02	<0.010	0.9	0.7	0.124	-
MB23																																	
MB24	12/07/2007		0.97	0.002	<0.001	0.0004	<0.05	0.683	0.034	0.554	<0.010	6.78	4.24	4.26	24170	-48	1.33	33	1	16100	316	<0.1	1150	8120	33.00	0.14	0.00	0.02	<0.010	8.4	0.3	8.140	-
MB25																																	
MB26	11/07/2007		0.04	<0.001	<0.001	0.0002	<0.05	0.003	0.001	0.031	<0.010	3.41	1.24	6.58	1170	-20	2.67	7	58	824	40	<0.1	60	193	0.12	0.31	0.97	0.05	0.012	28.7	1.4	27.300	-
MB27																																	
MB28																																	
MB29																																	
MB30																																	
MB31																																	
MB32																																	
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4																																	
ML1B5																																	
MLIB6	12/07/2007		3.52	<0.001	<0.001	0.0002	0.09	0.091	0.051	0.861	<0.010	8.60	0.63	3.44	4876	-26	4.67	127	<1	2810	22	<0.1	70	1480	127.00	0.05	0.01	<0.01	<0.010	16.3	<0.1	16.300	-
ML1B7																																	
ML1B8																																	
MLIB9	12/07/2007		0.02	0.004	<0.001	0.0001	<0.05	0.384	0.002	0.040	<0.010	0.64	0.66	6.22	9602	-52	2.32	11	69	6440	34	<0.1	592	2700	0.16	0.22	0.12	0.02	<0.010	2.8	0.4	2.360	-
MLWZ1	11/07/2007	(MB7)	0.03	0.002	0.002	<0.0001	4.13	0.181	0.015	2.350	<0.010	10.20	21.90	-	-	-	-	43	<1	813	182	<0.1	300	228	43.00	1.32	0.00	0.06	<0.010	0.7	0.6	0.097	

Groundwater Results - September 2007

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm), Redox (mV)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1																																	
MB2	13/09/2007		0.02	0.001	<0.001	0.0001	2.09	0.882	0.014	0.624	<0.010	15.30	9.22	5.10	1838	-22	1.08	10	49	1260	220	<0.1	165	418	0.20	0.39	0.30	0.03	<0.010	0.9	0.7	0.204	-
MB3																																	
MB4																																	
MB5																																	
MB6																																	
MB7	13/09/2007		0.27	<0.001	<0.001	<0.0001	3.74	0.080	0.023	2.510	<0.010	6.74	7.87	3.57	523	-57	1.30	31	<1	418	110	<0.1	42	118	31.00	0.36	0.02	0.05	<0.010	1.1	1.0	0.053	-
MB8	13/09/2007		0.15	<0.001	<0.001	<0.0001	<0.05	0.003	0.003	0.618	<0.010	0.11	<0.05	4.87	271	-68	0.44	15	34	268	5	<0.1	20	48	0.44	0.42	1.70	<0.01	<0.010	0.3	0.3	<0.010	-
MB9																																	
MB10																																	
MB11	14/09/2007		8.25	0.002	0.001	0.0002	1.14	0.516	0.070	2.310	<0.010	13.60	2.95	2.95	2120	1	2.15	149	<1	1460	32	<0.1	177	632	149.00	0.28	0.01	0.04	<0.010	0.9	0.6	0.343	-
MB12																																	
MB13	13/09/2007		0.02	<0.001	<0.001	<0.0001	0.38	0.487	0.003	0.514	<0.010	10.10	5.58	6.33	3440	58	0.82	55	103	2960	22	<0.1	218	1120	0.53	0.19	0.47	0.01	<0.010	13.4	2.8	10.600	-
MB14	13/09/2007		<0.01	0.005	0.001	<0.0001	1.52	0.248	0.019	0.796	<0.010	1.10	7.20	5.85	27830	-76	0.44	61	178	17500	35	<0.1	1470	8970	0.34	0.16	0.12	<0.01	<0.010	0.9	0.8	0.021	-
MB15																																	
MB16																																	
MB17																																	
MB18	13/09/2007		<0.10	<0.010	<0.010	<0.0010	<0.50	0.198	<0.010	0.690	<0.100	5.57	3.24	6.82	28700	-25	0.48	26	276	27400	360	<0.1	2040	13400	0.09	0.15	0.14	0.09	<0.010	1.9	1.6	0.259	-
MB19																																	
MB20																																	
MB21	14/09/2007		<0.01	0.004	<0.001	0.0001	1.55	0.192	0.011	0.929	<0.010	0.57	3.28	5.42	23210	-39	0.43	50	78	14700	58	<0.1	882	9110	0.64	0.10	0.09	0.04	<0.010	0.2	0.2	<0.010	-
MB22	14/09/2007		0.06	<0.001	<0.001	<0.0001	<0.05	0.056	<0.001	0.021	<0.010	8.41	3.65	5.32	29010	-36	0.67	7	4	134	20	<0.1	16	58	1.75	0.27	0.25	0.28	<0.010	0.8	0.3	0.549	-
MB23																																	
MB24	14/09/2007		0.77	0.003	<0.001	0.0002	<0.05	0.371	0.025	0.397	<0.010	3.41	1.19	4.35	22030	-49	3.41	40	1	14900	68	<0.1	1130	8530	40.00	0.13	0.00	0.04	<0.010	5.8	0.5	5.270	-
MB25																																	
MB26	13/09/2007		1.35	<0.001	0.002	0.0002	0.42	0.286	0.013	3.410	<0.010	2.72	1.30	4.94	967	-110	0.41	32	52	680	22	<0.1	60	164	0.62	0.37	0.87	0.39	0.156	33.2	22.0	11.200	-
MB27																																	
MB28																																	
MB29																																	
MB30																																	
MB31																																	
MB32																																	
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4																																	
ML1B5																																	
MLI B6	14/09/2007		3.04	<0.001	<0.001	0.0003	0.32	0.055	0.040	1.510	<0.010	5.55	1.48	3.36	3546	-52	1.51	151	<1	2440	20	<0.1	90	1270	151.00	0.07	0.01	0.06	<0.010	2.2	0.8	1.450	-
ML1B7																																	
ML1B8																																	
MLIB9	13/09/2007		0.14	0.002	0.002	0.0001	0.46	0.231	0.006	0.194	<0.010	3.96	3.45	4.92	218	-104	0.49	10	33	152	46	<0.1	9	44	0.30	0.20	3.67	0.04	<0.010	0.9	0.8	0.071	-
MLWZ1	13/09/2007	(MB7)	0.26	0.001	0.001	<0.0001	3.77	0.081	0.024	2.55	<0.010	6.02	7.27	-	-	-	-	27	<1	314	96	<0.1	43	117	27	0.37	0.02	0.06	<0.010	1	1	<0.010	-

Groundwater Results - December 2007

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems
LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soils) Standing Advice from DoE LWQB on dewatering trigger values taken from ASS Guideline Series (2004), NG denotes no guideline

Notes: Guideline values have in the first instance been reported from DoE 2003 'Assessment Levels for Soil, Sediment and Water' where no guidance is given ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3 values have been adopted
All results expressed as mg/L except for pH (pH units), ratios (unitless) and EC (µS/cm), Redox (mV)
a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value
c) Values for Estuarine environments, d) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
e) Equivalent to the upper limit for highly salt tolerant plant species
f) Ammonia-N trigger values for Freshwater (pH = 7.0) and Marine (pH = 8.0) ecosystems per Table 8.3.7 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3
Duplicates are shown at the bottom of the table with a designation MLWZ. Corresponding primary samples are identified in brackets in column 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			Dissolved Metals									Total Metals		Field Parameters				Acid Sulfate Soil Parameters							ASS Ratios			Nutrients					
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	Total Aluminium	Total Iron	pH	E.C	Redox	DO	Total Acidity (CaC03)	Total Alkalinity (CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N	NH_3-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	0.1	0.05	-	-	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	NG	NG	6.5-8.5	NG	NG	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7	2.18 [f]
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	NG	NG	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]	0.91 [f]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	NG	NG	2300 [e]	NG	NG	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	NG	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG	NG
MB1																																	
MB2	11/12/2007		0.13	0.003	<0.001	<0.0001	14.10	2.630	0.017	0.750	<0.010	29.50	45.20	5.51	4673	-123	0.11	160	161	2010	960	<0.1	585	62	0.99	9.38	0.28	0.16	<0.010	1.0	1.0	0.069	0.059
MB3																																	
MB4																																	
MB5																																	
MB6																																	
MB7	11/12/2007		0.09	0.008	<0.001	0.0001	14.20	0.158	0.018	4.390	<0.010	5.49	25.80	3.57	523	-57	1.30	83	32	1030	84	<0.1	298	293	2.59	1.02	0.11	0.02	0.01	0.7	0.7	0.030	0.23
MB8	11/12/2007		0.28	0.002	<0.001	<0.0001	0.29	0.014	0.005	1.280	<0.010	5.00	3.47	5.97	266	-138	0.54	40	35	188	2	<0.1	20	46	1.14	0.43	1.75	0.02	<0.010	0.6	0.6	<0.010	0.246
MB9																																	
MB10																																	
MB 11	12/12/2007		<0.10	<0.010	<0.010	<0.0010	3.02	2.620	0.024	3.210	<0.100	3.81	6.52	5.48	45630	125	0.00	124	79	35700	135	<0.1	3520	16000	1.57	0.22	0.02	0.01	<0.010	1.9	1.8	0.052	-
MB12																																	
MB13	11/12/2007		0.01	<0.001	<0.001	0.0009	3.00	0.739	0.019	2.620	<0.010	5.38	9.28	6.16	9944	26	0.46	110	231	7190	72	<0.1	618	26	0.48	23.41	0.37	0.02	<0.010	2.4	1.2	1.240	0.462
MB14	11/12/2007		<0.01	0.006	<0.001	0.0003	2.07	0.263	0.017	2.510	<0.010	4.11	5.84	5.91	26750	-150	0.11	133	170	19900	50	<0.1	1760	15500	0.78	0.11	0.10	<0.01	<0.010	0.6	0.6	<0.010	0.455
MB15																																	
MB16																																	
MB17																																	
MB18	11/12/2007		<0.10	<0.010	<0.010	<0.0010	<0.50	0.120	<0.010	1.940	<0.100	1.46	0.64	6.05	48	96	1.40	169	281	37400	82	<0.1	2800	154	0.60	18.18	0.10	0.01	0.01	<0.1	<0.1	0.060	<0.100
MB19																																	
MB20																																	
MB 21	12/12/2007		<0.01	<0.001	<0.001	0.0003	1.48	0.233	0.010	1.210	<0.010	8.89	11.80	5.70	22950	48	2.62	69	82	14900	61	<0.1	886	10000	0.84	0.09	0.09	0.01	<0.010	1.8	1.8	0.023	-
MB 22	12/12/2007		0.05	<0.001	<0.001	0.0010	<0.05	0.073	0.008	0.690	<0.010	48.80	25.40	4.34	2059	154	4.26	45	<1	1520	746	<0.1	172	568	45.00	0.30	0.01	0.08	<0.010	5.2	1.4	3.880	-
MB23																																	
MB 24	12/12/2007		0.13	<0.001	<0.001	0.0003	<0.05	0.557	0.022	1.290	<0.010	5.59	2.18	4.66	22710	155	1.41	40	1	16100	183	<0.1	1270	9740	40.00	0.13	0.00	<0.01	<0.010	6.3	0.6	5.780	-
MB25																																	
MB26	11/12/2007		0.65	<0.001	0.002	0.0004	0.36	0.340	0.014	2.570	<0.010	5.10	2.37	5.94	1089	105	0.14	48	57	974	16	<0.1	80	168	0.84	0.48	0.71	0.07	0.015	34.4	10.0	24.400	5.45
MB27																																	
MB28																																	
MB29																																	
MB30																																	
MB31																																	
MB32																																	
ML1B1																																	
ML1B2																																	
ML1B3																																	
ML1B4																																	
ML1B5																																	
ML1 B6	12/12/2007		1.20	<0.001	0.002	0.0002	10.50	0.062	0.023	4.440	<0.010	3.10	17.70	5.94	1089	105	0.14	222	<1	1890	2	<0.1	107	1080	222.00	0.10	0.01	<0.01	<0.010	0.9	0.8	0.094	-
ML1B7																																	
ML1B8																																	
ML1 B9	12/12/2007		0.04	<0.001	<0.001	<0.0001	<0.05	0.244	0.003	0.139	<0.010	1.93	0.33	3.88	3191	297	0.16	33	<1	478	18	<0.1	21	187	33.00	0.11	0.05	<0.01	<0.010	4.8	0.8	4.050	-
MLWZ1	11/12/2007	(MB7)	0.10	0.01	<0.001	0.00	15.20	0.161	0.016	3.860	<0.010	5.91	28.50	-	-	-	-	86	27	1000	86	<0.1	245	268	3.19	0.91	0.11	0.02	<0.010	0.7	0.6	0.016	0.12

Surface-water Results 2007 - August Runoff Samples

Definitions: LOR (Limits of reporting), FWG (Freshwater Guidelines) for slightly - moderately disturbed systems, MEPG (Marine Ecosystem Protection Guidelines) for slightly - moderately disturbed systems, LIWG (Long Term Irrigation Water Guidelines), ASS (Acid Sulfate Soil Guidelines)

Notes: Guideline values have in the first instance been reported from DoE 2003 *'Assessment Levels for Soil, Sediment and Water'* where no guidance is given ANZECC/ARMCANZ 2000 *Freshwater and Marine WQ Guidelines* Chapter 3 values have been adopted

All results expressed as mg/L except for pH and ratios (unitless), EC (µS/cm). NG denotes no guideline

a) Aluminium trigger level relates to waters with a pH >6.5, no guideline is provided for water pH< 6.5. Note that cells exceeding the trigger concentration for Al have been highlighted irrespective of recorded pH

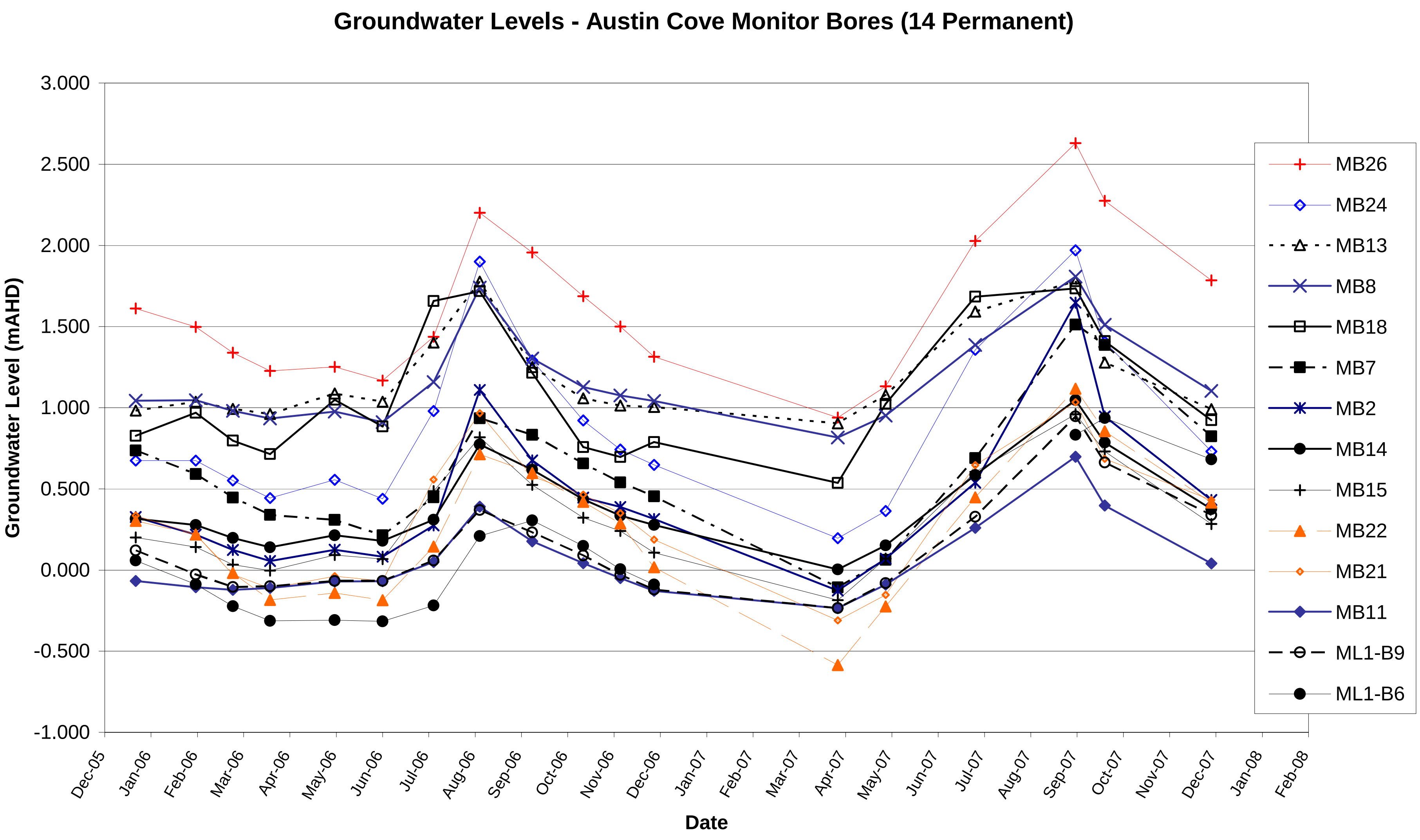
b) The laboratory limit of reporting is recognised as exceeding the guideline trigger value

c) Values for Esturine environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

d) Values for Wetland environments Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

e) Equivalent to the upper limit for highly salt tolerant plant species

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
			Total Metals									Field Parameters		Acid Sulfate Soil Parameters							ASS Ratios			Nutrients				
Sample ID	Date	Trigger	Aluminium	Arsenic	Chromium	Cadmium	Iron	Manganese	Nickel	Zinc	Selenium	pH	E.C	Total Acidity (mg/L CaC03)	Total Alkalinity (mg/L CaC03)	TDS	TSS	Hydrogen sulfide	Sulfate	Chloride	Acidity: Alkalinity	Sulfate: Chloride	Alkalinity: Sulfate	Total P	Reactive P	Total N	TKN	NOx-N
		LOR	0.01	0.001	0.001	0.0001	0.05	0.001	0.001	0.005	0.01	-	-	1	1	1	1	0.1	1	1	-	-	-	0.01	0.01	0.1	0.1	0.01
		FWG	0.055 [a]	0.013	0.010	0.0002	NG	1.9	0.011	0.008	0.005 [b]	6.5-8.5	NG	NG	NG	NG	NG	0.001 [b]	NG	NG	NG	NG	NG	0.06 [d]	0.03 [d]	1.5 [d]	NG	0.7
		MEPG	NG	0.05	0.05	0.0007	NG	NG	0.007	0.015	0.07	7.5-8.5 [c]	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0.03 [c]	0.005 [c,b]	0.75 [c]	NG	0.045 [c]
		LIWG	5	0.1	0.1	0.01	0.2	0.2	0.2	2	0.02	NG	2300 [e]	NG	NG	1500 [e]	NG	NG	NG	710 [e]	NG	NG	NG	NG	NG	NG	NG	NG
		ASS	1	NG	NG	NG	NG	NG	NG	NG	NG	<6	NG	>40	NG	NG	NG	NG	NG	NG	>1	>0.5	<5	NG	NG	NG	NG	NG
MLSW1	08/08/2007		0.39	0.002	0.001	0.0001	1.94	0.182	0.001	0.010	<0.010	7.14	420	17	57	456	4	<0.1	12	83	0.30	0.14	4.75	0.98	0.83	4.0	4.0	0.069
MLSW2	08/08/2007		0.49	<0.001	<0.001	<0.0001	0.94	0.006	0.001	0.011	<0.010	7.70	1025	6	57	626	<1	<0.1	31	256	0.11	0.12	1.84	0.82	0.79	2.7	2.7	0.030
MLSW3	08/08/2007		1.17	<0.001	0.001	0.0004	1.33	0.030	0.002	0.007	<0.010	7.36	1385	12	30	956	10	<0.1	42	388	0.40	0.11	0.71	0.10	0.02	1.4	1.3	0.060
MLSW4	08/08/2007		0.42	<0.001	<0.001	<0.0001	1.53	0.041	0.002	0.007	<0.010	7.44	1102	10	53	638	<1	<0.1	47	312	0.19	0.15	1.13	0.46	0.37	2.2	2.1	0.041
MLSW5	08/08/2007		2.17	0.001	0.001	0.0004	2.08	0.033	0.002	0.017	<0.010	7.79	592	9	41	326	12	<0.1	19	149	0.22	0.13	2.16	0.09	<0.010	1.8	1.8	0.020
MLSW6	08/08/2007		0.25	<0.001	<0.001	<0.0001	1.32	0.022	<0.001	0.014	<0.010	7.67	550	8	98	318	4	<0.1	10	113	0.08	0.09	9.80	0.28	0.16	2.5	2.5	0.032
MLSW7	08/08/2007		0.33	<0.001	<0.001	0.0002	2.47	0.062	0.001	0.010	<0.010	7.12	491	12	68	388	4	<0.1	14	107	0.18	0.13	4.86	1.06	0.89	4.5	4.4	0.039
MLSW8	08/08/2007		0.68	<0.001	0.001	0.0002	3.34	0.325	0.002	0.009	<0.010	7.12	414	22	65	408	8	<0.1	10	85	0.34	0.12	6.50	1.44	0.96	6.7	6.7	0.037
Summary Statistics		Min	0.25	0.001	0.001	0.0001	0.94	0.006	0.001	0.007	0.010	7.12	414	6	30	318	1	0.1	10	83	0.08	0.09	0.71	0.09	0.01	1.4	1.3	0.020
		Median	0.46	0.001	0.001	0.0002	1.74	0.037	0.002	0.010	0.010	7.40	571	11	57	432	4	0.1	17	131	0.20	0.12	3.45	0.64	0.58	2.6	2.6	0.038
		Mean	0.74	0.001	0.001	0.0002	1.87	0.088	0.002	0.011	0.010	7.42	747	12	59	515	6	0.1	23	187	0.23	0.12	3.97	0.65	0.50	3.2	3.2	0.041
		Max	2.17	0.002	0.001	0.0004	3.34	0.325	0.002	0.017	0.010	7.79	1385	22	98	956	12	0.1	47	388	0.40	0.15	9.80	1.44	0.96	6.7	6.7	0.069


Groundwater Levels - Austin Cove Monitor Bores (14 Permanent)
Groundwater Level (mAHD)
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Date
MB26
MB24
MB13
MB8
MB18
MB7
MB2
MB14
MB15
MB22
MB21
MB11
ML1-B9
ML1-B6

Appendix D

Lake Water Balance and Water Quality Modelling

Water Balance and Salt Modelling Parameters

- Total lake area : 16.6 ha, nominal water level: 2.5m AHD, a base level: -0.5m AHD
- Overflow occurs at : 2.7m AHD
- Bore inflow occurs at : 2.3m AHD, end of summer level: 2.2m AHD
- Water Input and definition:
  (1) Direct rainfall, using monthly rainfall measured at Pinjarra Station 1987-2006, assuming 22 mg/L salinity, 0.001 mg/L TN and 0.001 mg/L TP (Hingston and Gailitis, 1976).
  (2) Roof water runoff based on 90% rainfall falling on a roof area of 16.8 ha (Cossill and Webley, 2006), assuming same concentration of salt, TN and TP as rainfall.
  (3) Bore water to top-up the lake with measured salinity 1,600 mg/L (Rockwater, 2006) and assuming 0.01mg/L TN, 0.01mg/L TP and 0.003mg/L PO4-P. The bore water quality is assumed constant during the simulation.
- Water Output:
  (1) Evaporation based on monthly average data from Medina Station (1990-2000) and 85% pan (Luke et al., 1988).
  (2) Irrigation when lake salinity is less than or equal to 1,600 mg/L; when the lake water is above 1,600 mg/L the dedicated Leederville Borewater (1,600 mg/L) used directly for irrigation.
  (3) Outlow from lake discharge via natural waterway towards Peel Harvey Estuary.

Formulas used in the calculation are the following:

- The monthly water balance is defined as: $dV/dt = R + BW + W - E - O$ (1)

where R is the rainfall volume (per month) entering the pit, BW is the bore water, RW is the roof run-off, E is the evaporation and O is the overflow.

Values of R , RW and E were calculated using the following formulas.

- The rainfall volume per month (m^3/day) was calculated as: $R = r.A_L$ (2)

where r is the 30years-averaged monthly rainfall measured at Pinjarra Station (mm/month), and A_L is the surface area of the lake (m^2),

- The roof run-off water volume per month (m^3/day) was calculated as: $RW = r_{coef} .A_R$ (3)

where A_R is the assumed total roof area (m^2).

- Evaporation from the lake was calculated as: $E = E/E_{pan} .E_{pan} .A$ (4)

where E/E_{pan} is the ratio of actual and pan evaporation and E_{pan} is the measured pan evaporation at Pinjarra station (mm/month).

Monthly average (2013-2029) Lake Water Balance and Salinity Model

Month	Initial Condition		Input Volumes			Output Volumes			Final Condition	
	Lake Vol (ML)	Lake Salinity (mg/L)	Rainfall (ML)	Roof Runoff (ML)	Bore water (ML)	Evapo (ML)	Irrigation (ML)	Overflow (ML)	Lake Vol (ML)	Lake Salinity (mg/L)
Jan	435	1433	1	1	1	-35	-18	0	386	1554
Feb	386	1554	2	1	31	-29	-11	0	379	1670
Mar	379	1670	4	3	24	-25	-6	0	380	1745
Apr	380	1745	7	6	2	-15	-4	0	375	1761
May	375	1761	18	16	1	-9	0	0	401	1651
Jun	401	1651	28	25	5	-7	0	-11	441	1480
Jul	441	1480	29	26	0	-7	0	-46	441	1325
Aug	441	1325	22	20	0	-10	0	-32	441	1231
Sep	441	1231	15	13	6	-13	-20	-2	440	1193
Oct	440	1193	8	7	24	-19	-20	0	440	1228
Nov	440	1228	5	5	36	-26	-20	0	440	1303
Dec	440	1303	1	1	45	-33	-20	0	434	1425
Total	**4997**	**17574**	**141**	**125**	**173**	**-229**	**-118**	**-93**	**4997**	**17566**

Nutrient Modelling

The nutrient modelling was conducted for period of 1 June 2012 – 31 December 2016 using The Center for Water Research's (www.cwr.uwa.edu) DYRESM-CAEDYM model. The DYRESM (**DY**namic **RES**ervoir **S**imulation **M**odel) is a 1D hydrodynamic driver which predicts the vertical distribution of temperature, salinity and density in lakes and reservoirs. For this study the DYRESM is coupled with CAEDYM (**C**omputational **A**quatic **E**cosystem **D**ynamics **M**odel) for predictions involving biological and chemical processes. A number of text files are required for both DYRESM and CAEDYM. They are configuration (.cfg), physical data and lake morphometry (.stg), initial profile (.pro), meteorological (.met), stream inflow (.inf), withdrawals (.wdr), CAEDYM configuration (.con) files. Details about these files can be found in DYRESM and CAEDYM user manual (http://www.cwr.uwa.edu.au/services/models/legacy/model/dyresmcaedym/dyresmcaedym_documentation.html).
The overview of CAEDYM (**C**omputational **A**quatic **E**cosystem **D**ynamics **M**odel) is given in the following figure.

The simulation is for conditions including a waterbird faecal phosphorus (Particulate Organic Phosphorus Labbile/POPL) loading of 92 g/day and without any storm water inflow. The simulation was run for 4.5 years, starting on 1 June 2012 (when both parts of the lake are complete and filled to create one water body) and finishing on 31 December 2016.

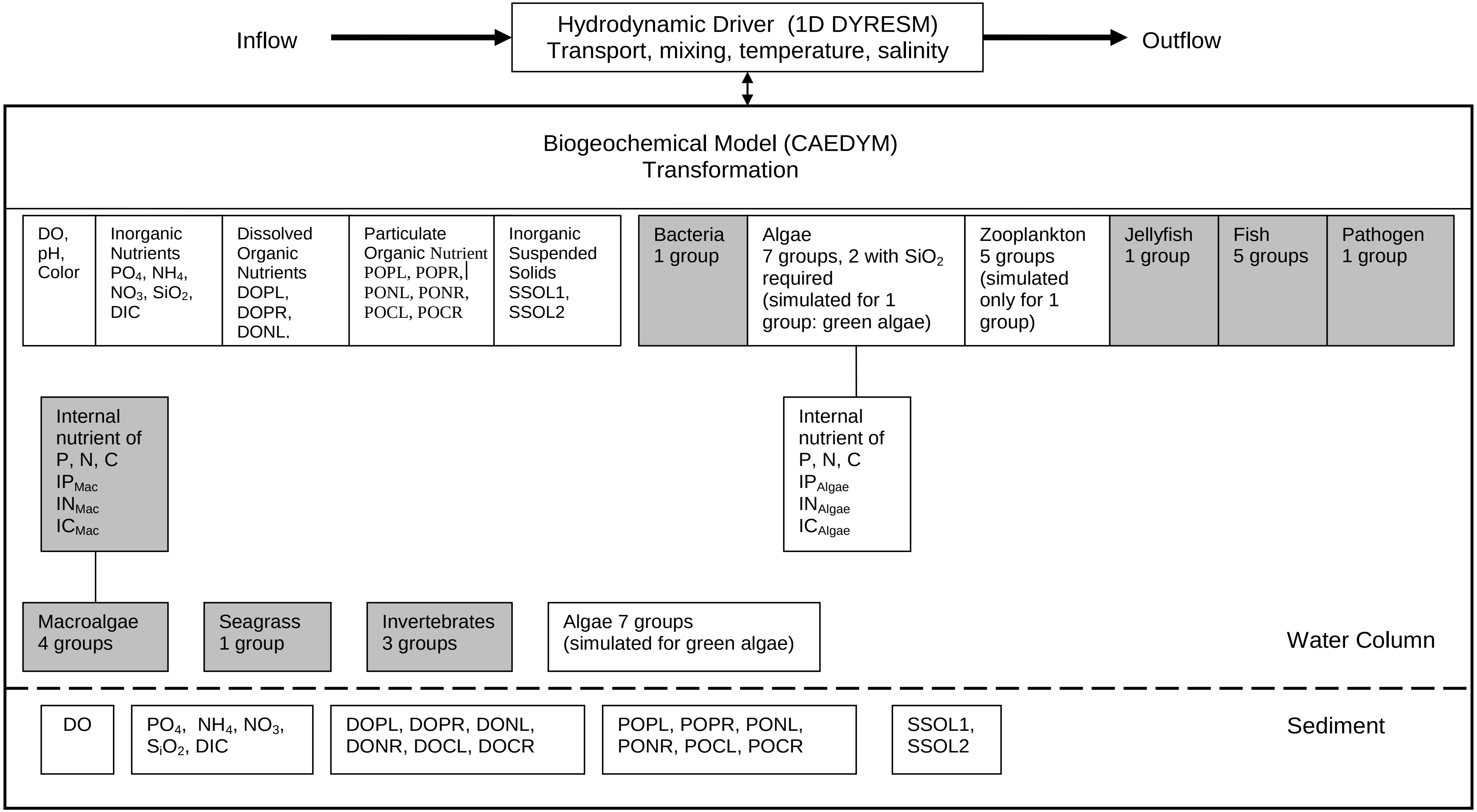
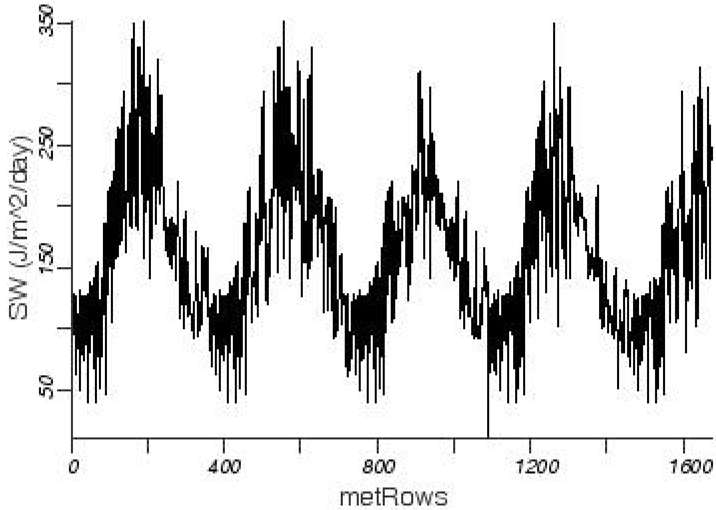


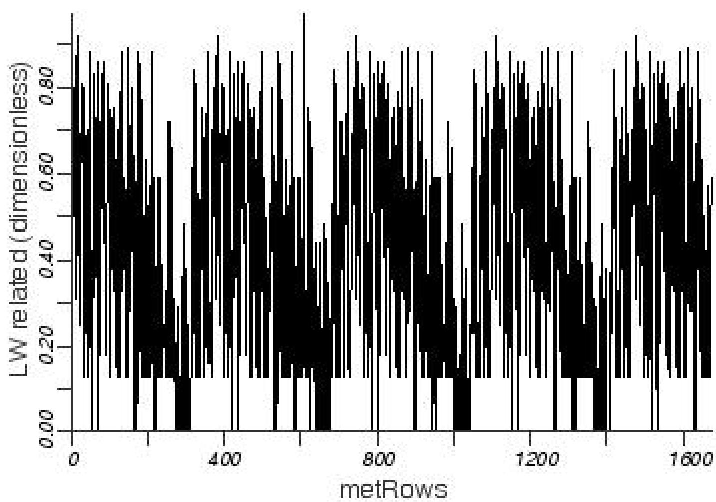
Figure . Overview of CAEDYM state variables adapted from Hipsey, et al 2006. Shaded-boxes represent variables not simulated for this study.

Detailed daily meteorological data and the DYRESM-CAEDYM simulation results are shown below. All figures start on day 1 June 2012.

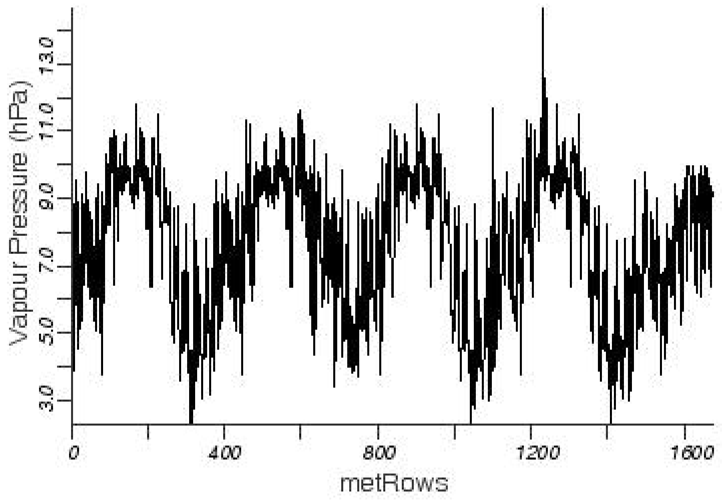
(1) Shortwave Radiation (joule/m^2/day):



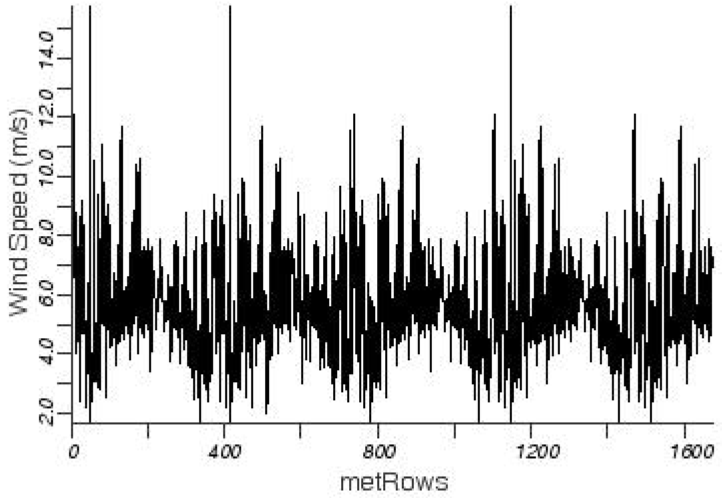
(2) Longwave-related, cloud cover (dimensionless):



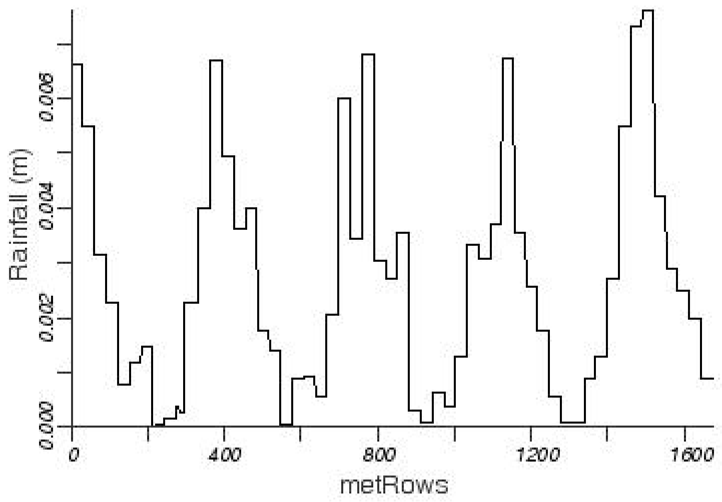
(3) Evaporation-related, Water Vapour Pressure (hPa):



(4) Wind speed (m/s):

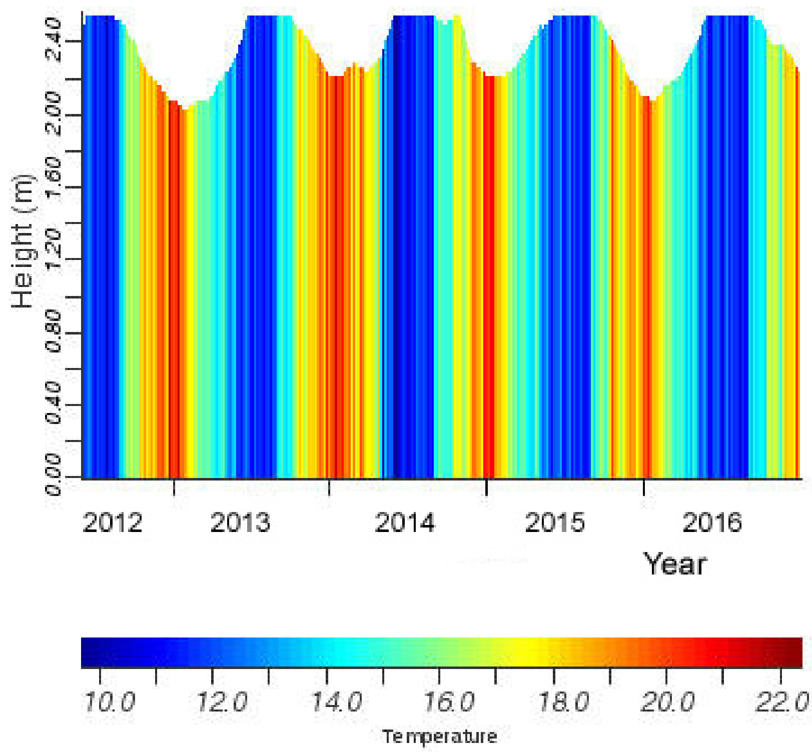


(5) Rainfall (m)

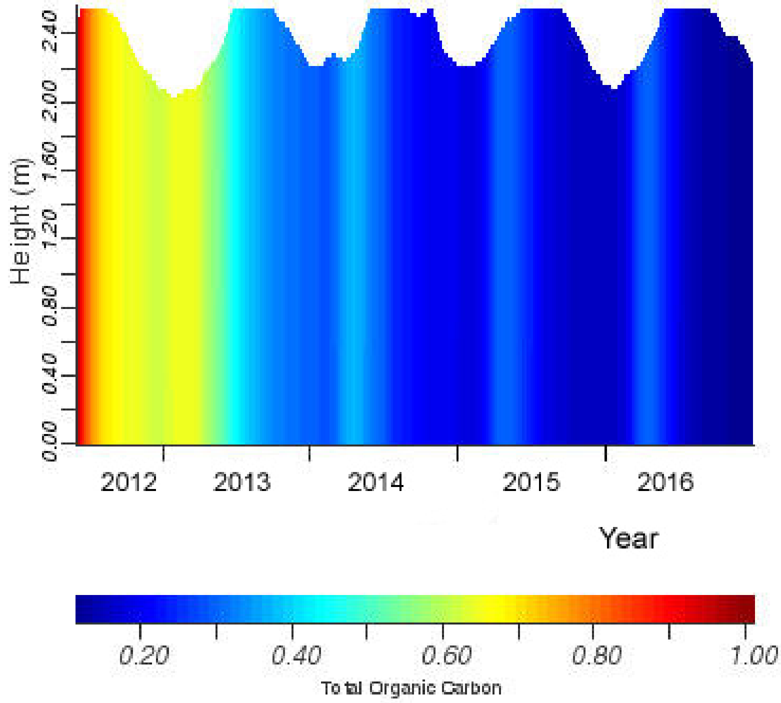


Simulation Results (daily resolution)

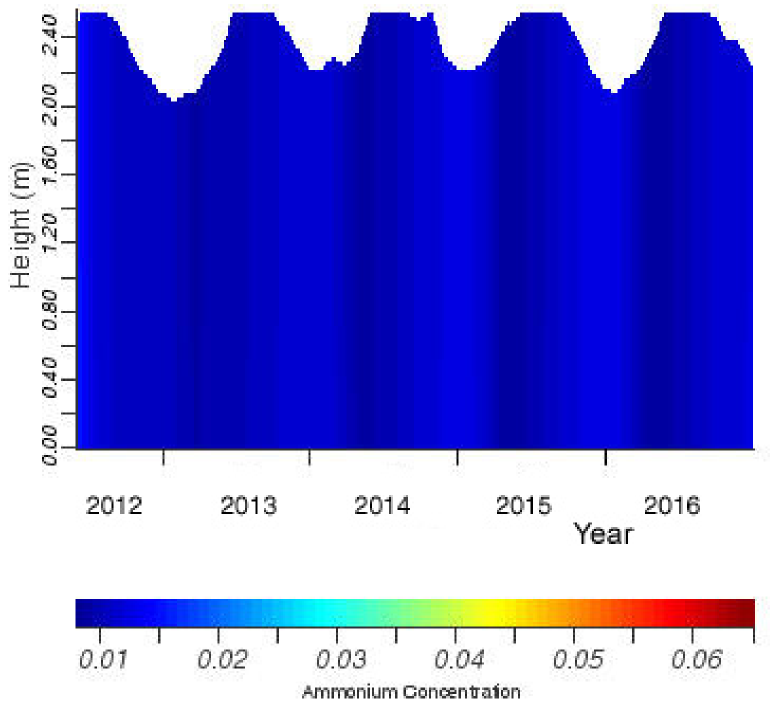
(1) Temperature (^{o}C)



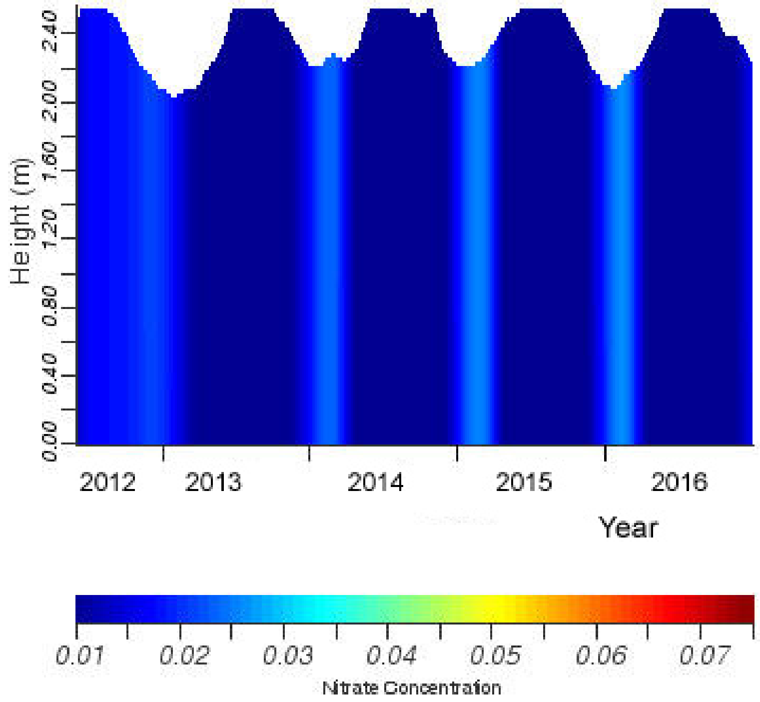
(2) Total Organic Carbon (mg/L)



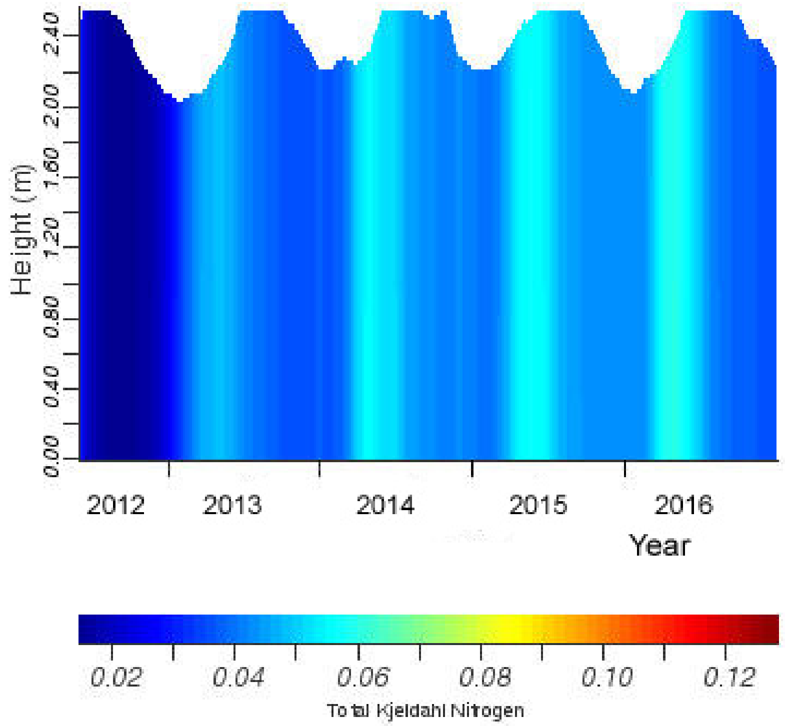
(3) NH_4-N (mg/L)



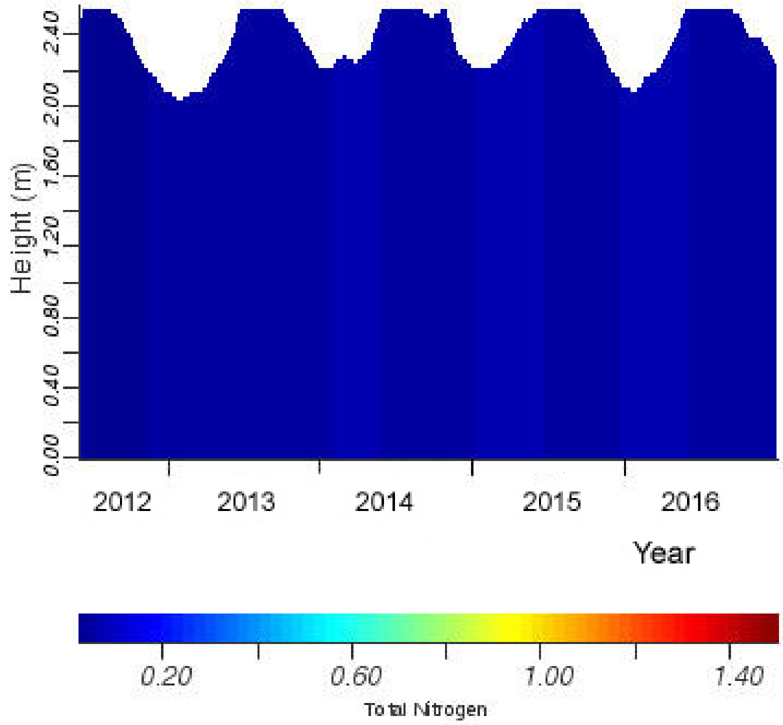
(4) NO_3-N (mg/L)



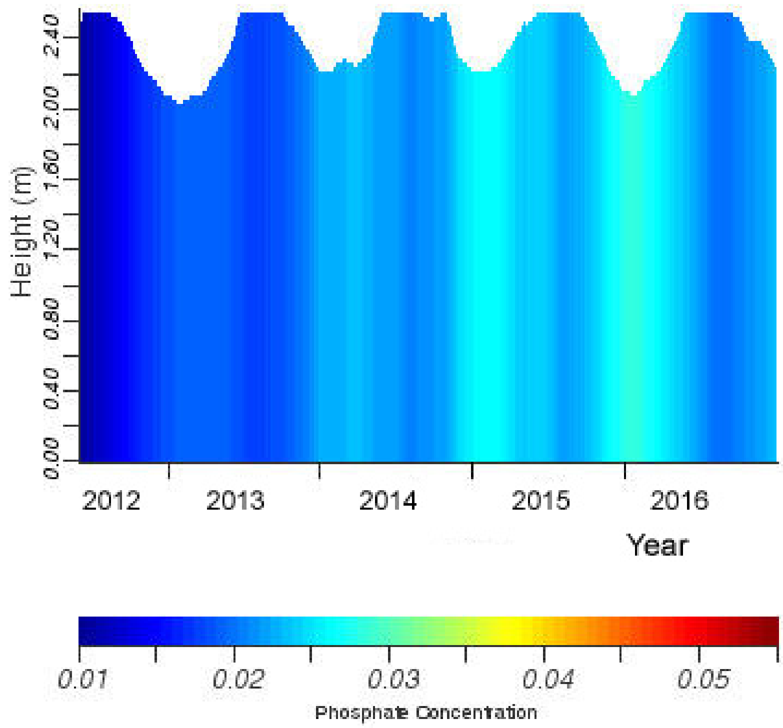
(5) TKN (mg/L)



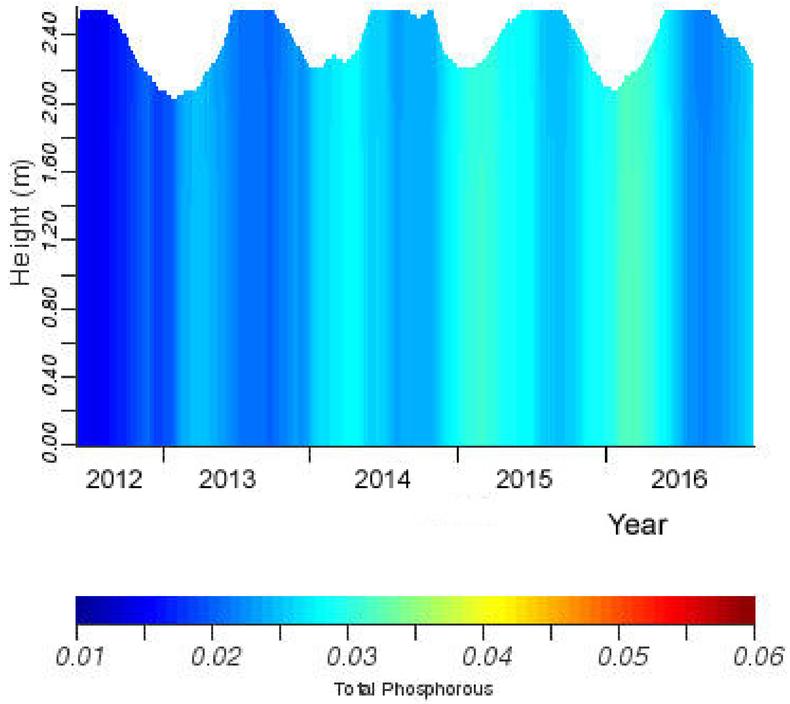
(6) TN (mg/L)



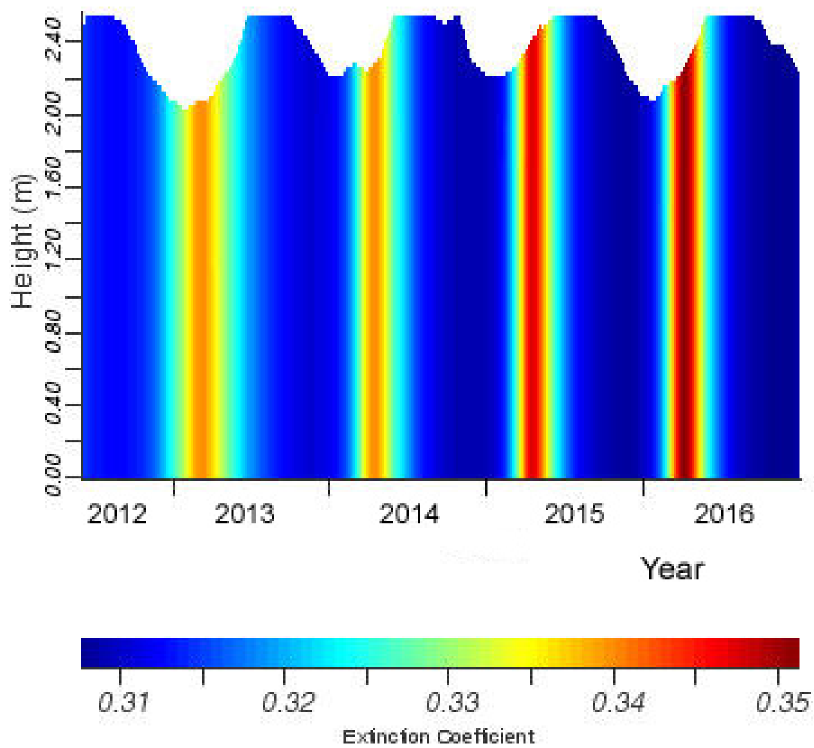
(7) PO_4-P (mg/L)



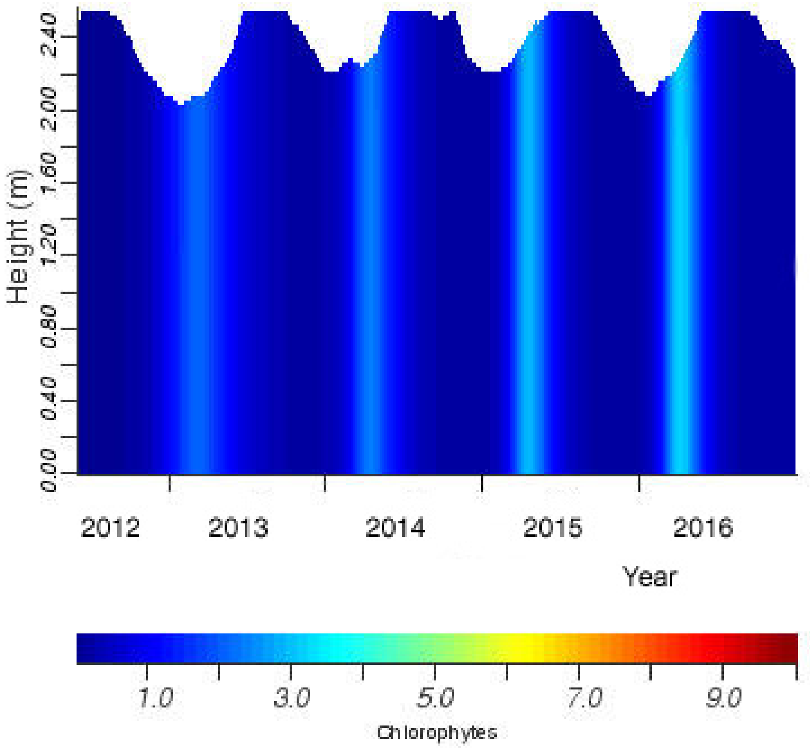
(8) TP (mg/L)

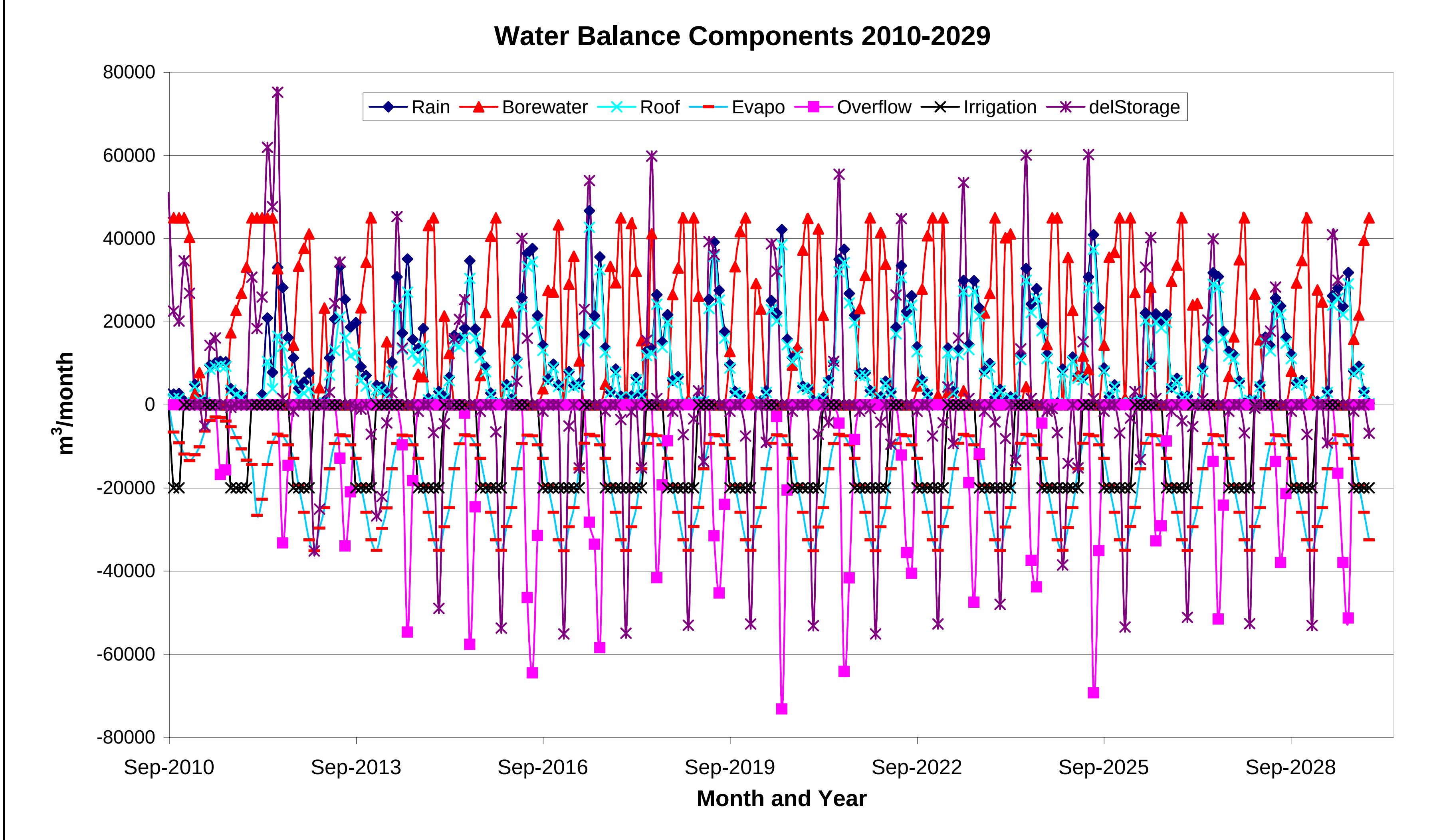


(9) Light extinction coefficient (/m)



(10) chlorophyll-*a* (µg/L)





Data Source: Simulation result

JDA Consultant Hydrologists	Job No. J3770 	Satterley Property Group Pty Ltd Austin Cove Phase 2 - UWMS **Water Balance Components 2010-2029**

Appendix E

NiDSS Modelling

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 29-Feb-08

Austin Cove Phase Two	
Total Nutrient Input - No WSUD (kg/yr)	4,455
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

(●) Total Phosphorus
( ) Total Nitrogen

Catchment Name Austin Cove Phase Two
Option Description Current Landuse- Beef Grazing Property
Catchment Area 271 ha

Land Use Breakdown

Residential : ~R25	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	ovals, grassed areas
POS : Passive / Basins	17.0%	native vegetation, unfertilised areas
Rural : Pasture	82.0%	general pasture
Rural : Residential ~R2.5/R5	1.0%	low density
Rural : Poultry	0.0%	specific high nutrient input land use
Commercial/Industrial	0.0%	town centre, business district

Total Residential 0.0%
Total Area 100.0%

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	20.00	kg/ha Rural/yr	16.40	kg/gross ha/yr	4,444	kg/yr	99.8%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.04		11		0.2%
	Sub Total			16.44		4,455		100.0%
		Total		**16.44**	kg/gross ha/yr	**4,455**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%
Nutrient Input : Rural Area	16.44	4,455	100.0%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0

Net Nutrient Input **16.44** **4,455** **100.0%**

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 29-Feb-08

Austin Cove Phase Two	
Total Nutrient Input - No WSUD (kg/yr)	13,374
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

( ) Total Phosphorus
(•) Total Nitrogen

Catchment Name	Austin Cove Phase Two	
Option Description	Current Landuse- Beef Grazing Property	
Catchment Area	271	ha

Land Use Breakdown

Residential : ~R25	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	0.0%	maintainance of verge by local authority		
POS : Active	0.0%	ovals, grassed areas		
POS : Passive / Basins	17.0%	native vegetation, unfertilised areas		
Rural : Pasture	82.0%	general pasture		
Rural : Residential ~R2.5/R5	1.0%	low density	Total Residential	0.0%
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	100.0%
Commercial/Industrial	0.0%	town centre, business district		

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	60.00	kg/ha Rural/yr	49.20	kg/gross ha/yr	13,333	kg/yr	99.7%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.15		41		0.3%
	Sub Total			49.35		13,374		100.0%
		Total		**49.35**	kg/gross ha/yr	**13,374**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	100%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%			
Nutrient Input : Rural Area	49.35	13,374	100.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**49.35**	**13,374**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	**5,938**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

(●) Total Phosphorus
( ) Total Nitrogen

Catchment Name	Austin Cove Phase 2	
Option Description	Residential Development- with no WSUD	
Catchment Area	271	ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)		
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	5.7%	maintainance of verge by landowners		
Road Reserves : Major	11.8%	maintainance of verge by local authority		
POS : Active	7.2%	ovals, grassed areas		
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.4%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	2.7%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	23.23	kg/net ha/yr	12.40	kg/gross ha/yr	3,361	kg/yr	56.6%
	Lawn	10.85		5.80		1,571		26.5%
	Pet Waste	3.12		1.66		451		7.6%
	Car Wash	0.13		0.07		19		0.3%
	Sub Total			19.93		5,402		91.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.19	kg/gross ha/yr	51	kg/yr	0.9%
	Pet Waste	7.35		0.53		143		2.4%
	Sub Total			0.72		194		3.3%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.12	kg/gross ha/yr	33	kg/yr	0.6%
	Minor Roads	20.00		1.14		309		5.2%
	Sub Total			1.26		342		5.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**21.91**	kg/gross ha/yr	**5,938**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness: 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	21.91	5,938	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**21.91**	**5,938**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	**24,486**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus

◉ Total Nitrogen

Catchment Name	Austin Cove Phase 2	
Option Description	Residential Development- with no WSUD	
Catchment Area	271	ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	5.7%	maintainance of verge by landowners
Road Reserves : Major	11.8%	maintainance of verge by local authority
POS : Active	7.2%	ovals, grassed areas
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutrient input land use
Commercial/Industrial	2.7%	town centre etc

Total Residential	**53.4%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	50.76	kg/net ha/yr	27.10	kg/gross ha/yr	7,345	kg/yr	30.0%
	Lawn	71.64		38.25		10,367		42.3%
	Pet Waste	12.37		6.60		1,790		7.3%
	Car Wash	0.04		0.02		5		0.0%
	Sub Total			71.98		19,507		79.7%
POS	Garden/Lawn	73.40	kg/ha POS/yr	5.28	kg/gross ha/yr	1,432	kg/yr	5.8%
	Pet Waste	29.18		2.10		569		2.3%
	Sub Total			7.39		2,002		8.2%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	3.46	kg/gross ha/yr	939	kg/yr	3.8%
	Minor Roads	132.00		7.52		2,039		8.3%
	Sub Total			10.99		2,978		12.2%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**90.36**	kg/gross ha/yr	**24,486**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping

☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	90.36	24,486	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**90.36**	**24,486**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	**5,938**
Reduction due to WSUD (kg/yr)	**3,147**
Percentage Overall Reduction	**53.0%**
Pecentage Development Reduction	**53.0%**
Cost of Selected Program ($/kg/yr)	**$21**

◉ Total Phosphorus
○ Total Nitrogen

Catchment Name	Austin Cove Phase 2	
Option Description	Residential Development - Reduction Scenario 1	
Catchment Area	271	ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)		
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	5.7%	maintainance of verge by landowners		
Road Reserves : Major	11.8%	maintainance of verge by local authority		
POS : Active	7.2%	ovals, grassed areas		
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.4%**
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	**100.0%**
Commercial/Industrial	2.7%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	23.23	kg/net ha/yr	12.40	kg/gross ha/yr	3,361	kg/yr	56.6%
	Lawn	10.85		5.80		1,571		26.5%
	Pet Waste	3.12		1.66		451		7.6%
	Car Wash	0.13		0.07		19		0.3%
	Sub Total			19.93		5,402		91.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.19	kg/gross ha/yr	51	kg/yr	0.9%
	Pet Waste	7.35		0.53		143		2.4%
	Sub Total			0.72		194		3.3%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.12	kg/gross ha/yr	33	kg/yr	0.6%
	Minor Roads	20.00		1.14		309		5.2%
	Sub Total			1.26		342		5.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**21.91**	kg/gross ha/yr	**5,938**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 25%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	40%	4.96	1,345	22.6%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	60%	3.48	942	15.9%	$0	$0	$0.0
Native Gardens (POS)	30%	0.06	15	0.3%	$0	$0	$0.0
Community Education : Fertiliser	100%	2.35	636	10.7%	$0	$1,519	$2.4
Community Education : Pet Waste	100%	0.55	149	2.5%	$0	$2,169	$14.6
Community Education : Car Wash	100%	0.02	5	0.1%	$0	$1,519	$320.4
Street Sweeping	100%	0.17	46	0.8%	$0	$19,563	$429.5
Totals		**11.57**	**3,137**	**52.8%**	**$0**	**$24,770**	**$7.9**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.04	10	0.2%	$541,499	$7,521	$3,911.8
Total		**0.04**	**10**	**0.2%**	**$541,499**	**$7,521**	**$3,911.8**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	21.91	5,938	100.0%
Nutrient Input : Rural Area	0.00	0	0.0%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	11.57	3,137	52.8%	$0	$24,770	$7.9
Removal via In-Transit Control	0.04	10	0.2%	$541,499	$7,521	$3,911.8
Total Removal	11.61	3,147	53.0%	$541,499	$32,291	$20.6

Net Nutrient Input	**10.30**	**2,791**	**47.0%**

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	**24,486**
Reduction due to WSUD (kg/yr)	**12,368**
Percentage Overall Reduction	**50.5%**
Pecentage Development Reduction	**50.5%**
Cost of Selected Program ($/kg/yr)	**$5**

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name	Austin Cove Phase 2	
Option Description	Residential Development - Reduction Scenario 1	
Catchment Area	271	ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)		
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	5.7%	maintainance of verge by landowners		
Road Reserves : Major	11.8%	maintainance of verge by local authority		
POS : Active	7.2%	ovals, grassed areas		
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**53.4%**
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	**100.0%**
Commercial/Industrial	2.7%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	50.76	kg/net ha/yr	27.10	kg/gross ha/yr	7,345	kg/yr	30.0%
	Lawn	71.64		38.25		10,367		42.3%
	Pet Waste	12.37		6.60		1,790		7.3%
	Car Wash	0.04		0.02		5		0.0%
	Sub Total			71.98		19,507		79.7%
POS	Garden/Lawn	73.40	kg/ha POS/yr	5.28	kg/gross ha/yr	1,432	kg/yr	5.8%
	Pet Waste	29.18		2.10		569		2.3%
	Sub Total			7.39		2,002		8.2%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	3.46	kg/gross ha/yr	939	kg/yr	3.8%
	Minor Roads	132.00		7.52		2,039		8.3%
	Sub Total			10.99		2,978		12.2%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
		Total		**90.36**	kg/gross ha/yr	**24,486**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 25%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	40%	10.84	2,938	12.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	60%	22.95	6,220	25.4%	$0	$0	$0.0
Native Gardens (POS)	30%	1.59	430	1.8%	$0	$0	$0.0
Community Education : Fertiliser	100%	7.53	2,040	8.3%	$0	$1,519	$0.7
Community Education : Pet Waste	100%	2.18	590	2.4%	$0	$2,169	$3.7
Community Education : Car Wash	100%	0.00	1	0.0%	$0	$1,519	$1,174.8
Street Sweeping	100%	0.38	102	0.4%	$0	$19,563	$192.1
Totals		**45.46**	**12,320**	**50.3%**	**$0**	**$24,770**	**$2.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.18	48	0.2%	$570,261	$7,920	$883.5
Total		**0.18**	**48**	**0.2%**	**$570,261**	**$7,920**	**$883.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	90.36	24,486	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	45.46	12,320	50.3%	$0	$24,770	$2.0
Removal via In-Transit Control	0.18	48	0.2%	$570,261	$7,920	$883.5
Total Removal	45.64	12,368	50.5%	$570,261	$32,690	$5.4
Net Nutrient Input	**44.72**	**12,118**	**49.5%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	**5,938**
Reduction due to WSUD (kg/yr)	**3,524**
Percentage Overall Reduction	**59.3%**
Pecentage Development Reduction	**59.3%**
Cost of Selected Program ($/kg/yr)	**$17**

◉ Total Phosphorus
○ Total Nitrogen

Catchment Name Austin Cove Phase 2
Option Description Residential Development - Reduction Scenario 2
Catchment Area 271 ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	5.7%	maintainance of verge by landowners
Road Reserves : Major	11.8%	maintainance of verge by local authority
POS : Active	7.2%	ovals, grassed areas
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	2.7%	town centre etc

Total Residential	**53.4%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	23.23	kg/net ha/yr	12.40	kg/gross ha/yr	3,361	kg/yr	56.6%
	Lawn	10.85		5.80		1,571		26.5%
	Pet Waste	3.12		1.66		451		7.6%
	Car Wash	0.13		0.07		19		0.3%
	Sub Total			19.93		5,402		91.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.19	kg/gross ha/yr	51	kg/yr	0.9%
	Pet Waste	7.35		0.53		143		2.4%
	Sub Total			0.72		194		3.3%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.12	kg/gross ha/yr	33	kg/yr	0.6%
	Minor Roads	20.00		1.14		309		5.2%
	Sub Total			1.26		342		5.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**21.91**	kg/gross ha/yr	**5,938**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 33%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	6.20	1,681	28.3%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	50%	2.90	785	13.2%	$0	$0	$0.0
Native Gardens (POS)	50%	0.09	25	0.4%	$0	$0	$0.0
Community Education : Fertiliser	100%	2.89	782	13.2%	$0	$1,519	$1.9
Community Education : Pet Waste	100%	0.72	196	3.3%	$0	$2,377	$12.1
Community Education : Car Wash	100%	0.02	6	0.1%	$0	$1,519	$242.7
Street Sweeping	100%	0.15	39	0.7%	$0	$19,563	$496.1
Totals		**12.97**	**3,515**	**59.2%**	**$0**	**$24,978**	**$7.1**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.03	9	0.1%	$468,356	$6,505	$3,911.8
Total		**0.03**	**9**	**0.1%**	**$468,356**	**$6,505**	**$3,911.8**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	21.91	5,938	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	12.97	3,515	59.2%	$0	$24,978	$7.1
Removal via In-Transit Control	0.03	9	0.1%	$468,356	$6,505	$3,911.8
Total Removal	13.00	3,524	59.3%	$468,356	$31,483	$16.9
Net Nutrient Input	**8.91**	**2,414**	**40.7%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 29-Feb-08

Austin Cove Phase 2	
Total Nutrient Input - No WSUD (kg/yr)	24,486
Reduction due to WSUD (kg/yr)	13,231
Percentage Overall Reduction	54.0%
Pecentage Development Reduction	54.0%
Cost of Selected Program ($/kg/yr)	$5

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name Austin Cove Phase 2
Option Description Residential Development - Reduction Scenario 2
Catchment Area 271 ha

Land Use Breakdown

Residential : ~R25	37.4%	med-low density residential areas (excludes road reserve area)
Residential : ~R35	16.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	5.7%	maintainance of verge by landowners
Road Reserves : Major	11.8%	maintainance of verge by local authority
POS : Active	7.2%	ovals, grassed areas
POS : Passive / Basins	19.2%	native vegetation, wetlands, wetland buffers, unfertilised areas
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	2.7%	town centre etc

Total Residential 53.4%
Total Area 100.0%

Nutrient Input Without WSUD

Residential	Garden	50.76	kg/net ha/yr	27.10	kg/gross ha/yr	7,345	kg/yr	30.0%
	Lawn	71.64		38.25		10,367		42.3%
	Pet Waste	12.37		6.60		1,790		7.3%
	Car Wash	0.04		0.02		5		0.0%
	Sub Total			71.98		19,507		79.7%
POS	Garden/Lawn	73.40	kg/ha POS/yr	5.28	kg/gross ha/yr	1,432	kg/yr	5.8%
	Pet Waste	29.18		2.10		569		2.3%
	Sub Total			7.39		2,002		8.2%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	3.46	kg/gross ha/yr	939	kg/yr	3.8%
	Minor Roads	132.00		7.52		2,039		8.3%
	Sub Total			10.99		2,978		12.2%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
		Total		**90.36**	kg/gross ha/yr	**24,486**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 33%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	13.55	3,673	15.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	50%	19.13	5,183	21.2%	$0	$0	$0.0
Native Gardens (POS)	50%	2.64	716	2.9%	$0	$0	$0.0
Community Education : Fertiliser	100%	10.11	2,740	11.2%	$0	$1,519	$0.6
Community Education : Pet Waste	100%	2.87	779	3.2%	$0	$2,377	$3.1
Community Education : Car Wash	100%	0.01	2	0.0%	$0	$1,519	$890.0
Street Sweeping	100%	0.35	95	0.4%	$0	$19,563	$206.8
Totals		**48.66**	**13,187**	**53.9%**	**$0**	**$24,978**	**$1.9**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	40%	0.16	44	0.2%	$529,650	$7,356	$883.5
Total		**0.16**	**44**	**0.2%**	**$529,650**	**$7,356**	**$883.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	90.36	24,486	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	48.66	13,187	53.9%	$0	$24,978	$1.9
Removal via In-Transit Control	0.16	44	0.2%	$529,650	$7,356	$883.5
Total Removal	48.82	13,231	54.0%	$529,650	$32,334	$4.8
Net Nutrient Input	**41.53**	**11,255**	**46.0%**			

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