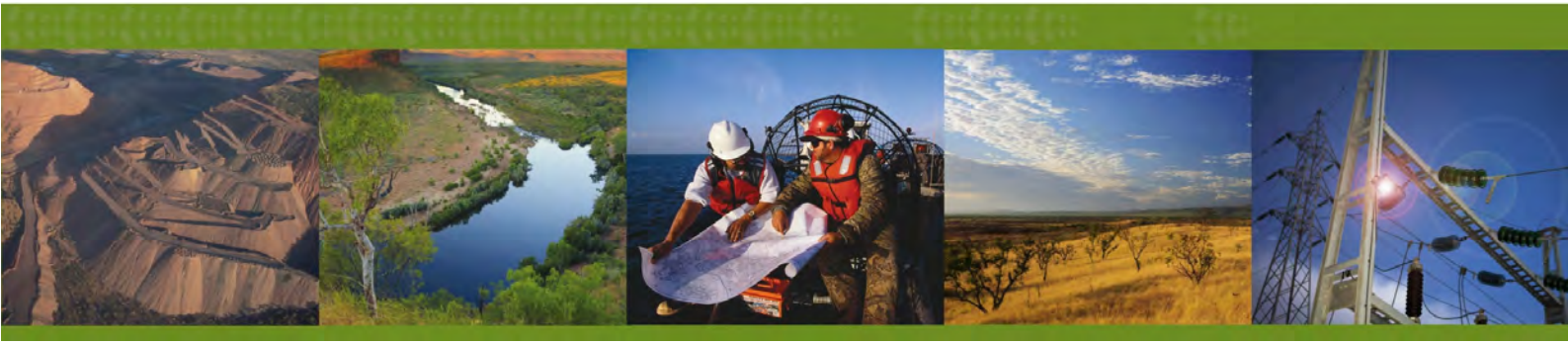
Appendix Two: Urban Water Management Plan



Lake Clifton Park Home Development Urban Water Management Plan

FINAL DRAFT

Prepared for
Beck Advisory acting for Tony Scolaro Family Trust
by Strategen

March 2013

STRATEGEN
environmental consultants

Lake Clifton Park Home Development Urban Water Management Plan

FINAL DRAFT

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March 2013

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Client: Beck Advisory acting for Tony Scolaro Family Trust

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Draft Report	A	Draft Report	M.Dunlop / D. Walsh	Electronic	23 Oct 12
Final Draft Report	0	Report for release to regulators	M.Dunlop / D. Walsh	Electronic	30 Oct 12
Final Draft Report	1	Report for release to regulators	M.Dunlop / D. Walsh	Electronic	14 Nov 12
Final Draft Report	2	Report for release to regulators	M.Dunlop / D. Walsh	Electronic	8 Feb 12
Final Draft Report	3	Report for release to regulators - reissue	M.Dunlop / D. Walsh	Electronic	27 Mar 12
Final Report					

Filename: BAD12112.01_R001 Rev3 - 27 March 2013

Executive summary

Beck Advisory group intends to redevelop Lot 21 Old Coast Road, Lake Clifton (the Site) into a Park Home development under a Development Approval. The site is located in the Shire of Waroona, approximately 100 km south of the Perth Central Business District. The total area of the site is approximately 6.05 ha.

The site is currently a caravan park. The redevelopment will involve the construction of new infrastructure including park homes, and a new wastewater treatment plant (WWTP). The project will include 120 park homes of one or two bedrooms with their own cooking and ablution facilities. The development is not a subdivision and all of the land will continue to be managed by the current owner, who will take responsibility for the maintenance and upkeep of infrastructure.

Park homes (demountable houses) will be selected by the buyer and installed by the developer. The developer is anticipating selling the park homes, with some to be retained by the developer for rental as holiday accommodation. The development will operate as a leased estate and owners will pay a fee to the developer for the upkeep of infrastructure and communal open space.

Lake Clifton, which is a part of the Peel-Yalgorup System, is located approximately 100m to the west of the site and is listed and protected under the Ramsar Convention. Because of this, water and nutrient management is a key issue for the development of the site

The Lake Clifton Park Home site will manage water and nutrients in an appropriate manner to minimise any potential impact upon Lake Clifton. This includes:

- sustainable water supply management with no net importing or exporting of potable water off the site
- installation of a Membrane Bioreactor style Wastewater Treatment Plant with dosing for phosphorus removal
- no flow of stormwater off the site in events up to the 1 in 100 year ARI event
- treatment of stormwater through nutrient stripping basins
- use of non-structural best management practices to reduce nutrient inputs at a development and lot scale
- installation of a wastewater treatment plant that produces an effluent with very low nitrogen and phosphorus concentrations
- ensuring that immobile stormwater is infiltrated within 96 hours to prevent mosquito and midge breeding (Table ES 1).

Table ES 1 provides a summary of the design elements and requirements for best management practices and how these comply with the key principles and objectives for water sensitive design on the site.

Through these measures, it is considered that the development complies with the water balance and nutrient objectives of the EPA (1998) *Guidance Statement No. 28, Development of the Lake Clifton Catchment.*

Table ES 1 Design elements and requirements for best management practices and critical control points

Category	Principles	Objectives	Development design elements and requirements
Water use	• 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 for the needs of all users, including community, industry and the environment.	Minimise the use of potable water where drinking water quality is not essential, particularly for ex-house uses.	The development will have a policy of sustainable self supply. Water for the development will be sourced from a mixture of sources, which will include: • rainwater • groundwater • recycled wastewater. At a lot level, rainwater collected from rooves will be used for in-house supply, with groundwater likely to be provided for garden use. Where rainwater volumes are not adequate for household use purposes, carted water will be used. Volumes of carted water are expected to be less than 15,000 L/household/year. Groundwater and recycled water will be used for irrigation of open space. Wastewater not recycled will be disposed of by irrigation of a tree lot area. This methodology meets the objective of minimising the use of potable water where drinking water quality is not essential, particularly for ex-house uses.
Groundwater levels and surface water flows	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	For ecological protection, 1 in 1-year ARI volume and peak flow rates maintained at or below 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 development area to pre-development flow rates.	There will be no flow off the site in events up to the 1 in 100-year ARI event, as is currently the case. Stormwater will not enter Lake Clifton in events up to the 1 in 100-year ARI event. As the water balance on the site is not anticipated to change, the development will not impact upon groundwater levels in the area.
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • 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 waterways and maintain water quality in the specified environment.	Implement current known best management practice as detailed in the DoW *Stormwater Management Manual for Western Australia* (DoW 2004 – 2007) 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, use of bioretention systems, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre-development levels. Minimise the export of pollutants such as phosphorus and nitrogen to surface or groundwater from stormwater and rainwater.	Best Management Practices (BMPs) have been implemented in the form of nutrient stripping basins through the development to minimise pollution. Non-structural BMPs on the site will be extensively utilised, including Sustainability Packages provided at point of sale and regular advice on methods to reduce fertilisers use at a lot scale. Open space landscaping on the site will be designed to minimise fertiliser and water use. Fertiliser will be of a slow release type and will used sparingly. Nutrient balance indicates that the new development and improved wastewater treatment will significantly reduce nutrient loads from the site.

Category	Principles	Objectives	Development design elements and requirements
Disease vector and nuisance insect management	• to reduce the health risk from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	Permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of Departments of Water and Health.	Detained stormwater will be fully infiltrated within 96 hours The existing water feature on the site shall be retained. This feature contains fish and is managed to prevent mosquito and midge breeding.

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1. Introduction and planning approval

1.1 Project description

The Tony Scolaro Family Trust intends to redevelop Lot 21 Old Coast Road, Lake Clifton (the Site) into a Park Home Development under a Development Approval. The site is located in the Shire of Waroona (SoW), approximately 100 km south of the Perth Central Business District (Figure 1). The total area of the site is approximately 6.05 ha.

The site is currently a caravan park. The redevelopment will involve the construction of new infrastructure including park homes, and a new wastewater treatment plant (WWTP). The project will include 120 park homes of one or two bedrooms with their own cooking and ablution facilities (Figure 2). The development is not a subdivision and all of the land will continue to be managed by the current owner, who will take responsibility for the maintenance and upkeep of infrastructure.

Park homes (demountable houses) will be selected by the buyer and installed by the developer. The park homes will be bought and leased by new occupants with some to be retained by the developer for rental as holiday accommodation. The development will operate as a leased estate and owners will pay a fee to the developer for the upkeep of infrastructure and communal open space. Lake Clifton, which is a part of the Peel-Yalgorup System, is located approximately 100m to the west of the site. Lake Clifton is considered to be an Environmentally Sensitive Area and includes a Ramsar wetland and an endangered thrombolite community. Because of this, water and nutrient management is a key issue for the development of the site.

1.2 Approvals

Because of the location of the development, the project was referred to the Environmental Protection Authority (EPA) in 2009. As part of the approval of the development under the Environmental Position Statement process (now Assessment of Proponent Information process), the EPA requested that the development demonstrate that the development needed to address the following objectives from EPA (1998) *Guidance Statement No. 28, Development of the Lake Clifton Catchment:*

1. Water balance: new developments should be managed so that the water balance following development is as close to the pre-development water balance as possible.
2. Nutrient loads: new developments should be managed so that phosphorus and nitrogen export to the lake catchment is negligible. At a minimum, a reduction should be achieved.
3. Regionally significant wetlands: new developments should be managed such that the direct impacts to humans and stock do not cause physical damage to the thrombolites, wetland vegetation, fringing wetland vegetation and dryland buffer of Lake Clifton (EPA 2009).

An Urban Water Management Plan (UWMP) is the normal mechanism for addressing the management of stormwater, groundwater and nutrients at the scale of a development. This UWMP has been prepared to address the first two of the above objectives. An Environmental Impact Assessment and a Wetland Buffer Definition Study have been prepared by Ecoscape to address the third objective.

The development was referred to the then Department of Environment, Water, Heritage and the Arts (DEWHA) under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). The development was considered to be 'not a controlled action' and was not assessed by DEWHA (DEWHA 2009).

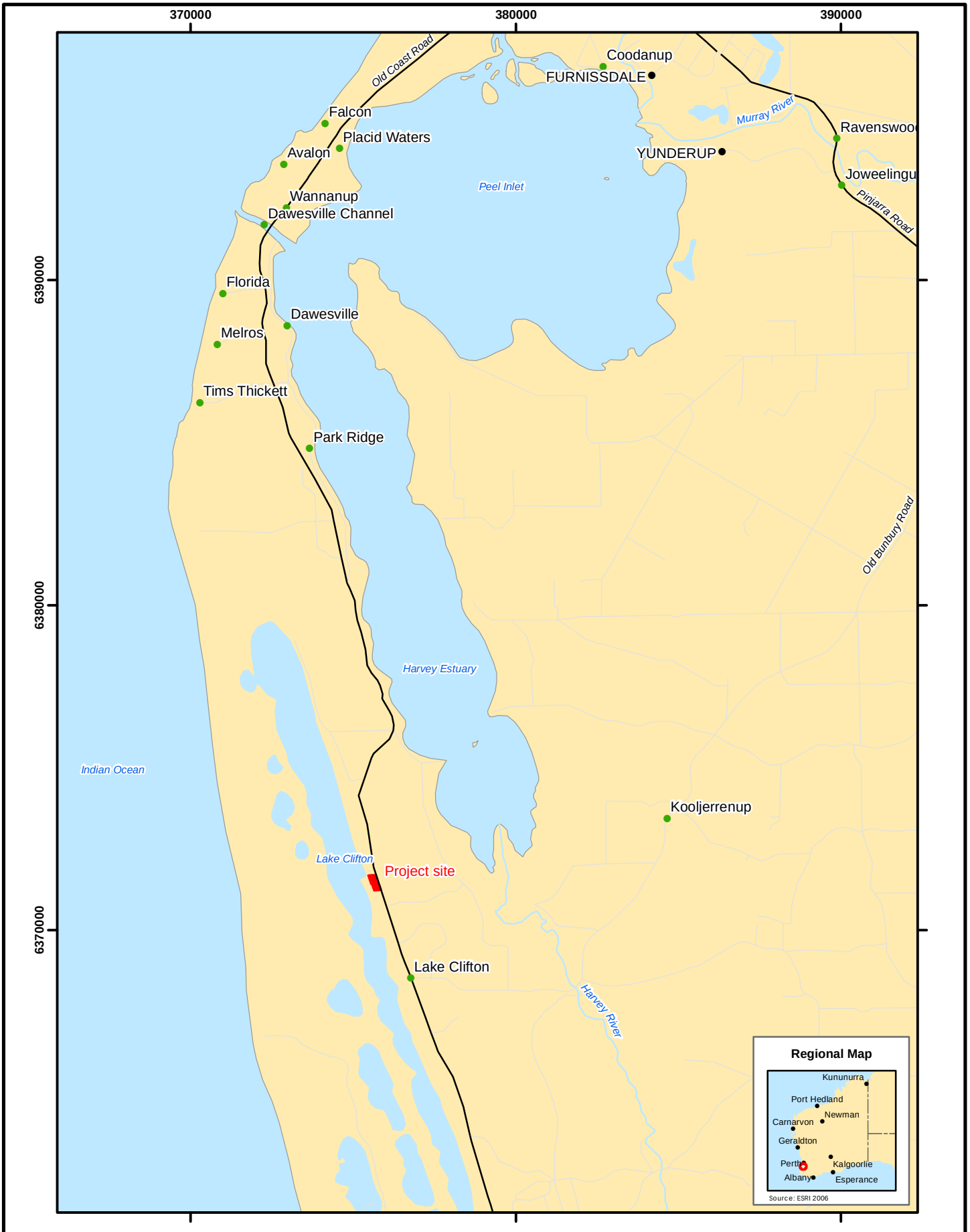

Figure 1 Site location

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Coordinate System: GDA 1994 MGA Zone 50
Date: 4/10/2012
Author: JCrute
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Source: Geoscience Australia 2006
Note that positional errors may occur in some areas

Legend

- Town
- Locations
- Major road
- Minor road
- Major river
- Lakes
- Lot boundary

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Lake Clifton Park Home Urban Water Management Plan

Development plan

Figure 2

1.3 Purpose of report

The purpose of the report is to provide Beck Advisory and Tony Scolaro Family Trust with an Urban Water Management Plan (UWMP) which addresses the EPA objectives and incorporates water sensitive urban design into the site redevelopment plans. This will assist with the approval of the development application, and will ensure that the redevelopment is consistent with *State Planning Policy 2.9 Water Resources* (Government of Western Australia 2006) and *Liveable Neighbourhoods* (WAPC & DPI 2009).

The Western Australian Planning Commission (WAPC) released the *Better Urban Water Management Guideline*s (WAPC 2008) which aims to integrate water cycle management with development planning. The *State Planning Policy 2.9 Water Resources* (Government of Western Australia 2006) outlines the key principles of integrated water cycle management which include:

- consideration of all water resources, including wastewater, in water planning
- integration of water and land use planning
- the sustainable and equitable use of all water sources, having consideration of the needs of all water users, including the community, industry and the environment
- integration of human water use and natural water process
- a whole-of-catchment integration of natural resource use and management.

This UWMP addresses these issues.

A copy of the UWMP checklist can be found in Appendix 1.

2. Design objectives

2.1 Key principles and objectives

The UWMP uses the following documents to define its key principles and objectives:

- *Liveable Neighbourhoods* (WAPC & DPI 2009)
- *Water Resources Statement of Planning Policy 2.9* (WAPC 2006)
- *Stormwater Management Manual for Western Australia* (DoW 2004 – 2007)
- *Decision Process for Stormwater Management in Western Australia* (DoE & SRT 2005)
- *Better Urban Water Management* (WAPC 2008).

The site is not covered by a Drainage and Water Management Plan, District Water Management Strategy or Local Water Management Strategy. The site is not considered to be within the Peel Harvey Catchment and as such advice for this catchment does not apply (Parker A [DoW] 2009, letter 19 December).

The key guiding principles of the UWMP are to:

- 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
- minimise public risk
- maintain the total water cycle of the site.

Summaries of principles and objectives applicable to the UWMP for the Site based on these documents are provided in Table 1 and summarised in Sections 2.1.1 to 2.1.3.

Table 1 Summary of UWMP principles and objectives

Category	Principles	Objectives
Water use	• 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 for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential, particularly for ex-house uses.
Groundwater levels and surface water flows	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• for ecological protection, 1 in 1-year ARI volume and peak flow rates maintained at or below 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 development area to pre-development flow rates.

Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • 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 waterways and maintain water quality in the specified environment.	• implement current known best management practice as detailed in the DoW *Stormwater Management Manual for Western Australia* (DoW 2004 – 2007) 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, use of bioretention systems, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre-development levels. • Minimise the export of pollutants such as phosphorus and nitrogen to surface or groundwater from stormwater and rainwater.
Disease vector and nuisance insect management	• to reduce the health risk from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	• permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of Departments of Water and Health.

2.1.1 Water Resources Statement of Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM).

WAPC (2006) defines IUWM (also known as total water cycle management) as promoting *'management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised'*.

IUWM should also promote water conservation measures, reuse and recycling of water and best practice in stormwater management (WAPC 2006). These objectives are consistent with Liveable Neighbourhoods (WAPC & DPI 2009).

2.1.2 Stormwater Management Manual for Western Australia

The DoW position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW 2004 – 2007), 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 water-logging
- 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 Department of Environment and Conservation [DEC] and DoW) and Swan River Trust released the *Decision Process for Stormwater Management in Western Australia* in 2005 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.

2.1.3 Better Urban Water Management

This UWMP has been developed to be consistent with the framework and process detailed in the guideline document *Better Urban Water Management* (WAPC 2008).

3. Site Characteristics

3.1 Climate

The Peel region experiences a Mediterranean type climate of hot dry summers and mild wet winters. The majority of the rainfall occurs between April and October (Table 2).

Table 2 Climate statistics for Harvey (2000 to 2012) (BoM Station 9812) (BoM 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Max Temp (°C)	29	29.5	27.8	24.1	21.2	18.8	17.7	18	19.2	21.4	24.1	26.8	23.1
Mean Min Temp (°C)	15.6	16.1	14.9	12.2	10.5	8.3	7.4	7.5	8.4	9.5	11.9	13.3	11.3
Mean Rainfall (mm)	13.2	11.7	11	52	106.4	154.2	149.5	131.7	112.4	49.7	38	14.4	845.1

3.2 Site conditions and topography

Topography across the study area can broadly be described as a gently undulating sandplain with outcropping limestone on low crests. Elevation ranges from 2 m to 10 m AHD (metres Australian Height Datum) (Figure 3).

The site is predominantly cleared, with some large trees remaining (Figure 3). An air strip lies between the site and Lake Clifton.

3.3 Geology and soils

The Geological Survey of Western Australia (1987) mapping of the site shows the site to be a mixture of Tamala limestone and Spearwood sand derived from Tamala limestone (

Figure 4). The limestone is pale yellow brown in colour with subangular to rounded quartz grains of marine origin. The sands are of a similar composition and are pale yellow to olive yellow in colour. This is consistent with the geotechnical investigations undertaken on site by Douglas Partners (2010) who described the soils of the site as:

- topsoil: dark grey silty sandy topsoil with rootlets to depths of between 0.1 m and 0.2 m, overlying
- sand: generally medium dense, orange-brown sand with a trace of silt to depths of between 0.3 m and 1.1 m, overlying
- limestone low to medium strength, light yellowish brown limestone underlying the sand at all test locations to the depth of investigation, being between 0.4 and 1.8 m.

A copy of the Douglas Partners report can be found in Appendix 2.

Phosphorus Retention Index (PRI) testing was undertaken by Ecoscape (2009). The PRI of the two samples taken were 20 and 24, being moderately to highly adsorbing (Ecoscape 2009).

The site is located in an area considered to have a high risk of actual or potential Acid Sulphate Soils (ASS) at a depth of less than 3 m from soil surface (DEC 2006). However, the presence of alkaline limestone on the site and lack of evidence of peaty soils in the geotechnical investigations indicate that ASS are unlikely to occur on the site.

There is no known contamination on the site.

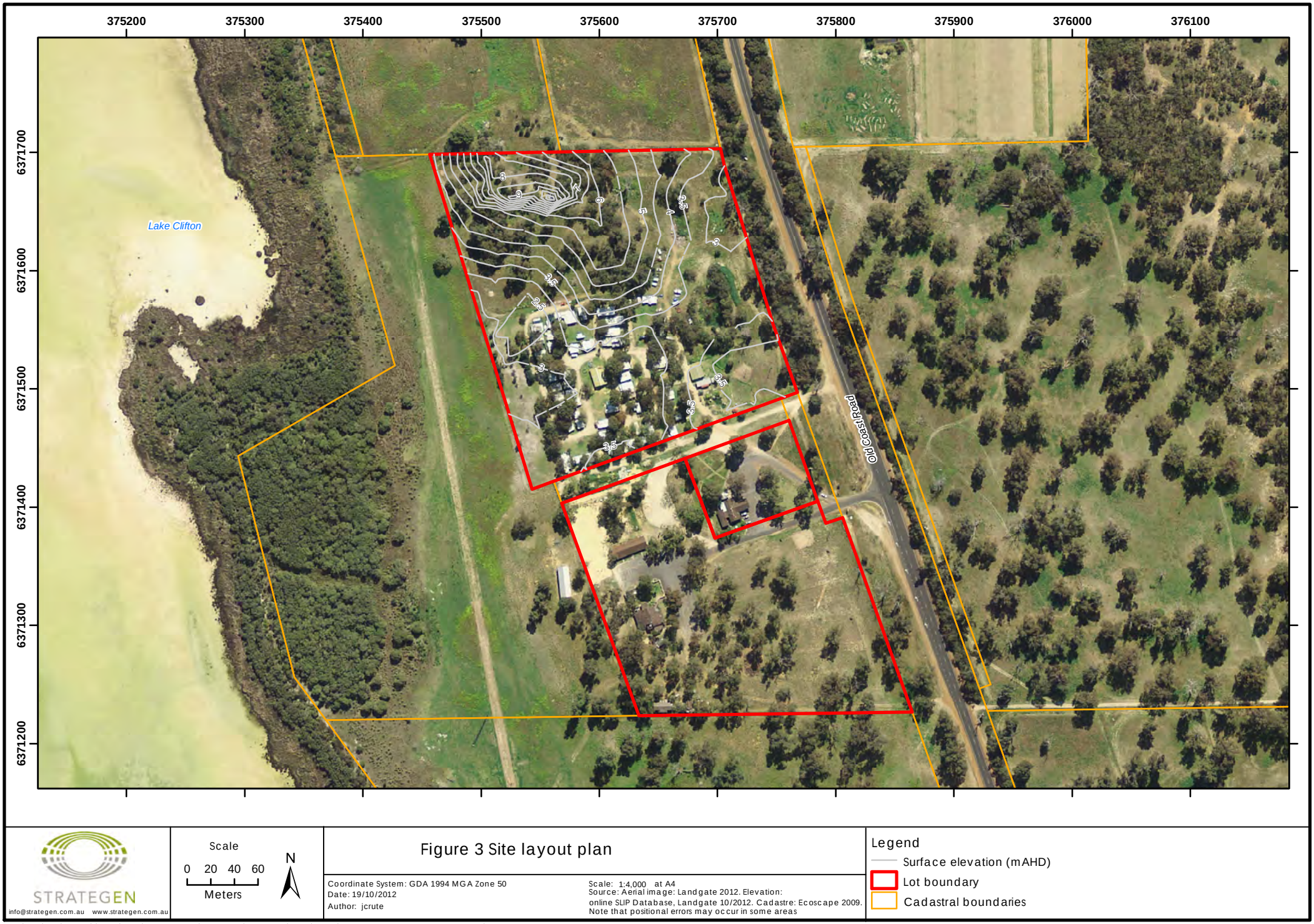

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Figure 3 Site layout plan

Coordinate System: GDA 1994 MGA Zone 50
Date: 19/10/2012
Author: jcrute

Scale: 1:4,000 at A4
Source: Aerial image: Landgate 2012. Elevation: online SLIP Database, Landgate 10/2012. Cadastre: Ecoscape 2009. Note that positional errors may occur in some areas

Legend
- Surface elevation (mAHD)
- Lot boundary
- Cadastral boundaries

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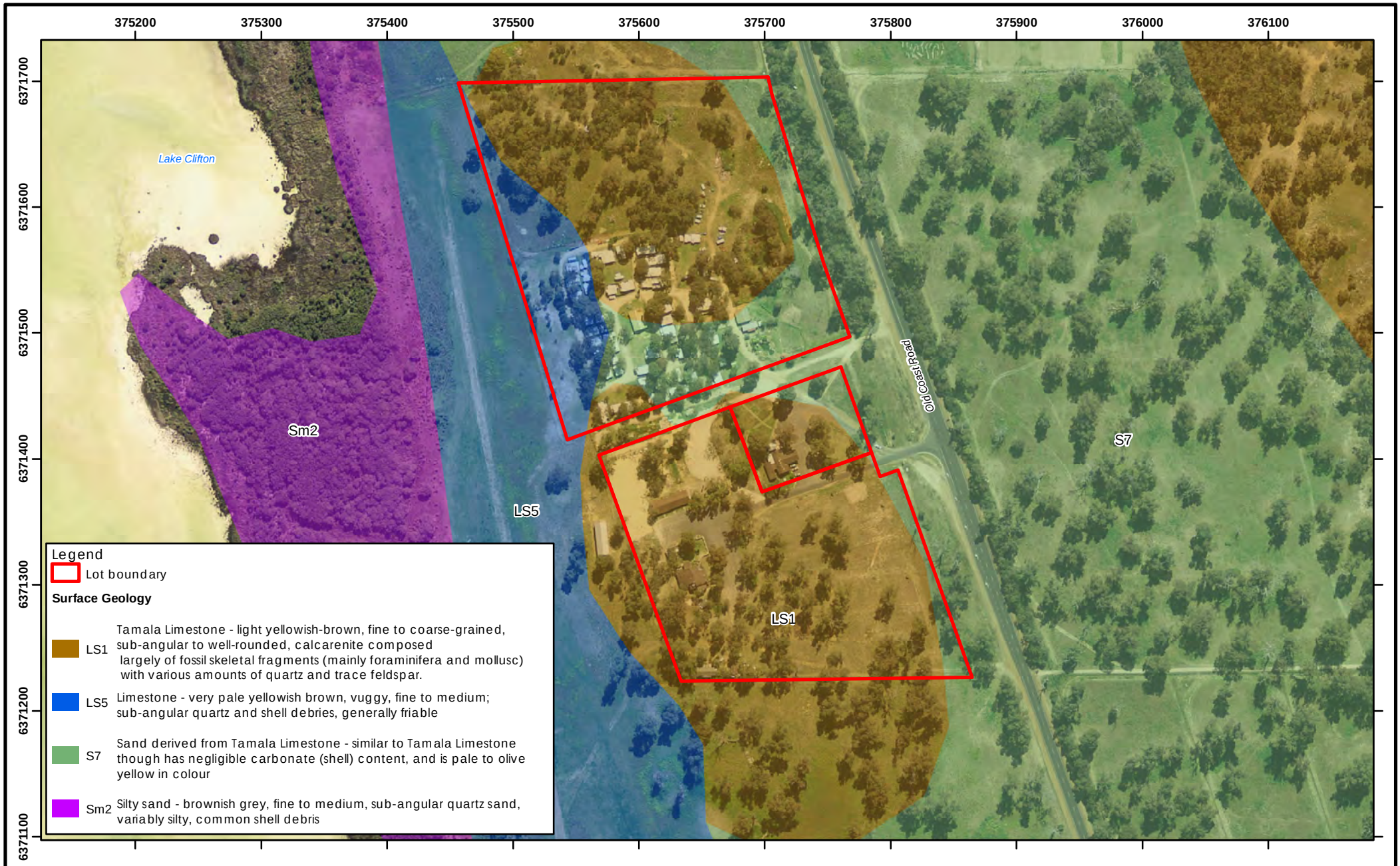

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Figure 4 Geological plan

Coordinate System: GDA 1994 MGA Zone 50
Date: 4/10/2012
Author: jcrute

Scale: 1:4,000 at A4
Source: Aerial image: Landgate 2012. Geology: DMP 10/2012.
Description geology: DMP 10/2012 & Ecoscape 2009.
Note that positional errors may occur in some areas

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3.4 Hydrology

3.4.1 Surface water hydrology

The primary surface water body in the area is Lake Clifton, to the west of the site (Figure 5). There are no surface water bodies on the site and the sandy nature of the local soils means that surface water flows are considered unlikely except in extreme events (greater than the 1 in 100 year Average Return Interval (ARI) event). Inspection of the site indicated no obvious surface water flow pathways, such as creeks or erosion lines.

Water levels in Lake Clifton were monitored by ENV Australia between January and October 2008 as part of a separate project (ENV 2009). Water levels varied between -0.7 and 0.5 m AHD over this period, being below sea level between approximately January and mid June (ENV 2009). Salinity in varied between 37 700 and 61 800 mg/L (ENV 2009). In comparison, seawater has a salinity of approximately 35 000 mg/L. The lake water is pH was alkaline, with pH varying between 7.86 and 8.46 (ENV 2009).

A search of the DoW database did not locate any long term surface water monitoring data for Lake Clifton. Limited data was available for the period 1983-6, which indicated water levels similar to those found by ENV. Monitoring of lake water levels and quality was not undertaken by Ecoscape.

ENV (2009) noted that nutrient concentrations within the Lake were highest concentrations in autumn and lowest in winter, which was considered to reflect dilution effects due to seasonal increasing and decreasing water volumes in the Lake. The monitoring work noted total nitrogen varying between 2.0 and 3.6 mg/L, and total phosphorus concentrations between 0.005 and 0.22 mg/L (ENV 2009).

3.4.2 Groundwater hydrology

The site lies on a small groundwater mound between Lake Clifton and the Peel-Harvey Estuary (Commander 1988). Regional groundwater data indicates that groundwater in the area flows towards Lake Clifton with groundwater levels less than 1 m AHD (Commander 1988).

Groundwater monitoring was undertaken by Ecoscape between April 2010 and August 2012 at six bore locations (Figure 6, Appendix 3). Groundwater levels on the site peaked in August 2011, with levels generally peaking between 0.391 and 0.424 m AHD, with a westward flow direction (Figure 6). The exception to this is MB03, which consistently experienced levels approximately 0.6 m higher than the other bores on the site. Maximum groundwater levels recorded at this bore is 1.00 mAHD. MB03 is located close to the lake and there is no obvious reason for this discrepancy. Minimum groundwater levels were recorded in February 2011 and ranged between 0 to 0.03 m AHD, with the exception of MB03.

The water levels in the bores that were not considered outliers were consistent with the levels observed by Commander (1988). No offsite bores were monitored for water levels concurrently with the onsite bores.

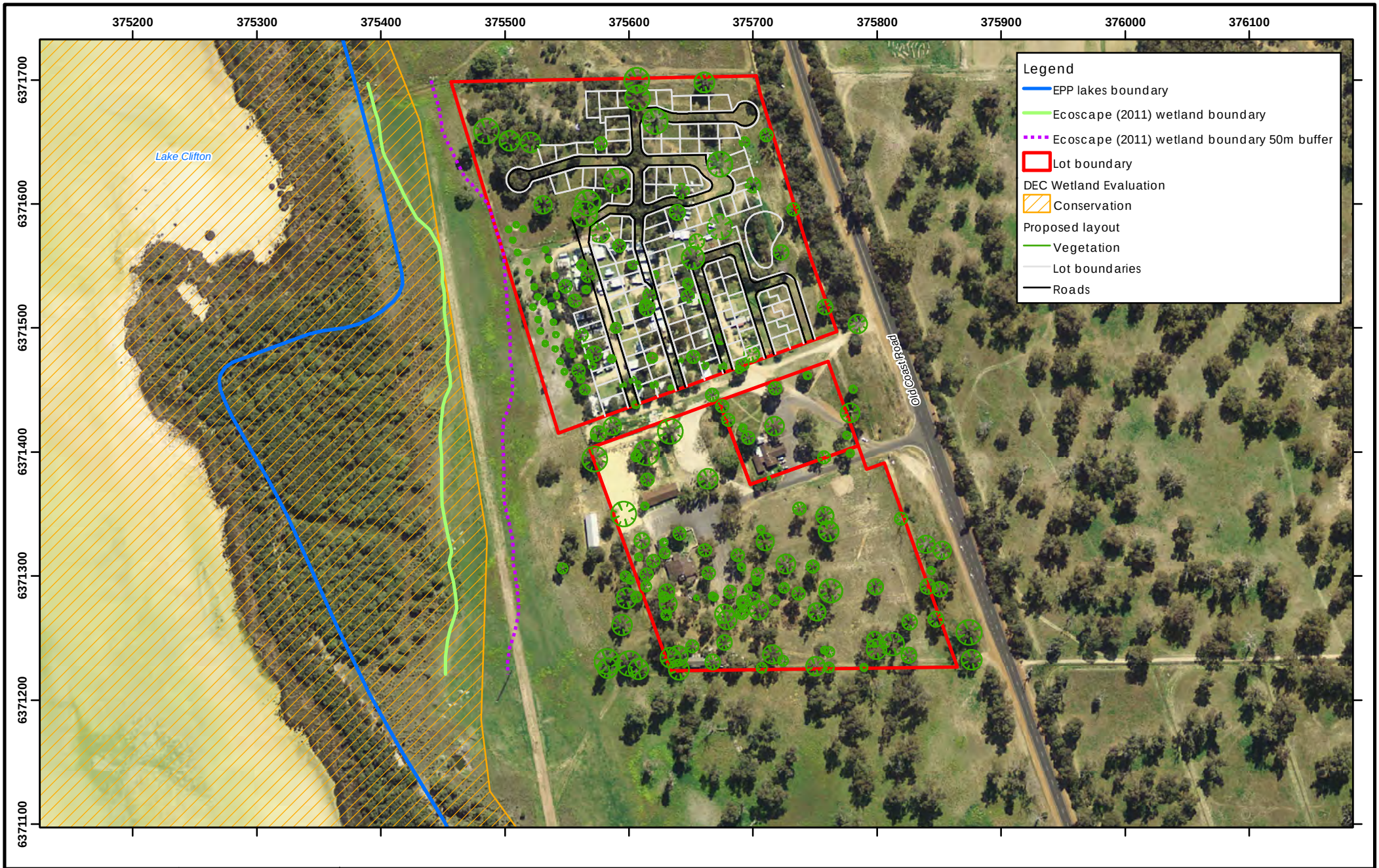

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Figure 5 Surface water and wetlands plan

Coordinate System: GDA 1994 MGA Zone 50
Date: 19/10/2012
Author: jcrute

Scale: 1:4,000 at A4
Source: Aerial image: Landgate 2012. Wetlands evaluation: DEC 2009.
Wetland boundary: Ecoscape 2011. Development layout: Doepel Marsh 2012.
Note that positional errors may occur in some areas

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Figure 6 Groundwater plan

Coordinate System: GDA 1994 MGA Zone 50
Date: 19/10/2012
Author: jcrute

Scale: 1:4,000 at A4
Source: Aerial image: Landgate 2012.
Monitoring bores and GW levels: Ecoscape 2010-2011.
Note that positional errors may occur in some areas

Legend
- Monitoring bores
- Groundwater level (mAHD)*
- Depth to groundwater (m bgl)*
- Surface elevation (mAHD)
- Lot boundary
- General direction of flow

*Date measured: 30/08/2011

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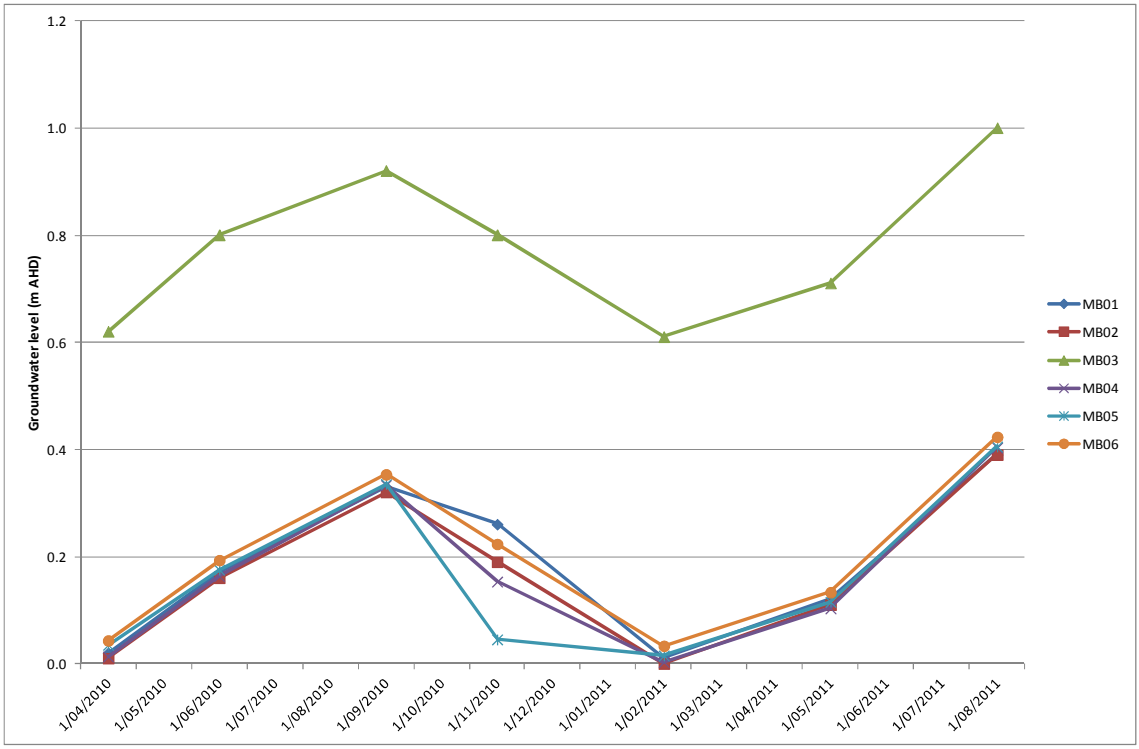

Figure 7 Variation in groundwater levels over time

Groundwater monitoring indicates a neutral to slightly alkaline groundwater with a generally fresh to slightly brackish characteristics (Table 3, Appendix 3).

Table 3 On site groundwater quality

Parameter	Minimum	Maximum	Median	Lake Clifton range of results (ENV 2009)
pH	7	7.7	7.4	7.86 – 8.49
Total dissolved solids (mg/L)	170	1200	535	37 700 - 61 800
Total nitrogen (mg/L)	0.15	11	2.90	2.0 - 3.6
Total phosphorus (mg/L)	<0.01	0.56	0.04	0.005 - 0.22

Nutrient levels in groundwater on the site were more variable than those recorded in Lake Clifton, but the median concentrations were within the range recorded at Lake Clifton. The total nitrogen levels varied between 0.15 and 11 mg/L, with a median concentration of 2.9 mg/L (Table 3). Total phosphorus concentrations varied from <0.01 to 0.56 mg/L, with a median of 0.04 mg/L (Table 3).

Full groundwater monitoring results can be found in Appendix 3.

3.5 Vegetation and flora

Vegetation and flora studies on the site were undertaken by Ecoscape in 2009. The vegetation was described as *Eucalyptus gomphocephala* (Tuart) Woodland, over *Agonis flexuosa* (Peppermint) Low Open Woodland over an understory of introduced grasses and weed species in the north and scattered A. *flexuosa* in the south of the site (Figure 8, Ecoscape 2009). This understorey reflected that the site has previously been parkland cleared. Greater than 90% of study area was considered to be completely degraded with little or no native understorey remaining (Ecoscape 2009).

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Meters

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Figure 8 Vegetation and fauna plan

Coordinate System: GDA 1994 MGA Zone 50
Date: 24/10/2012
Author: jcrute

Scale: 1:4,000 at A4
Source: Aerial image: Landgate 07/2012.
Vegetation & habitat trees: Ecoscape 2009.
Note that positional errors may occur in some areas

Path: Q:\GIS\Consult\2012\BAD\BAD12112.01\ArcMap_documents\R001\RevA\BAD12110_01_R001_RevA_F008.mxd

A total of 27 vascular plant species were observed in the survey area, 17 of which were introduced (Ecoscape 2009). Because of the lack of native vegetation, it was decided that a spring survey of the site was not required.

3.6 Fauna

The site is considered to have low habitat value due to lack of understorey and low number of trees (Ecoscape 2009). The following species of conservation significance may potentially use t he site:

- *Pseudocheirus occidentalis* (Western Ringtail Possum) may disperse through the site
- *Calyptorhynchus baudinii* (Baudin's Black-Cockatoo) may utilise the Tuarts on the site for nesting hollows
- *Charadrius rubricollis* (Hooded Plover) may feed within the adjacent Lake Clifton (Ecoscape 2009).

Potential habitat trees for Black-Cockatoo and Western Ringtail Possum have been identified and will be retained (Figure 8).

3.7 Wetlands

Lake Clifton is classified in the DEC Geomorphic Wetlands Swan Coastal Plain dataset as a Conservation Category Wetland and is located approximately 100m to the west of the site (Figure 5). Lake Clifton is listed and protected under the Ramsar Convention Ramsar sites as a wetland of international importance (Ecoscape 2009).

Lake Clifton is maintains significant natural values for wildlife and a community of critically endangered stromatolites (Ecoscape 2009). The thrombolites rely on the inflow of fresh groundwater containing calcium and bicarbonate for their growth (ENV 2009). The lake is also provides important habitat for waterbirds over the summer months, when other water bodies on the Coastal Plain dry up (CALM 1995).

A wetland boundary delineation study was undertaken by Ecoscape (2011) to better delineate the boundary of Lake Clifton. This boundary was based on the presence of wetland vegetation and other factors in accordance with *Draft Guideline for the Determination of Wetland Buffer Requirements* and discussions with the DEC (WAPC 2005) (Figure 5). The development has been designed to avoid infrastructure being placed within 50 m of the wetland boundary.

3.8 Servicing

The site currently provides its own water supply from two bores located within the property. Caravans on the site do not have their own sanitary facilities. Groundwater is provided washing, toilet and laundry purposes at the ablutions block. Each caravan is provided with a standpipe with a tap.

Bores on the property are not metered. Based on estimates of use for caravan parks from DoH of 270 L/caravan/day when in use (Richard A [DoH] 2012, pers. comm. 3 August), and assuming that two thirds of the caravans are in use at any time, the total water use for the site is estimated at 3.9 ML/yr.

Through the UWMP process, the developer has become aware that the site does not have current licenses for groundwater abstraction on the site. The developer is in the process of lodging an application for an abstraction license.

Wastewater from the ablutions block and caretaker's house are treated through the use of septic tanks and infiltrated on site. Effluent quality at the outlet of the existing system was tested by Strategen on 3 August 2012. The effluent had a total nitrogen concentration of 91 mg/L and a total phosphorus concentration of 8 mg/L. This is considered to be a high nitrogen concentration for treated wastewater. In comparison, the new wastewater treatment plant being constructed at Alkimos achieves a median nitrogen concentration of 7 mg/L (Water Corporation 2010).

3.9 Landscaping

Landscaping on the site will predominantly consist of native vegetation with some grassed areas. Existing trees will be predominantly retained on the site to provide habitat, as shown on Figure 2.

The development on the site will be undertaken as a leased estate, with park home owners paying fees to the developer for upkeep. Other park homes may be rented out by the developer as weekend or holiday accommodation. Landscaping outside the park home lots will be maintained by the developer as part of the overall lease arrangement. Water for development scale landscaping will be sourced from either recycled wastewater or bores on the site.

Because of the small lot size, it is likely that the lots will predominantly consist of roofed area and hardstand for car parking and outdoor living. Landscaping will be undertaken by the owners of the lots under the supervision of the owner/manager. Water for this landscaping will come from bores and/or rainwater.

The existing water feature will be retained (Figure 2). This feature consists of a lined, above ground koi pond with a waterfall feature to keep water moving and prevent mosquito breeding. The feature operates effectively without issues and is considered to be part of the character of the site. The pond is well maintained and is considered to comply with the requirements of the DoW *Interim Position Statement: Constructed Lakes* (2007) in that it does not cause water quality problems and is well managed. The pond does not have a drainage or irrigation water function.

The development is currently fenced to prevent access to the air strip and beyond that, Lake Clifton. This fencing is proposed to be retained.

4. Water use sustainability initiatives

4.1 Water balance and philosophy

The development is not located on a reticulated water or wastewater supply network. The nearest reticulated supply network is several kilometres from the site and the development is not proposing to connect to this network.

The development will have a policy of sustainable self supply. Water for the development will be sourced from a mixture of sources, which are likely to include:

- rainwater
- groundwater
- recycled wastewater.

At a lot level, rainwater collected from rooves will be used for in-house supply. Residents may be provided with groundwater for irrigation.

Groundwater and recycled water will be used for irrigation of open space. Wastewater not recycled will be disposed of by irrigation of a tree lot area. This methodology meets the objective of minimising the use of potable water where drinking water quality is not essential, particularly for ex-house uses. Should groundwater be required but no allocation available, the developer will seek to purchase an allocation from another user and/or minimise non-potable water demands on the site.

4.2 Water supply and efficiency measures

4.2.1 Water supply

Potable water use estimation

Not all of the park homes are anticipated to be occupied on a full time basis. It is anticipated that:

- 40% of the site to be used in frequently, being12 times a year for up to three days
- 40% of the site to be utilised for approximately five days per week for six months a year
- 20%of the site will consist of full time residents.

Using the Water Efficiency Calculator (Water Corporation undated), and assuming two permanent residents per park home with water efficient fixtures, the internal water use is estimated at 85 kilolitres (kL)/house/year or 43 kL/person/year. Assuming that the irrigated area of the lot is 70 m^2 with water efficient features, then total water use is estimated at 65 kL/person/year. This demand will depend primarily on the frequency of use of the site. Owners who are not often present are less likely to landscape and irrigate their lots.

Rainwater tanks

Rainwater provides a sustainable source of water that can be used for drinking water. Each home will be required to include a rainwater tank of at least 15,000 L in volume to be connected to the whole roof area. The developer will install all the park homes, including services. This ensures that the installation of measures such as rainwater tanks will be undertaken in a standardised manner, consistent with the requirements of SoW and Plumbers' Licensing Board.

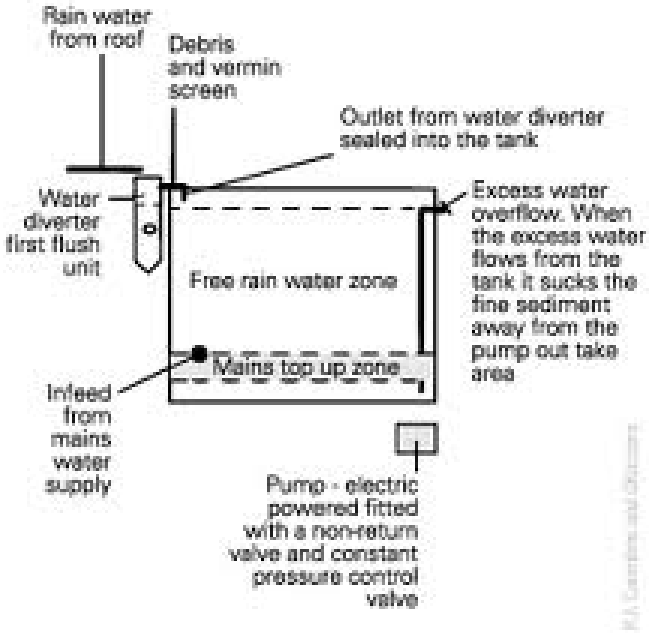


Figure 9 Rainwater tank with reticulated water top up (source *www.yourhome.gov.au*)

Rainwater tanks will be designed and installed to ensure water quality is maintained. All rainwater tanks will include:

- screened inlet and overflow to prevent birds, animals and insects from gaining direct access to the water (including mosquitoes)
- a cover and sealed manhole to allow access while preventing light from reaching the water, as light encourages the growth of bacteria and algae
- first flush diverter to downpipe to flush off leaves and debris and prevent gutters blocking
- guttering and piping that is self draining or fitted with drainage points to prevent mosquito breeding
- an overflow pipe that extends into anaerobic zone to remove sludge and sediment off bottom of tank
- pump to provide pressure and flow for in-house water use (Figure 9).

Overflow from the tank will enter the soakwell on the lot.

A 15,000 L tank is estimated to provide 63 kL/yr of water if connected to the full roof area. This volume may not be adequate for permanent residents or frequent users if the use occurs over summer. In this case, residents would be expected to organise and pay for their own water cartage. It is anticipated that the amount of additional water required will average at most one tank full (15,000 L) per park home per year, as some park homes will not be frequently occupied.

Owners will be provided with information on maintaining their tanks, which will include advice on:

- cleaning of gutters and downpipes
- pruning of trees and shrubs around the property
- the need to desludge the tank every two to three years (DoH, undated).

Reticulated non-potable supply

Anon-potable supply may be provided to residents for irrigation. This would include provision of a low flow tap in the front yard, signposted to show that the water was not suitable for potable use. This system is unlikely to require licensing from Department of Health. Annual checks would be undertaken to confirm that the system has not been cross connected for internal use.

Should all residents use this water for irrigation, then the estimated demand would be 2.9 ML/yr.

4.2.2 Lot scale water efficiency measures

The developer will install all park homes on the site. The developer will ensure that all units are fitted with water efficient showers and toilets as part of the fit out of the units to reduce water use on the site.

A Sustainability Package detailing the water supply situation and appropriate water conservation measures on the site will be explained to buyers at the time of sale. This will outline the need to conserve water on the site and provide information on low water use fixtures and sustainable gardens as well as advice on being waterwise in the home.

Landscaping will be undertaken by the owner. A portion of lots are likely to be used as holiday homes, in which case these lots are unlikely to be heavily landscaped and irrigated.

4.2.3 Irrigation and development scale water efficiency measures

The main factor determining water use at a development scale is the use of water for irrigation. The total area of open space on the site that may possibly require irrigation is estimated at 1.8 ha, assuming that all of this is to be irrigated. Road reserves on the site are very narrow (approximately 6 m wide) and will be fully paved. Approximately 0.9 ha of this will be irrigated with treated wastewater, as outlined in Section 4.3.1. This leaves a balance of approximately 0.9 ha to be irrigated with bore water. Assuming this is irrigated at a rate of 7,500 kL/ha/yr, this would result in a total of 6.8 ML/yr of water being used for irrigation.

The open space will be predominantly planted, with small areas of grass where amenity is required. Plantings will consist of local native species. This type of landscaping requires little input of fertiliser and water beyond the establishment phase. As such, irrigation demands are anticipated to be limited beyond establishment. The 6.8 ML/yr provided above is therefore considered to be an overestimate of the actual irrigation demand.

Grassed areas on the site will require irrigation. Irrigation water will be sourced from either recycled wastewater or groundwater. If recycled wastewater is chosen, then the irrigation system will the a Recycled Water Quality Management Plan (RWQMP) will be prepared and approved by Department of Health, as per the *Guidelines for the Non-potable Uses of Recycled Water in Western Australia* (DoH 2011).

Existing trees will be predominantly retained on the site to provide habitat, as shown on Figure 2.

4.2.4 Groundwater use and availability

DoW (letter dated 28 November 2012) has indicated that abstraction bores on the site should be located more than 200 m from the CCW because of potential salt intrusion issues. Of the two bores present on the site, one is located within 200 m of the boundary of the CCW. This bore is located in a proposed lot and will be relocated to a site more than 200 m from the boundary as part of the development process. Bores will be designed to be shallow to minimise the intrusion of deeper saltier water associated with the saline lake.

Development groundwater demands will be kept below 2000 kL/ha or 12 000 kL for the development, as required by the *South West Coastal Groundwater Area Groundwater Management Plan* (Water Authority of Western Australia 1989). Groundwater use on the site shall be metered. Groundwater use for irrigation is expected to consist of:

- up to 6.8 ML/yr for POS irrigation
- 2.9 ML/yr for domestic irrigation.

Limited volumes of groundwater will be required for WWTP operation. Commissioning volumes for the WWTP are estimated at 60-80 kL. During operation, WWTP use will be limited to the occasional requirements for flushing out of the reticulation system for maintenance and testing of tanks or other infrastructure at replacement, and are anticipated to average less than 30 kL per year. The total volume of groundwater required is estimated at approximately 9.8 ML/yr.

4.2.5 Water Balance

The current water cycle on the site consists of inputs from rainwater being infiltrated on site and abstracted by bores for use as a water supply. This water is used for domestic purposes and irrigation. Water used for domestic purposes is treated and the effluent is disposed of on site. Water used for irrigation is either used by plants or infiltrates to groundwater. No water is bought to the site as a reticulated supply and water does not leave the site as stormwater or untreated wastewater.

The development is not proposing to significantly alter this process. Excepting the importation of potable water to top up tanks, the development consists of a closed cycle, with rainwater water being captured on site and reinfiltrated via landscaping and the tree lot.

The volume of water imported to the site is estimated at a maximum of 15,000 L per park home per year. This is equivalent to 1.8 ML/yr over the 6 ha site. This water will be used for domestic purposes, treated and used for irrigation. Assuming that none of this water is lost due to evapotranspiration (an unlikely worst case scenario), the total increase is equivalent to an additional 30 mm of recharge. Rainfall in the area is estimated to average 845 mm/yr (Section 3.1).

4.3 Wastewater management

Wastewater on the site will be collected and treated using a Membrane Biological Reactor (MBR) type WWTP. The MBR plant is an activated sludge treatment plant using membrane ultrafiltration and alum dosing to remove nutrients. Effluent disinfection will be undertaken to produce a fit-for-purpose effluent quality and may include the use of liquid sodium hypochlorite and ultraviolet radiation, depending on whether the effluent is to be reused or irrigated on the tree lot (Worley Parsons 2012, Appendix 4). The plant will be designed to achieve a very high effluent quality of:

- 5 mg/L total nitrogen
- 1 mg/L total phosphorus (Worley Parsons 2012, Appendix 4).

In comparison, the new wastewater treatment plant being constructed at Alkimos achieves a median total nitrogen concentration of 7 mg/L and total phosphorus concentration of 12 mg/L (Water Corporation 2010).

Advice received from Department of Health (DoH) considers that design for effluent disposal systems for holiday facilities should be based on 270 L/day for one bedroom units and 540 L/day for two bedroom units (Richard A [DoH] 2012, pers. comm. 3 August). In comparison, the estimation using the Water Corporation rates outlined in Section 4.2.1 gives an in-house consumption of approximately 234 L/day for a two person household.

The development is anticipated to consist of 100 two bedroom units and 20 one bedroom units. Using the occupancy assumptions outlined above, the peak wastewater production volume using DoH rates is estimated at 59 kL/day and 8.3 megalitres per year (ML/yr). This compares to a peak volume of 28 kL/day and 4.6 ML/yr using the Water Corporation rates. This assumes that all of the water used in-house becomes wastewater. A conservative approach to wastewater has been taken, with the wastewater treatment plant and effluent disposal area sized based on the DoH rates to meet their requirements.

Based on the estimated capacity of the plant (less than 100 kL/day), the new wastewater treatment plant and associated disposal method will not require a works approval or registration with DEC. The treatment plant design will require approval from SoW.

Treated wastewater reuse and disposal

Consideration was given to the use of this water for irrigation of crops off site, as nearby areas are used for vegetable and turf farming. The volume of treated wastewater that could be provided by the site is potentially 4.6 to 8.3 ML/yr. Irrigation rates for vegetables are estimated at 5 to 15 ML/yr (Water and Rivers Commission 1996). Turf farm irrigation rates are anticipated to be similar. In the best scenario (i.e. maximum estimate for wastewater volumes and minimum irrigation rate), 1.66 ha of vegetables could be irrigated using the treated wastewater.

In order for off-site irrigation to occur, the following steps would be required:

1. The irrigator would be required to obtain DoH approval, including preparing a Recycled Water Management Plan (RWQMP).
2. If edible crops were chosen, the wastewater would need to be treated to a very high standard, suitable for irrigation of edible crops. The irrigator would be required to test water quality on a regular basis, including continuous online testing for disinfectant residuals (such as chlorine), turbidity and pH and weekly bacteriological testing (DoH 2011). If a turf farm was selected, daily testing would be required for disinfectant residuals and pH would still be required (DoH 2011). If the effluent quality does not meet criteria, then supply may be discontinued (DoH 2011).
3. Annual reporting to DoH and three yearly audits of the irrigation system would be required (DoH 2011).
4. An agreement of supply would need to be signed between the Park Home site and the irrigator, with involvement of ERA (Hilton H [ERA] 2012, pers. Comm. 12 July).

This would place a significant onus on the irrigator for what is effectively a small amount of water that can be had without significant cost from locally available groundwater. The option of reuse of treated wastewater off site was therefore discounted.

The options and need for reuse of treated wastewater on site are being assessed. The use of effluent outside a fenced irrigation area without access would require a RWQMP and appropriate measures to be undertaken to manage effluent quality. The WWTP proposed is able to treat the effluent to a suitable standard suitable for irrigation with some restricted public access, such as signs advising that the area was irrigated with wastewater and not to enter the area during irrigation (DoH 2011). Continuous online testing would be required (DoH 2011). A fenced irrigation area is required for situations where the effluent does not meet the testing criteria or when rain is forecast (DoH 2011).

Providing treated effluent to homeowners for irrigation is more problematic, as it opens the risk of cross connection of treated wastewater to potable supplies and homeowners working directly with treated wastewater. Managing this risk is difficult and such schemes are in their infancy in Australia. This option is not being considered at Lake Clifton.

Wastewater management approvals

Based on the estimated capacity of the plant (less than 100 kL/day), the new wastewater treatment plant and associated disposal method will not require a works approval or registration with DEC under the Environmental Protection Regulations 1987. The treatment plant design will require approval from SoW.

As the wastewater system will treat more than 0.54 kL/day, DoH approval is required for the WWTP. required to approve all wastewater systems treating greater than 0.54 kL/day of sewage.

4.3.1 Effluent disposal area sizing

The sizing of the effluent disposal area has been undertaken to comply with the guidelines for nutrient loadings and effluent in *Water Quality Protection Note 22: Irrigation with nutrient rich wastewater* (WQPN 22) (DoW 2008). The document recommends that the guidelines for nutrient loads for sandy soils that are adjacent to areas with a risk of eutrophication of:

- maximum nitrogen load of 140 kilograms per hectare per year (kg/ha/yr)
- maximum phosphorus load of 10 kg/ha/yr (DoW 2008).

These guidelines cover inputs from wastewater and other nutrient sources, such as fertilisers.

Based on an assumed effluent nitrogen concentration of 5 mg/L and a volume of 8.3 ML/yr, a total of 41 kg per year of nitrogen would be present in the WWTP effluent. This will require 0.30 ha of irrigated area to meet the load criteria (Appendix 5). This is a low nitrogen concentration for a wastewater effluent, but is considered to be achievable through the use of the MBR plant. The effluent disposal area will be designed as a tree lot to maximise nutrient uptake. A species suitable for use in tree lots, such as Blue Gum, will be used. The location of the tree lot area is shown in Figure 2.

Based on an assumed effluent phosphorus concentration of 1 mg/L, a total of 8.3 kg per year of nitrogen would be present in the WWTP effluent. This requires an irrigated area of 0.83 ha to meet the load criteria (Appendix 5). This is the larger of the two requirements and the irrigated area has been designed on this basis.

5. Stormwater and groundwater management

5.1 Groundwater management

Groundwater levels on the site are not anticipated to change as a result of the development. Any increase in recharge on the site caused by the development is anticipated to be offset by the drying climate being experienced in South-Western Australia.

A separation of 1.2 to 1.5 m between design groundwater levels and finished lot levels is generally required for developments on the Swan Coastal Plain to ensure that the risk of water logging and rising damp in developments is limited. The minimum road levels proposed on the development are approximately 3.35 mAHD in the south-east corner of the site (Figure 10). The maximum groundwater level recorded on the site that was not considered an outlier was 0.42 mAHD (Section 3.4.2). To allow for variation between dry and wet years, a clearance between the maximum groundwater level and design groundwater level (DGL) of 0.6 m has been used to ensure that sufficient clearance can be maintained. The design groundwater level has therefore been set at 1.02 mAHD, which is below the levels estimated by Commander for the area (Section 3.4.2).

The difference between the DGL and the minimum lot level is 2.32 m, which is considered to provide adequate separation to groundwater. Control of groundwater by subsoil drainage is not proposed on the site.

Minimum base levels of basins on the site are proposed at 2.30 mAHD. This allows approximately 1.3 m separation from base levels to groundwater, which is considered more than adequate for infiltration and ensuring the bottom of basins remain dry outside of storm events.

Earthworks on the site will be limited to minimal amounts of cut and fill required to shape basins and ensure lots are comparatively flat (Figure 10). Fill is required on the southern boundary so that stormwater does not discharge onto the adjacent land holding to the south and adequate road grades are provided for drainage. This fill will be sourced from the material removed to shape the basins and from cut operations from the north-west portion of the site.

As the water balance on the site is not anticipated to change, the development will not impact upon groundwater levels in the area.

Management measures for water quality on the site will jointly address surface water and groundwater quality on the site, as all stormwater will be infiltrated on the site. Details of these measures can be found in Section 5.3.

STRATEGEN

Lake Clifton Park Home Development Urban Water Management Plan

Earthworks Plan

Figure 10

5.2 Stormwater quantity management

One of the aims of stormwater management on the site is to maintain pre-development flows off the site. There is currently no flow off the site in a 1 in 100 year ARI rainfall event and no flow off the site will occur post-development. Water will therefore be treated and infiltrated within the development. Storage in events up to the 1 in 100-year ARI event will be retained within the development. This maintains the current surface water hydrology of Lake Clifton, where water does not enter via surface runoff.

5.2.1 1 in 1 year Average Return Interval event

Lot scale measures

Lots will be required to retain the 1 in 1 year ARI storm event on the lot. To ensure this occurs, the developer will install two 1.2 m diameter by 1.5 m deep soakwells on each lot. The soakwells will receive overflow from the rainwater tank. This is based on a total area of hardstand and roofing on the lot of 120 m^2. Development covenants will limit residences to this total area. Lot connections between soakwells and the development stormwater system are not considered necessary.

Development scale measures

In the 1 in 1 year ARI event, water from roads will enter a series of manholes and gully pits in the road reserve (Figure 11). From there, the water travels to a series of three nutrient stripping basins, two in the east of the site and one in the west, via bubble-up structures. The basins will be stepped to maximise the useability of the space available while preventing the need for fencing or other structures (Figure 12). The lower areas of the nutrient stripping basins will be planted with local species that are tolerant of inundation and have nutrient stripping properties in line with water sensitive urban design principles. This allows for treatment of events up to and including the 1 in 1 year ARI event. The higher levels of the nutrient stripping basins are likely to be native vegetation, but may be landscaped in turf, if this is considered to offer better amenity to the area.

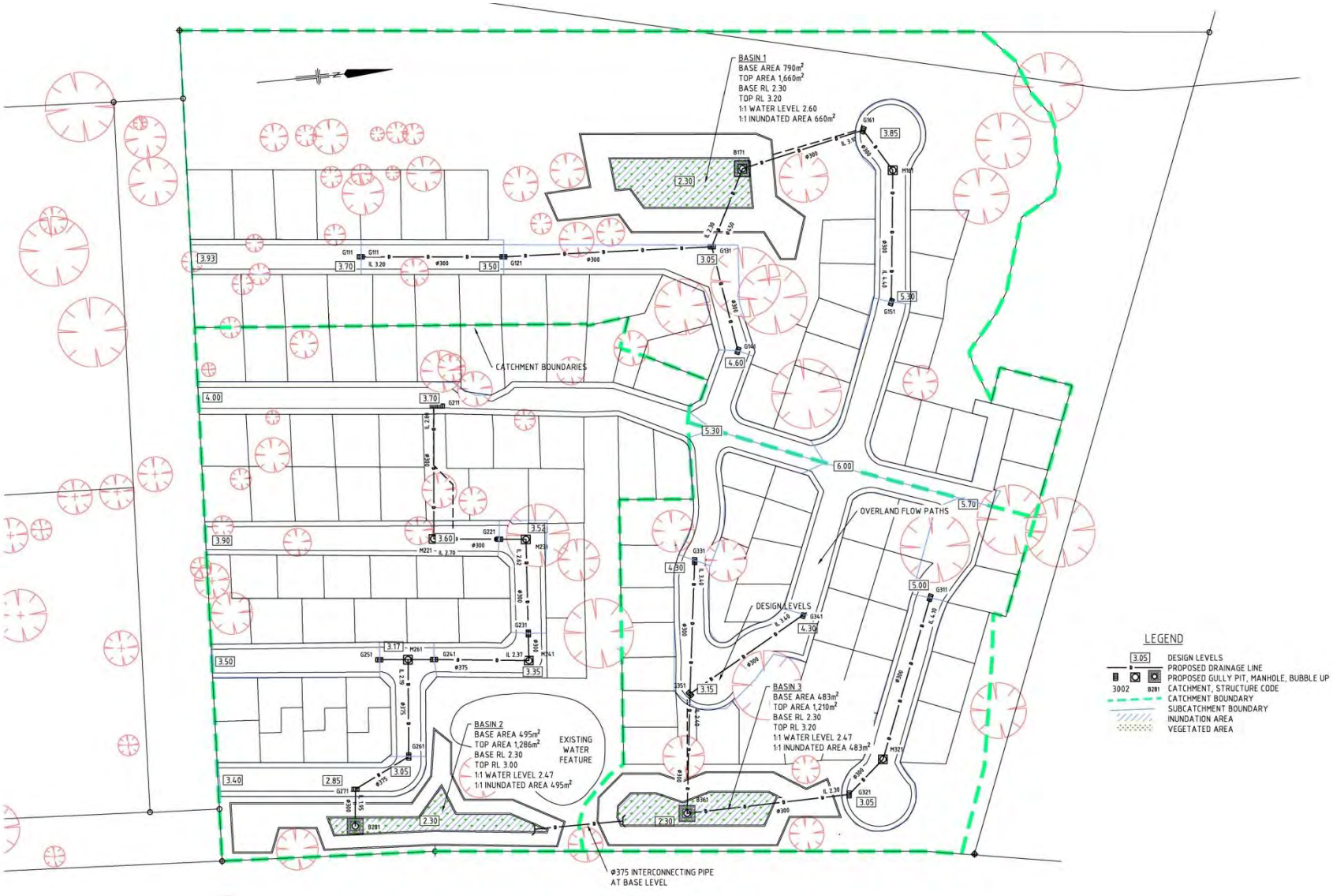
In the 1 in 1 year event, only the bottom level of each basin is anticipated to be inundated (Figure 11). Water may flow between Basins 2 and 3 in all events order to balance water levels and flows.

Road reserves in the development have been limited to a width of six metres. The small width of the road reserve and small lot size (with associated driveways) means that road scale vegetated areas are not suitable on the site. Because of the limited width, manholes and gully pits will be installed in the centre of the road. These manholes and gully pits will need to be trafficable. In sandy and limestone soils, trafficable manholes and pits may experience erosion and subsidence if open bases are used, causing road subsidence. Closed base manholes have therefore been selected for this development.

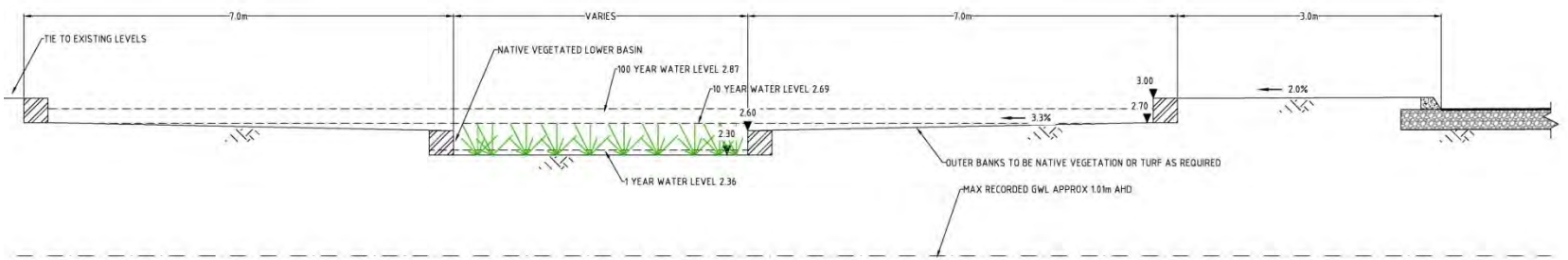
Design calculations for the basins in all events can be found in Appendix 6.

5.2.2 1 in 10 year Average Return Interval event

The 1 in 10 year ARI event is similar to the 1 in 1 year event, in that all flow from the roads is piped (Figure 13). In the 1 in 10 year ARI event, the soakwells on the lots will overflow into the road drainage system. In this event, the higher level of each basin will become inundated.



STRATEGEN	Lake Clifton Park Home Development Urban Water Management Plan 1 in 1 year ARI event plan	Figure 11



TYPICAL SECTION THROUGH BASIN 1

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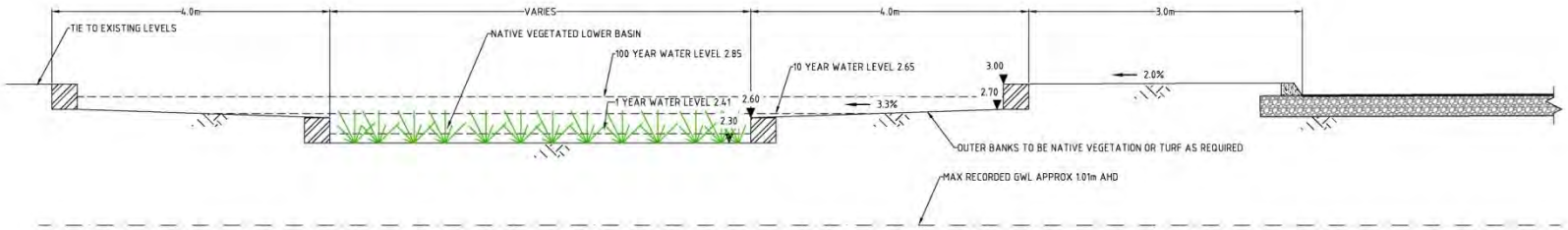

TYPICAL SECTION THROUGH BASIN 2

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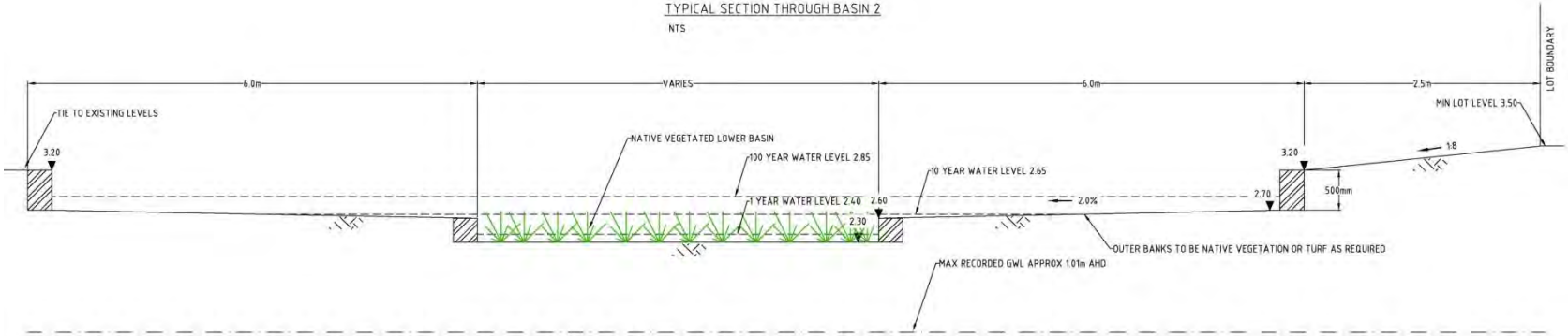

TYPICAL SECTION THROUGH BASIN 3

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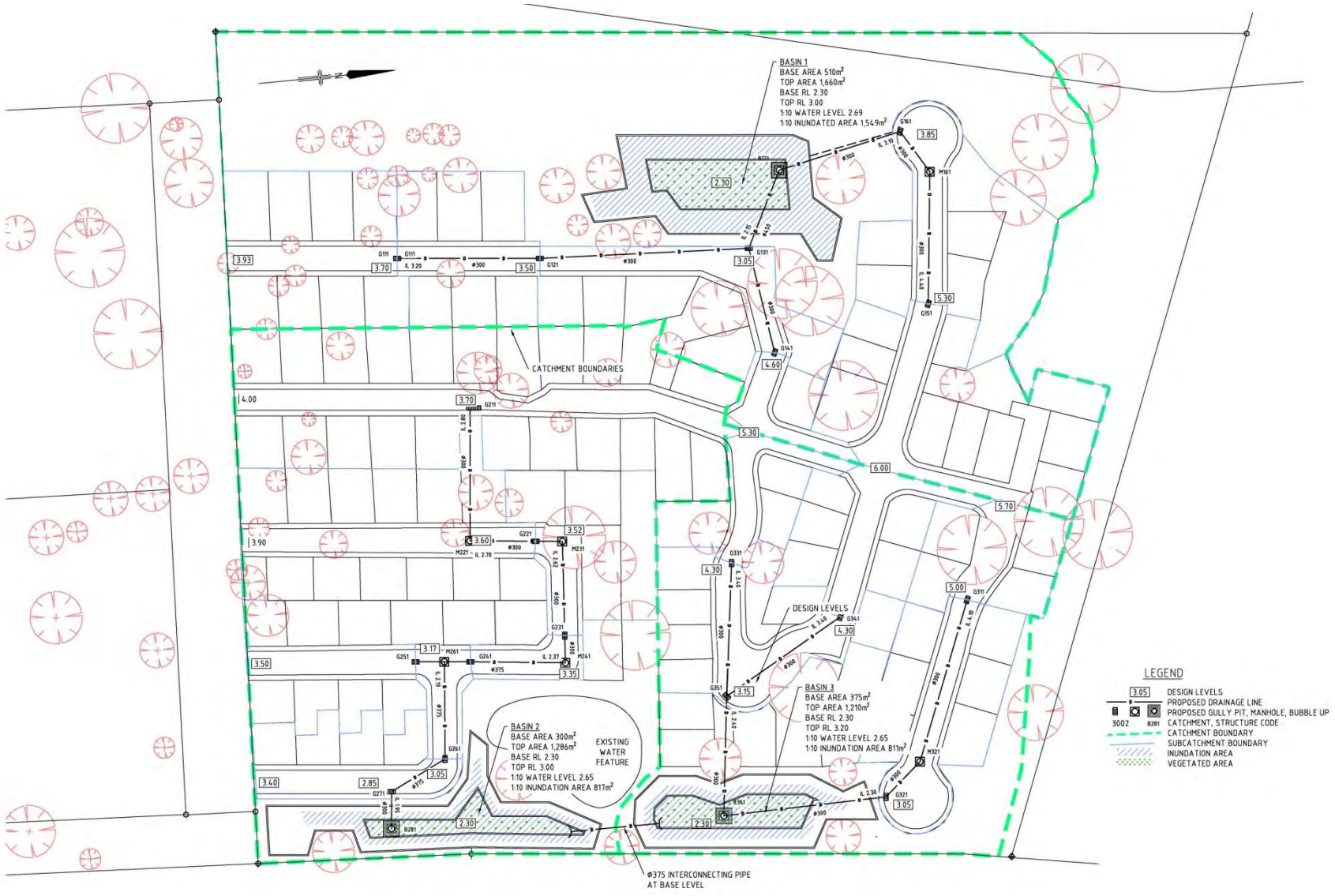
STRATEGEN	Lake Clifton Park Home Development Urban Water Management Plan Basin cross sections	Figure 12

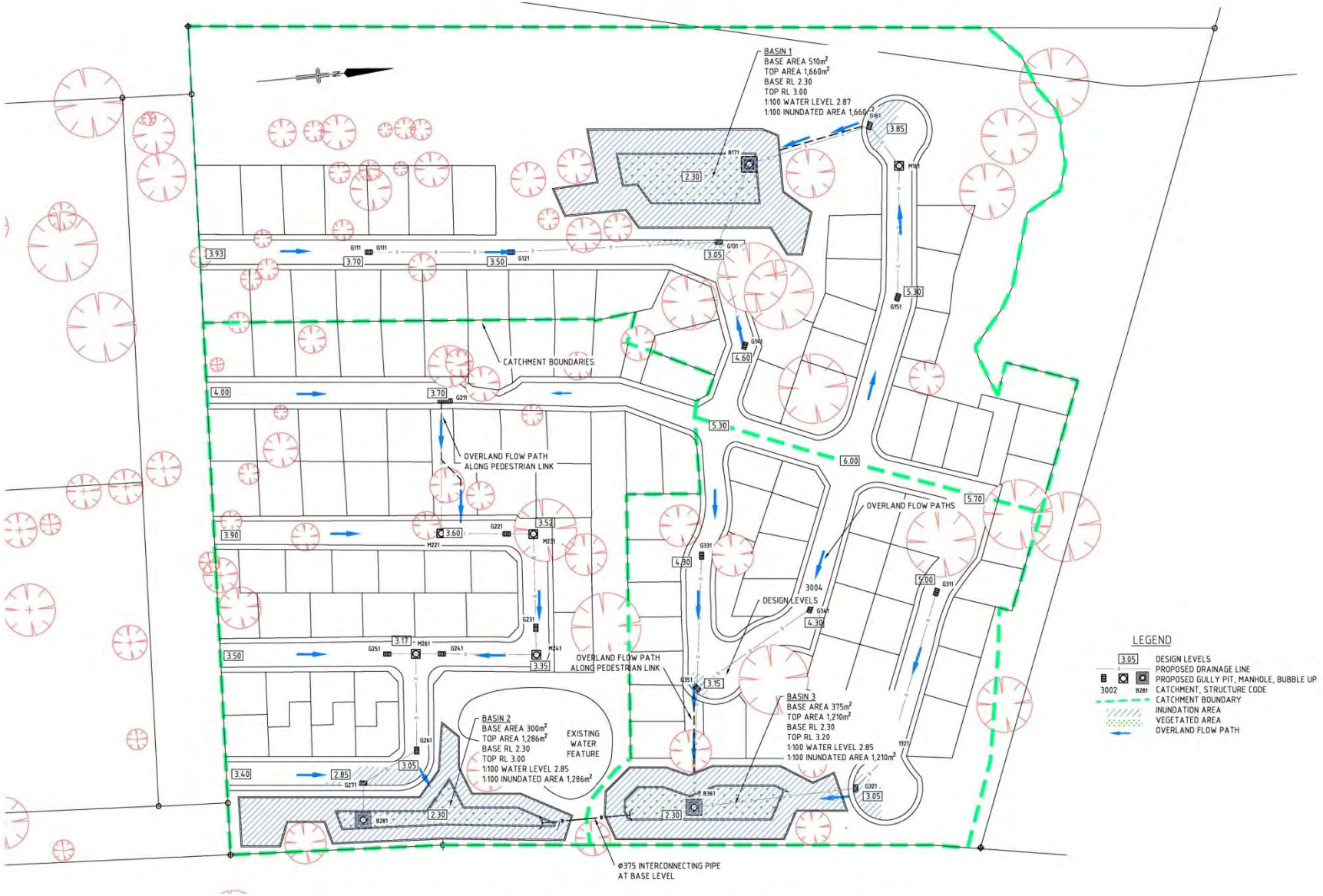


STRATEGEN

Lake Clifton Park Home Development Urban Water Management Plan

1 in 10 year ARI event plan

Figure 13



STRATEGEN

Lake Clifton Park Home Development Urban Water Management Plan

1 in 100 year ARI event plan

Figure 14

5.2.3 1 in 100 year Average Return Interval event

In the 1 in 100 year ARI event, water will enter the basins by both piped and overland flow (Figure 14). Basins will be inundated with a minimum of 0.15 m of freeboard allowed (Table 4). Some inundation of the road reserve will occur adjacent to the basins up to the kerb height which will dissipate generally within minutes after the peak flow, as capacity is attained within the piped drainage system. This will not prevent access or egress from the site and thus meets accessibility criteria required under Liveable Neighbourhoods (WAPC & DPI 2009) (Figure 14).

Table 4 Basin volumes and inundated areas in the 1 in 100 year ARI event

Basin	Top of basin level (mAHD)	Base level (mAHD)	Top area (m^2)	Base area (m^2)	Critical storm duration (hrs)	Top water level (mAHD)	Inundated area (m^2)	Volume (m^3)
1	3.20	2.30	1660	510	3	2.87	1660	538
2	3.00	2.30	1286	300	3	2.85	1286	364
3	3.20	2.30	1210	375	3	2.85	1210	375

The basins will be dry within 96 hours of the 1 in 100 year ARI event, meeting the objectives for prevention of mosquito and nuisance insect breeding outlined in Table 1. By managing all flows up to and including the 1 in 100 year ARI event by infiltration on site, the development meets the objectives for surface water flows outlined in Table 1.

5.3 Water quality management

5.3.1 Structural best management practices

The structural best management practices on the site consist of the three nutrient stripping basins. These basins will be planted with native vegetation designed to strip nutrients. The vegetation will be harvested on the site and removed to prevent overgrowth and nutrients in dead vegetation being remobilised. This allows new growth to form and take up additional nutrients.

5.3.2 Non-structural best management practices

Non-structural best management practices are considered to be a key element of nutrient management on the site. These are partially driven by the need to reduce water usage on the site.

At a development scale, landscaping will consist primarily of native plantings with turf used sparingly where appropriate. If treated wastewater is used for irrigation, then fertiliser will not be necessary and will not be applied. If treated wastewater is not used, then fertiliser will be applied sparingly to turf areas, when rain is not forecast. Slow release fertilisers will be used.

At a lot level, residents will be encouraged to use native vegetation for planting. Sustainability Packages will be provided at the point of sale, outlining appropriate fertiliser regimes and when and how this should be applied. This information will be followed up on an annual basis with letter drops outlining the need to minimise fertiliser use. Pets will not be allowed on the site to reduce pet waste loadings and to prevent attacks on wildlife.

5.4 Nutrient balance

A nutrient balance was undertaken on the site based on the assumptions and method of the Nutrient Irrigation Decision Support System (NIDSS) presented in the *Southern River/ Forrestdale/ Brookdale/ Wungong Urban Water Management Strategy, (*Water and Rivers Commission [WRC] 2002), with additions to allow for treated wastewater disposal. The NIDSS model was prepared by JDA Consultant Hydrologists for the WRC for the purpose of estimating pre- and post- urbanisation nutrient loads in the Southern River catchment. This study represents the most detailed available study of residential nutrient loadings in Western Australia and is based on a mixture of:

- surveys of residential nutrient input rates from fertiliser, car washing and pet waste
- City of Armadale records of POS fertiliser use between 1996 and 2000
- analysis by JDA of effectiveness of nutrient input source controls including community education programs, native gardens and water pollution control ponds (Appendices D and E of WRC 2002).

This is the most recent comprehensive survey and analysis of the type available for the Swan Coastal Plain. Information on nutrient loads for holiday homes and short stay accommodation is not available for Western Australia. As such, the information presented in this report is considered to be the most appropriate information on which to base a nutrient model of the site. A copy of the nutrient balance model can be found in Appendix 5.

For the pre-development scenario, the current estimates of effluent volumes and the measured concentrations were used. In this scenario, approximately 583 kg/yr of total nitrogen (TN) and 57 kg/yr of total phosphorus (TP) added per year (Appendix 5). There are currently no best management practices or stormwater management measures beyond soakwells used on the site. As discussed in Section 3.8, the wastewater treatment plant on the site does not appear to be operating well in terms of the removal of nitrogen and phosphorus.

In the post-development scenario, the wastewater treatment system results in significant reductions in nutrient loads from wastewater. Using the more conservative DoH volume estimates for wastewater, the nutrient load drops from 359 kg/yr TN to 41 kg/yr TN and from 32 kg/yr TP to 8 kg/yr TP (Appendix 5).

In the post development scenario, it is assumed that a number of nutrient management measures have been put in place to reduce nutrient loads, as discussed above. These include the use of low fertiliser native gardens for lots and open space and community education. With the implementation of these measures, the estimated post-development nutrient loads are reduced to 140 kg/yr TN and 24 kg/yr TP (Appendix 5). This is less than half the nutrient load in the pre-development scenario. The development therefore offers a significant improvement in nutrient loads compared to the current scenario.

6. Management of subdivisional works

Works undertaken will include vegetation removal, bulk earthworks, installation of underground services and installation of park homes. Dewatering is not anticipated to be required for this development.

This work will be undertaken by the developer. Given the location of the site, there are unlikely to be any sensitive receivers for dust and noise beyond the current residents. The developer will manage the impacts of dust and noise in a manner consistent with *Environmental Guidance for Planning and Development* (EPA 2008).

7. Monitoring and maintenance

Monitoring and maintenance will be undertaken by the developer in line with the schedule in Table 5.

Table 5 Monitoring and maintenance schedule

Function	Item to monitor	Trigger to action	Maintenance action required	Monitoring frequency
Drainage management system	Structural effectiveness (build up of rubbish, debris and sediment)	Rubbish, debris and sediments causing build up or blockages	Remove any material causing blockages	Every 3 months
	Sediment build up	Sediment taking up more than 15% of pit depth	Remove sediment	Every 3 months
	Vegetation build up	Vegetation becoming overgrown and covering more than 80% of the basin area	Remove vegetation and remove cuttings from the site	Remove vegetation every three years
	Weeds	Weeds are noxious or invasive or cover more than 25% of basin area	Remove weeds	Every 3 months
	Rubbish/litter	Litter entering basins	Remove litter and inspect for source. If recurring problem, consider actions	Every 3 months
Groundwater	Quality	Results outside guidelines as outlined in Section 7.1	Consider alterations to fertiliser regimes, as outlined in Section 7.1	Every 3 months
Non-potable groundwater supply to residents	Appropriate use of system (no cross connections or potable use)	Detection of cross connections or potable use.	Explain to residents that system is for non-potable purposes, remove any cross connections	Every 12 months
Open space	Weeds	Presence of noxious or invasive weeds that may impact Lake Clifton	Remove weeds	Spring and autumn
	Fire risk – build up of vegetation	Inspection of native vegetation and turf	As per Shire and FESA regulations	Spring each year

7.1 Groundwater monitoring

Post-development monitoring will be undertaken in line with the *Water Monitoring Guidelines for Better Urban Water Management Strategies/Plans (Draft)* (DoW 2011); or the final guidelines when these are developed. Post-development monitoring will occur from the installation of the first park homes until two years following the completion of construction.

The monitoring will include quarterly monitoring for water levels and quality Water monitoring will include:

- water levels
- pH and electrical conductivity
- total nitrogen, nitrate/nitrite, ammonia, Kjeldahl nitrogen, total phosphorus and phosphate.

Parameters will be monitored at bores 1, 2, 5 and 6, which are adjacent to the development. Results will be compared to the baseline results outlined in Section 3.4.2. Should nutrient concentrations exceed pre-development concentrations for two consecutive events, then investigations will be undertaken into the reason for this exceedence. Management measures undertaken may include:

- changes to fertilisation regimes such as reducing amounts of fertiliser used or altering timing if this is considered a factor (e.g. avoiding rainy periods)
- advising residents of the matter and to reduce their fertiliser use.

Monitoring results and any subsequent actions will be provided to DoW on an annual basis.

Additional monitoring may be required to meet the requirements of DoH and SoW with respect to the wastewater system. This monitoring will be reported to these agencies will be undertaken and reported in compliance with their licences and permits.

8. Implementation plan

Developer commitments and the roles of the developer are discussed in Table 6. No outside funding is being sought for this development.

Table 6 Developer commitments

Role	Responsibility	Requirement	Period
Post-development monitoring	Developer	Undertake post-development monitoring in a manner consistent with Table 5.	Two years following completion of construction
Maintenance of open space and structural drainage controls	Developer	Maintain open space and drainage controls in a manner consistent with Table 5.	Life of development.
Non-structural controls: public awareness of Water Sensitive Urban Design	Developer	Provide Sustainability Packages, including information regarding non-structural control issues such as fertiliser application and native gardens to new residents.	Point of sale
	Developer	Provide annual reminders of the need to limit fertiliser use and ways to limit water and fertiliser use. Limit use of fertiliser on open space and ensure any fertiliser used is of a slow release variety and is applied when rain is not anticipated.	Life of development.
Water efficiency	Developer	Construction of waterwise open space, including retention of native vegetation and low water use landscaping. Provision of information regarding water supply and water efficiency to buyers.	At construction.
Wastewater treatment plant construction and management	Developer	Construct and operate wastewater treatment plant in a manner consistent with all approvals. If wastewater to be reused for irrigation, gain approvals and operate system in a manner consistent with approvals.	Life of development.
Non-potable groundwater supply system	Developer	Assess requirement for reticulated supply provided. If required, obtain relevant approvals	Prior to construction.
	Developer	Maintain and operate reticulated non-potable supply.	Life of development.
	Developer	Ensure that residents are aware that supply is non-potable and inappropriate use and cross connections do not occur	Life of development.
	Owner	Manage rainwater tanks in a manner consistent with health requirements	Life of development.
	Owner	Use non-potable supply appropriately	Life of development.

9. Summary

The Lake Clifton Park Home site will manage water and nutrients in an appropriate manner to minimise any potential impact upon Lake Clifton. This includes:

- sustainable water supply management with no net export and limited importing of potable water
- installation of a Membrane Bioreactor style Wastewater Treatment Plant with dosing for phosphorus removal
- no flow of stormwater off the site in events up to the 1 in 100 year ARI event
- treatment of stormwater through nutrient stripping basins
- use of non-structural best management practices to reduce nutrient inputs at a development and lot scale
- installation of a wastewater treatment plant that produces an effluent with very low nitrogen and phosphorus concentrations
- ensuring that immobile stormwater is infiltrated within 96 hours to prevent mosquito and midge breeding (Table 7).

Table 7 provides a summary of the design elements and requirements for best management practices and how these comply with the key principles and objectives for water sensitive design on the site.

Through these measures, it is considered that the development complies with the water balance and nutrient objectives of the EPA (1998) *Guidance Statement No. 28, Development of the Lake Clifton Catchment*.

Table 7 Design elements and requirements for best management practices and critical control points

Category	Principles	Objectives	Development design elements and requirements
Water use	• 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 for the needs of all users, including community, industry and the environment.	Minimise the use of potable water where drinking water quality is not essential, particularly for ex-house uses.	The development will have a policy of sustainable self supply. Water for the development will be sourced from a mixture of sources, which will include: • rainwater • groundwater • recycled wastewater. At a lot level, rainwater collected from rooves will be used for in-house supply, with groundwater likely to be provided for garden use. At a lot level, rainwater collected from rooves will be used for in-house supply, with groundwater likely to be provided for garden use. Where rainwater volumes are not adequate for household use purposes, carted water will be used. Volumes of carted water are expected to be less than 15,000 L/household/year. Groundwater and recycled water will be used for irrigation of open space. Wastewater not recycled will be disposed of by irrigation of a tree lot area. This methodology meets the objective of minimising the use of potable water where drinking water quality is not essential, particularly for ex-house uses.
Groundwater levels and surface water flows	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	For ecological protection, 1 in 1-year ARI volume and peak flow rates maintained at or below 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 development area to pre-development flow rates.	There will be no flow off the site in events up to the 1 in 100-year ARI event, as is currently the case. Stormwater will not enter Lake Clifton in events up to the 1 in 100-year ARI event. As the water balance on the site is not anticipated to change, the development will not impact upon groundwater levels in the area.
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • 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 waterways and maintain water quality in the specified environment.	Implement current known best management practice as detailed in the DoW *Stormwater Management Manual for Western Australia* (DoW 2004 – 2007) 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, use of bioretention systems, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre-development levels. Minimise the export of pollutants such as phosphorus and nitrogen to surface or groundwater from stormwater and rainwater.	Best Management Practices (BMPs) have been implemented in the form of nutrient stripping basins through the development to minimise pollution. Non-structural BMPs on the site will be extensively utilised, including Sustainability Packages provided at point of sale and regular advice on methods to reduce fertilisers use at a lot scale. Open space landscaping on the site will be designed to minimise fertiliser and water use. Fertiliser will be of a slow release type and will used sparingly. Nutrient balance indicates that the new development and improved wastewater treatment will significantly reduce nutrient loads from the site.

Category	Principles	Objectives	Development design elements and requirements
Disease vector and nuisance insect management	• to reduce the health risk from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	Permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of Departments of Water and Health.	Detained stormwater will be fully infiltrated within 96 hours The existing water feature on the site shall be retained. This feature contains fish and is managed to prevent mosquito and midge breeding.

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List of appendices

The following appendices are contained on CD-ROM inside the back cover of this report

Appendix 1 UWMP Checklist

Checklist for integrated water cycle management assessment of application for subdivision or urban water management plan

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide a brief description of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals.

UWMP item	Deliverable	Included?	Location in text
Executive summary			
Development design elements and compliance with design objectives	Table 1: Design elements & compliance	✓	Executive Summary
Key design requirements for detailed design – critical control points and elements	Table 2: Design requirements for critical control points		
Introduction and planning approval			
Location plan, adjoining lots, key landscape features and roads. Local Water Management Strategy. Structure plan, zoning and land use. Subdivision plan and/or approval	Location plan, site context plan, subdivision layout plan or combination of above	✓	Section 1, Figure 2
Design objectives			
Agreed design objectives and source of objective		✓	Section 2
Site characteristics			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		✓	Section 3
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	✓	Section 3.2, Figure 3
Geotechnical - topography, test pit locations, soil zones and descriptions, site classification zones, proposed earthworks and approximate finished contour levels	Geotechnical plan	✓	Section 3.3, Figure 4
Environmental - sensitive or significant vegetation areas, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	✓	Sections 3.5 - 3.7, Figures 5 and 7.
Surface Water – topography, 100 year floodways and flood fringe areas, 100 year proposed flow paths, water quality of flows entering and leaving (if applicable)	Surface Water Plan	✓	Section 3.4.1, Figure 5
Groundwater – topography, test bore locations, groundwater pre development, groundwater post development, water quality details, groundwater variation hydrograph	Groundwater Plan plus details of groundwater monitoring and testing	✓	Section 3.4.2, Figure 6.
Landscape - proposed public open space areas, water source, bore(s), lake details (if applicable), approx watering requirements and water balance, indicative irrigation schedule. Demonstrate compliance with DoW Constructed Lakes Position Statement if applicable	Landscaping plan	✓	Section 3.9
Water use sustainability initiatives			
Water supply & efficiency measures		✓	Section 4
Fit-for-purpose strategy and agreed actions. If non-potable supply, support with water balance		✓	Section 4
Wastewater management		✓	Section 4.3

UWMP item	Deliverable	Included?	Location in text
Stormwater and groundwater management design			
Flood protection - peak flow rates, top water levels at control points,100 year flow paths - floodways and flood fringe zones and/or along roads and reserves, 100 year inundation areas and volumes	100yr event Plan Long section of critical points	✓	Section 5.2.3, Figure 13
Stormwater management system - storage areas, flows and hydraulic grade lines for both major and minor events including controlling inverts (critical control points). Locations and arrangements for agreed structural and non-structural best management practices and treatment trains supported by sizing criteria, areas of inundation, flow paths and cross sections. Show integration with landscaping	1yr event Plan 5yr event Plan Typical cross sections	✓	Sections 5.2 and 5.3, Figures 10-13
Post development groundwater levels and fill requirements (including existing and final surface levels), outlet controls, and any subsoils (showing drawdown/impacts near sensitive environments). Describe modelling assumptions.	Groundwater/subsoil Plan Typical cross section (max and minimum)	✓	Section 5.2, Figure 9
Actions to address acid sulfate soils or contamination		N/A	No risk of ASS or contamination on site
Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages		✓	Sections 3.5 – 3.7
Management of disease vector and nuisance insects		✓	Section 3.9
Management of subdivisional works			
Management of construction activities including dewatering, acid sulfate soils, constructed best management practices, and dust, sediment and erosion control – timing and possible staging		✓	Section 6
Monitoring program			
Sampling and assessment plan including duration and arrangements for ongoing actions		✓	Section 7.1
Implementation plan			
Roles, responsibilities, funding for implementation		✓	Section 8
Maintenance arrangements as agreed		✓	Section 7.2
Assessment and review		✓	Section 8

Appendix 2 Geotechnical Report

Douglas Partners
Geotechnics • Environment • Groundwater

Integrated Practical Solutions

REPORT
ON
PRELIMINARY GEOTECHNICAL INVESTIGATION

PROPOSED RESIDENTIAL SUBDIVISION
LOTS 19 – 21 OLD COAST ROAD
LAKE CLIFTON, WA

Prepared for
TONY SCOLARO FAMILY TRUST

Project 76038
August 2010

Douglas Partners
Geotechnics • Environment • Groundwater

REPORT
ON
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The Association of Consulting Engineers Australia

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RDS:DR
Project: 76038
18 August 2010

REPORT ON PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION
LOTS 19 – 21 OLD COAST ROAD, LAKE CLIFTON, WA

1. INTRODUCTION

This report presents the results of a geotechnical investigation undertaken for a proposed residential subdivision at Lots 19 - 21 Old Coast Road, Lake Clifton. This investigation was commissioned in a fax dated 18 June 2010 by Hamish Beck of Beck Advisory on behalf of Tony Scolaro Family Trust and was undertaken in accordance with Douglas Partners' proposal dated 12 May 2010.

The purpose of the investigation is to assess the sub surface conditions beneath the site and thus provide factual information on:

- the ground conditions encountered during the investigation;
- depth to groundwater, if encountered at the time of the investigation;
- depth to limestone, if encountered; and
- the nutrient retention capacity of the soils.

Details of the field work and laboratory testing are presented in this report.

2. SITE DESCRIPTION

The site comprises a rectangular shaped area of approximately 17.3 ha. It is bounded by Old Coast Road to the east, vacant land to the north and south and Lake Clifton to the west of the (Refer to Drawing 1, Appendix A).

At the time of the investigation the site generally comprised vacant land covered with grass, small shrubs and large trees. A small caravan park, a petrol station and a few residential houses occupy the central portion of the site. Limestone outcrop was observed in many locations.

The site is generally flat with surface levels of between RL 2 m and 5 m AHD, and two high points at around RL 8 m to 10 m AHD in the north-western and south-western corners.

The Lake Clifton–Hamel 1:50 000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site comprise sand derived from Tamala Limestone overlying limestone, possibly at shallow depth.

3. FIELD WORK METHODS

Field work was carried out on 16 July 2010 and comprised the excavation of eight test pits (TP1 to TP8) and 5 boreholes (BH9 to BH13).

The test pits were excavated using a Komatsu 5 tonne excavator equipped with a 600 mm toothed bucket. The boreholes were drilled using a 110 mm diameter hand auger. Each test location was logged in general accordance with AS1726 – 1993 by a suitably experienced representative from Douglas Partners. Representative soil samples were recovered from selected locations for subsequent laboratory testing. Perth Sand Penetrometer (PSP) tests were carried out adjacent to selected test locations in accordance with AS1289.6.3.3 to assess the *in situ* conditions of the shallow soils.

All test locations were determined using existing site features and are shown on Drawing 1, Appendix A. Surface elevations at each test location were interpolated from a contour plan provided by the client and are quoted in metres above Australian Height Datum (AHD).

4. FIELD WORK RESULTS

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix B, together with notes defining descriptive terms and classification methods.

The ground conditions encountered at the test locations generally comprise topsoil overlying sand and limestone. A summary of the conditions encountered is provided below:

TOPSOIL - dark grey silty sandy topsoil with rootlets to depths of between 0.1 m and 0.2 m;

SAND - generally medium dense, orange-brown sand with a trace of silt to depths of between 0.3 m and 1.1 m; and

LIMESTONE - low to medium strength, light yellowish brown limestone underlying the sand at all test locations to the depth of investigation.

The depths below existing surface level and relative levels of the top of the limestone at each test location are summarised in Table 1, below.

Table 1 – Summary of Limestone Depths and Levels

Test Location	Interpolated Surface Level (m AHD)	Depth to Top of Limestone (m)	Interpolated Level of Top of Limestone (m AHD)
TP1	6.0	0.6	5.4
TP2	2.8	0.6	2.2
TP3	5.0	0.4	4.6
TP4	3.2	0.3	2.9
TP5	2.4	1.1	1.3
TP6	5.9	0.8	5.1
TP7	4.8	0.4	4.4
TP8	3.0	0.4	2.6
BH9	3.2	0.4	2.8
BH10	2.6	0.4	2.2
BH11	3.2	0.6	2.6
BH12	3.5	0.7	2.8
BH13	2.7	0.5	2.2

4.2 Groundwater

No free groundwater was observed within any of the test pits or boreholes on 16 July 2010 to RL 0.9 m AHD.

5. LABORATORY TESTING RESULTS

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of the particle size distribution on two sand samples and the point load index on five irregular lump samples of limestone.

The results of the testing are summarised in Table 2 and test certificates are presented in Appendix C.

Table 2 – Summary of Geotechnical Laboratory Test Results

Test	Depth (m)	Soil Type	% fines	d_{10} (mm)	d_{60} (mm)	Is50 (MPa)
TP1	0.7	LIMESTONE – light yellow-brown	-	-	-	1.23
TP2	0.8	LIMESTONE – light yellow-brown	-	-	-	0.24
TP4	0.4	LIMESTONE – light yellow-brown	-	-	-	0.74
TP5	1.2	LIMESTONE – light yellow-brown	-	-	-	0.32
TP8	0.8	LIMESTONE – light yellow-brown	-	-	-	0.35
BH9	0.3	SAND – orange-brown	3	0.08	0.22	-
BH12	0.5	SAND – orange-brown	4	0.08	0.19	-

Notes:
- The %Fines is the amount of particles smaller than 75 µm;
- A d_{10} of 0.10 mm means that 10 % of the sample particles are finer than 0.10 mm;
- A d_{60} of 0.38 mm means that 60 % of the sample particles are finer than 0.38 mm;
- Is50: Point load index; and
- '-' means not tested.

A suite of chemical analyses was also undertaken on five selected samples by a NATA registered laboratory and comprised the determination of:

- pH;
- electrical conductivity;
- cation exchange capacitys; and
- phosphorus retention indexs.

The results of the testing are summarised in Table 3 and test certificates are presented in Appendix C.

Table 3 – Summary of Chemical Laboratory Test Results

Test	Depth (m)	Soil Type	pH	EC (µS/cm)	PRI (mL/g)	CEC (meq/100g)
TP1	0.5	SAND – orange-brown	6.4	1,400	11	2.9
TP4	0.2	SAND – orange-brown	7.3	1,500	18	4.3
TP7	0.3	SAND – orange-brown	7.4	1,600	9.2	2.4
BH11	0.2	SAND – orange-brown	7.2	1,500	7.8	9.5
BH13	0.5	SAND – orange-brown	7.4	1,200	19	7.7

Notes:
- EC: Electrical conductivity;
- PRI: Phosphorus retention index;
- CEC: Cation exchange capacity.

6. LIMITATIONS

Douglas Partners (DP) has prepared the factual report for this project at Lots 19 – 21 Old Coast Road, Lake Clifton in accordance with DP's proposal dated 12 May 2010 and acceptance received from Tony Scolaro Family Trust dated 18 June 2010. This report is provided for the exclusive use of Tony Scolaro Family Trust for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results provided in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. Actual ground conditions and materials behaviour observed or inferred at the test locations may differ from those which may be encountered elsewhere on the site.

This report must be read in conjunction with the attached "Notes Relating to This Report" and any other attached explanatory notes and should be kept in its entirety without separation of

individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others which are not supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

7. REFERENCES

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Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.

Australian Standard AS 1726-1996, Geotechnical Site Investigation.

DOUGLAS PARTNERS PTY LTD

Reviewed by:

Daniel Reaveley
Geo-Environmental Scientist

pp Michael J Thom
Principal

APPENDIX A

Site Plan and Test Locations

Douglas Partners
Geotechnics • Environment • Groundwater

Brisbane, Cairns, Canberra, Darwin, Gold Coast, Melbourne, Minto

Newcastle, Perth, Sydney Sunshine Coast, Townsville, Wollongong, Wyong

Title: LOTS 19-21 OLD COAST ROAD, LAKE CLIFTON

TEST LOCATION PLAN

Client:	TONY SCOLARO FAMILY TRUST			Office: PERTH	
Drawn By:	R. DA SILVA	Scale: 1 : 2 500	Project No: 76038	DRAWING 1	Revision: A
Approved By:	--		Date: 26-07-10		

APPENDIX B

Results of Field Work

Notes Relating to this Report

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NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in

clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section

is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 2.8 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 2
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.							
	0.6	LIMESTONE - low strength, light yellow-brown limestone.		D	0.8				
	0.9	Pit discontinued at 0.9m (due to slow progress)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 5.0 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 3
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.							
	0.4	LIMESTONE - low to medium strength, light yellow-brown limestone.		D	0.6				
	0.9	Pit discontinued at 0.9m (due to refusal)							
4	1								1

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▽ Water level

CHECKED	
Initials:	
Date:	19.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 3.2 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 4
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
3	0.15	TOPSOIL - dark brown, silty sandy topsoil.							
		SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.		D	0.2				
	0.3	LIMESTONE - low to medium strength, light yellow-brown limestone.		D	0.4				
	0.5	Pit discontinued at 0.5m (due to refusal)							
2									
1									1

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 15.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 2.4 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 5
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.15	SAND - medium dense, grey mottled dark grey, fine to medium grained, humid sand with some silt.							
2		- becoming light grey with some shells from 0.6m.							
		- becoming light grey from 0.9m.							
	1			D	1.0				1
	1.1	LIMESTONE - low to medium strength, very light yellow-brown limestone.							
1				D	1.2				
	1.5	Pit discontinued at 1.5m (due to slow progress)							

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 5.9 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 6
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.0	FILLING (SAND) - medium dense, light orange-brown, fine to medium grained, humid sand with trace of silt.							1
	0.8	LIMESTONE - low strength, light yellow-brown limestone.							
4	1.4	Pit discontinued at 1.4m (due to slow progress)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: R
Date: 14.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 4.8 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 7
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.		D	0.3				
	0.4	LIMESTONE - low to medium strength, light yellow-brown limestone with some sand infill to 1.8m.							
4									
	1			D	1.2				1
3	1.8	Pit discontinued at 1.8m (due to slow progress)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

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TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 3.0 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 8
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.2	SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.							
	0.4	LIMESTONE - low to medium strength, light yellow-brown limestone with some sand infill to 1.0m.		D	0.8				
~1	1.0	Pit discontinued at 1.0m (due to slow progress)							1

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

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BOREHOLE LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 2.6 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH 10
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	TOPSOIL - dark grey, silty sandy topsoil.							
		SAND - orange-brown, fine to medium grained, humid sand with some silt.		D	0.3				
	0.4	Bore discontinued at 0.4m (due to refusal on limestone)							

RIG: 110mm Hand Auger **DRILLER:** R Da Silva **LOGGED:** R Da Silva **CASING:**
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

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BOREHOLE LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 3.2 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH 11
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
3	0.1	TOPSOIL - dark grey, silty sandy topsoil.							
		SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt and charcoal fragments.		D	0.2				
	0.6	Bore discontinued at 0.6m (due to refusal on limestone)							
2	1								1

RIG: 110mm Hand Auger **DRILLER:** R Da Silva **LOGGED:** R Da Silva **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 16.7.10

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 3.5 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH 12
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
3	0.1	TOPSOIL - dark grey, silty sandy topsoil.							
		SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.		D	0.5				
	0.7	Bore discontinued at 0.7m (due to refusal on limestone)							
2	1								1

RIG: 110mm Hand Auger **DRILLER:** R Da Silva **LOGGED:** R Da Silva **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: M
Date: 19.8.10

Douglas Partners
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BOREHOLE LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 2.7 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH 13
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey, silty sandy topsoil.							
		SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.							
	0.5	Bore discontinued at 0.5m (due to refusal on limestone)		D	0.5				

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110mm Hand Auger **DRILLER:** R Da Silva **LOGGED:** R Da Silva **CASING:**

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.8.10

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 3.2 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH 9
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
3	0.2	TOPSOIL - dark grey, silty sandy topsoil.							
		SAND - orange-brown, fine to medium grained, humid sand with some silt.		D	0.3				
	0.4	Bore discontinued at 0.4m (due to refusal on limestone)							
2	1								1

RIG: 110mm Hand Auger **DRILLER:** R Da Silva **LOGGED:** R Da Silva **CASING:**
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date: 19.7.10

Douglas Partners
Geotechnics • Environment • Groundwater

TEST PIT LOG

CLIENT: Tony Scolaro Family Trust
PROJECT: Lots 19-21 Old Coast Road
LOCATION: Lake Clifton, WA

SURFACE LEVEL: 6.0 m AHD *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP 1
PROJECT No: 76038
DATE: 16 Jul 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
									5 10 15 20
		TOPSOIL - dark brown, silty sandy topsoil.							
	0.15	SAND - medium dense, orange-brown, fine to medium grained, humid sand with some silt.		D	0.5				
	0.6	LIMESTONE - medium strength, light yellow-brown limestone.		D	0.7				
	0.9	Pit discontinued at 0.9m (due to refusal)							
5	1								1

RIG: 5 Tonne Komatsu Excavator (600mm toothed bucket)
LOGGED: R Da Silva

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: AL
Date: 19.8.10

Douglas Partners
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APPENDIX C

Laboratory Testing Results

Point Load Strength Index
AS 4133.4.1

Mining and Civil Geotest Pty Ltd
Unit 1, No. 1 Pusey Road
Jandakot WA 6164

Client:	Tony Scalaro Family Trust	Report No.	60017-P10/1838-1842
Project:	Lots 19-21 Old Coast Road	Date Tested:	30/07/2010
Location:	Lake Clifton	Tested By:	S Sandilands
Date of Sampling and Sampling Method:	Tested as received	Client No.:	60017

Sample No. P10/	Sample	Rock Type	Moisture	Test Type	L (mm)	W (mm)	D (mm)	P (kN)	Is (MPa)	Is50 (MPa)	Remarks
1838	TP 1, 0.7m	Limestone	M	L	70	85	40	4.69	1.08	1.23	
1839	TP 2, 0.8m	Limestone	M	L	60	100	41	1.05	0.20	0.24	
1840	TP 4, 0.4m	Limestone	M	L	80	140	46	4.67	0.57	0.74	
1841	TP 5, 1.2m	Limestone	M	L	90	100	50	1.63	0.26	0.32	
1842	TP 8, 0.8m	Limestone	M	L	100	100	48	1.73	0.28	0.35	

Comments

KEY:

Moisture	**Test Type**
D - Dry	L - Lump
M - Moist	A - Axial
W - Wet	D - Diametral

Approved Signatory :

Kevin M Jones

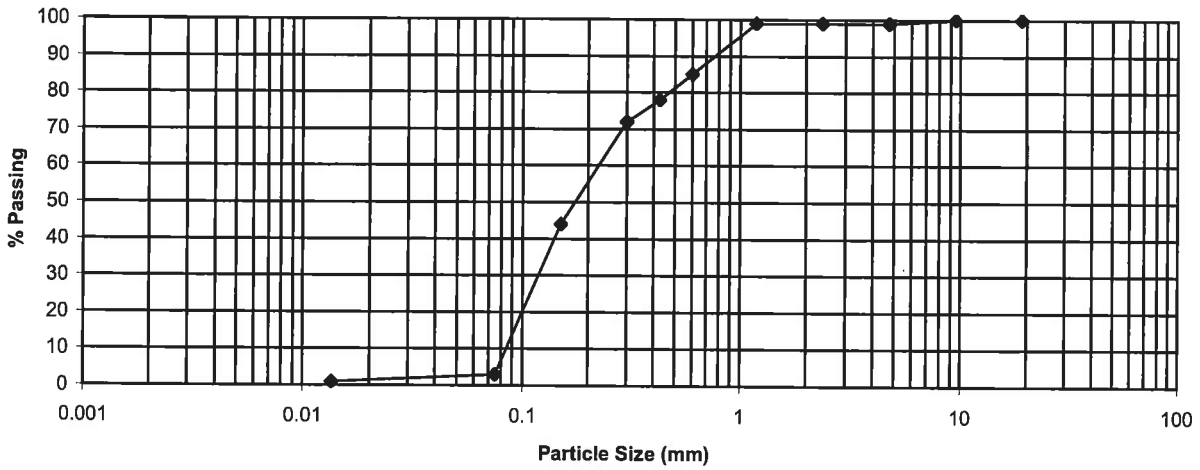
C:\Laboratory\Reports\Douglas 60017\60017-P10.1838-1842 PLI.xls

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P10/1843**
Sample No:	**P10/1843**
Issue Date:	**30 July 2010**
Sample Location:	**BH 9**
Depth (m):	**0.3**

Client: **Tony Scolaro Family Trust**
Project: **Lots 19 - 21 Old Coast Road**
Location: **Lake Clifton**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	99
1.18	99
0.600	85
0.425	78
0.300	72
0.150	44
0.075	3
0.0135	1

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

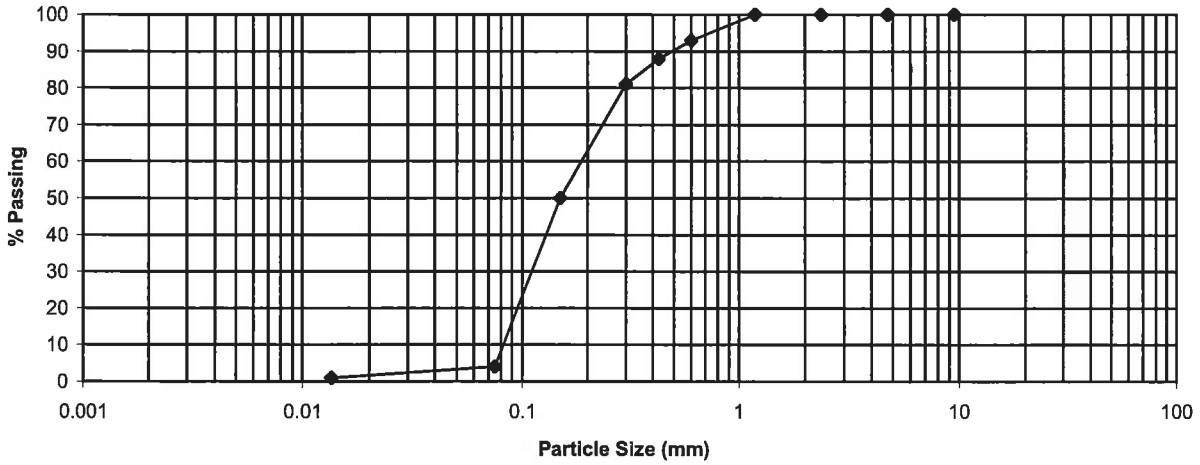
Approved signature

Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

		Job No:	**60017**
		Report No:	**60017-P10/1844**
		Sample No:	**P10/1844**
		Issue Date:	**30 July 2010**
Client:	**Tony Scolaro Family Trust**	Sample Location:	**BH 12**
Project:	**Lots 19 - 21 Old Coast Road**	Depth (m):	**0.5**
Location:	**Lake Clifton**		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	93
0.425	88
0.300	81
0.150	50
0.075	4
0.0135	1

Plasticity index tests
Australian Standard 1289.

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA
WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

mpl Laboratories
Part of the Envirolab Group ENVIROLAB GROUP
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Tel: +61 8 9317 2505 / Fax: +61 8 9317 4163
email: laboratory@mpl.com.au
www.envirolabservices.com.au
Envirolab Services (WA) Pty Ltd ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 104222

Client:
Douglas Partners Perth
36 O'Malley St
Osbourne Park
WA 6017

Attention: Rob Shapland

Sample log in details:

Your Reference:	**76038, Lot 19-21 Old Coast Rd**
No. of samples:	5 Soils
Date samples received:	21/7/10
Date completed instructions received:	21/7/10
Location:	Lake Clifton

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by:	2/08/10
Date of Preliminary Report:	Not issued
Issue Date:	2/08/10

NATA accreditation number 9804. This document shall not be reproduced except in full.
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Joshua Lim
Reporting Supervisor

MPL Reference: 104222
Revision No: R 00

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Miscellaneous Inorg - soil						
Our Reference:	UNITS	104222-1	104222-2	104222-3	104222-4	104222-5
Your Reference	----------	TP1	TP4	TP7	BH11	BH13
Depth	----------	0.5	0.2	0.3	0.2	0.5
Date Sampled		16/07/2010	16/07/2010	16/07/2010	16/07/2010	16/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/7/10	27/7/10	27/7/10	27/7/10	27/7/10
Date analysed	-	27/7/10	27/7/10	27/7/10	27/7/10	27/7/10
pH 1:5 soil:water	pH Units	6.4	7.3	7.4	7.2	7.4
Electrical Conductivity soil	µS/cm	1,400	1,500	1,600	1,500	1,200
Phosphorus Retention Index	mL/g	11	18	9.2	7.8	19

ESP/CEC Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	104222-1 TP1 0.5 16/07/2010 Soil	104222-2 TP4 0.2 16/07/2010 Soil	104222-3 TP7 0.3 16/07/2010 Soil	104222-4 BH11 0.2 16/07/2010 Soil	104222-5 BH13 0.5 16/07/2010 Soil
Exchangeable Ca*	meq/100g	2.6	4.0	1.8	8.9	7.1
Exchangeable K*	meq/100g	0.08	0.05	0.09	0.08	0.03
Exchangeable Mg*	meq/100g	0.21	0.20	0.33	0.40	0.43
Exchangeable Na*	meq/100g	0.05	0.06	0.18	0.06	0.08
Cation Exchange Capacity*	meq/100g	2.9	4.3	2.4	9.5	7.7

Method ID	Methodology Summary
WILAB.5A	pH - Measured using pH meter and electrode in accordance with APHA 21st ED, 4500-H+.
WILAB.5A	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA2510 21st ED and Rayment & Higginson.
Ext-028	Subcontracted to Chemistry Centre (WA)
Ext-054	Analysed by Envirolab Services Sydney, accreditation number 2901

Client Reference: 76038, Lot 19-21 Old Coast Rd

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			27/7/10	104222-1	27/7/10 || 27/7/10	LCS	27/7/10
Date analysed	-			27/7/10	104222-1	27/7/10 || 27/7/10	LCS	27/7/10
pH 1:5 soil:water	pH Units		WILAB.5A	[NT]	104222-1	6.4 || 6.4 || RPD: 0	LCS	99%
Electrical Conductivity soil	µS/cm	1	WILAB.5A	<1.0	104222-1	1400 || [N/T]	LCS	96%
Phosphorus Retention Index	mL/g		Ext-028	[NT]	104222-1	11 || [N/T]	[NR]	[NR]
QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Exchangeable Ca*	meq/100 g	0.01	Ext-054	<0.01	104222-1	2.6 || 2.6 || RPD: 0	LCS	95%
Exchangeable K*	meq/100 g	0.01	Ext-054	<0.01	104222-1	0.08 || 0.07 || RPD: 13	LCS	96%
Exchangeable Mg*	meq/100 g	0.01	Ext-054	<0.01	104222-1	0.21 || 0.21 || RPD: 0	LCS	92%
Exchangeable Na*	meq/100 g	0.01	Ext-054	<0.01	104222-1	0.05 || 0.06 || RPD: 18	LCS	86%
Cation Exchange Capacity*	meq/100 g	1	Ext-054	<1.0	104222-1	2.9 || 2.9 || RPD: 0	[NR]	[NR]

Report Comments:

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform & E.coli levels are less than 1cfu/100mL.
The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC& ARMC 2004.

Asbestos was analysed by Approved Identifier: Not applicable for this job
Airborne fibres were analysed by Approved Counter: Not applicable for this job

INS: Insufficient sample for this test; NT: Not tested; PQL: Practical Quantitation Limit; <: Less than; >: Greater than
RPD: Relative Percent Difference; NA: Test not required; LCS: Laboratory Control Sample; NR: Not requested
NS: Not specified; NEPM: National Environmental Protection Measure
DOL: Sample rejected due to particulate overload

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however were analysed at a frequency to meet of exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD a matrix spike recoveries for the sample batch were within laboratory acceptance criteria.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spike and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and Speciated Phenols is acceptable.
Surrogates: 60-140% is acceptable for general organics and 10-140% for SVOC and Speciated Phenols.

Appendix 3 Groundwater Monitoring Results

Results of water level sampling - Lake Clifton

Depth to groundwater (m bTOC)

Site	8/04/2010	25/06/2010	2/09/2010	18/11/2010	24/02/2011	30/05/2011	30/08/2011
MB01	5.05	4.9	4.74	4.81	5.06	4.95	4.68
MB02	3.43	3.28	3.12	3.25	3.44	3.33	3.05
MB03	7.13	6.95	6.83	6.95	7.14	7.04	6.75
MB04	3.09	2.94	2.77	2.95	3.1	3	2.7
MB05	4.19	4.05	3.89	4.18	4.21	4.11	3.82
MB06	3.57	3.42	3.26	3.39	3.58	3.48	3.19

Surveyed top of casing levels

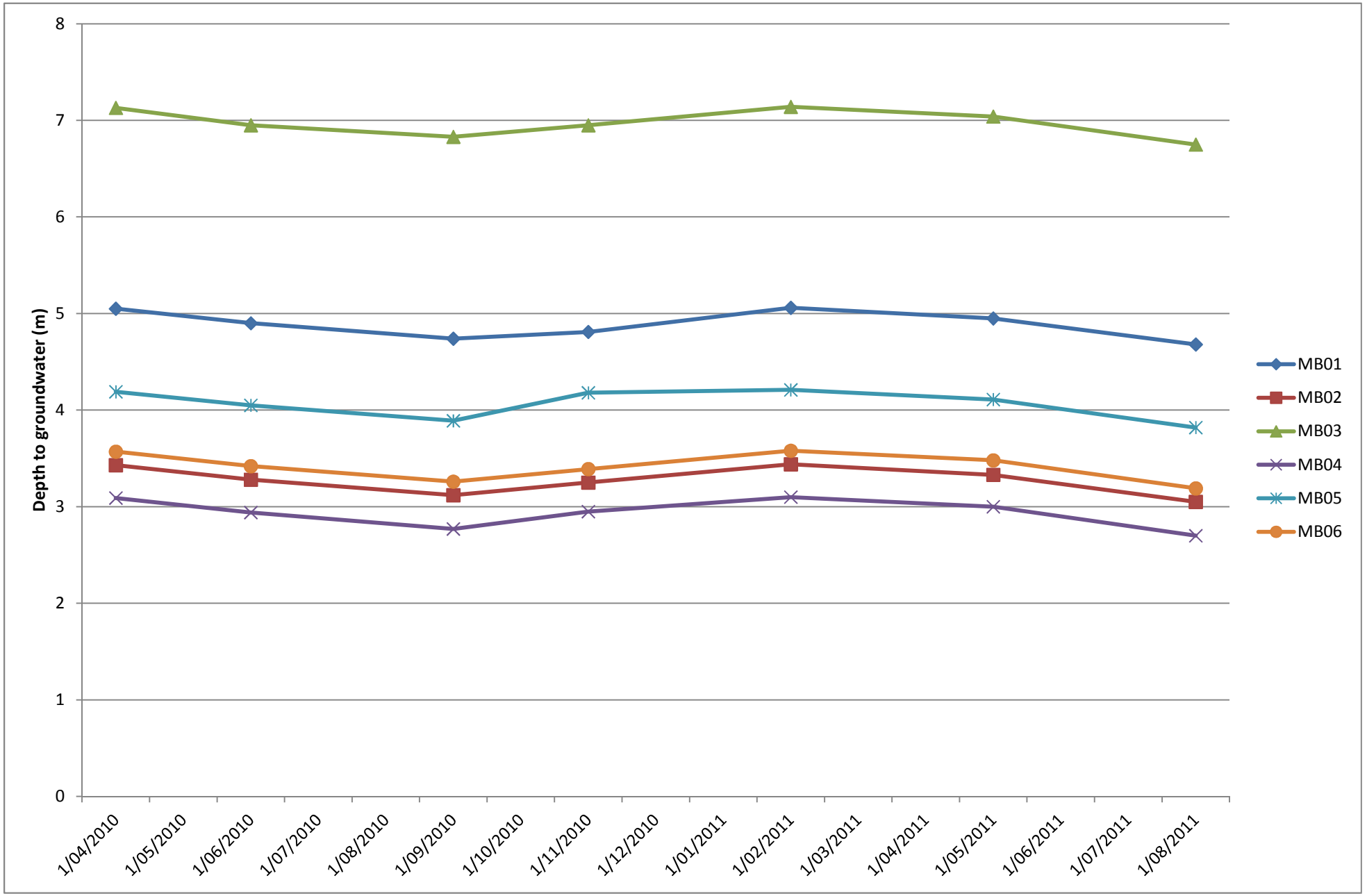
Location	Lake Clifton	Lake Clifton	Lake Clifton	Lake Clifton	Lake Clifton	Lake Clifton
ID	MB01	MB02	MB03	MB04	MB05	MB06
AHD (m) T.O.C.	5.071	3.441	7.151	3.104	4.226	3.614
Ground level	4.471	2.841	6.551	2.504	3.626	3.014

Depth to groundwater (m bgl)

Site	8/04/2010	25/06/2010	2/09/2010	18/11/2010	24/02/2011	30/05/2011	30/08/2011
MB01	4.45	4.3	4.14	4.21	4.46	4.35	4.08
MB02	2.83	2.68	2.52	2.65	2.84	2.73	2.45
MB03	6.53	6.35	6.23	6.35	6.54	6.44	6.15
MB04	2.49	2.34	2.17	2.35	2.5	2.4	2.1
MB05	3.59	3.45	3.29	3.58	3.61	3.51	3.22
MB06	2.97	2.82	2.66	2.79	2.98	2.88	2.59

Groundwater level (m AHD)

Site	8/04/2010	25/06/2010	2/09/2010	18/11/2010	24/02/2011	30/05/2011	30/08/2011
MB01	0.021	0.171	0.331	0.261	0.011	0.121	0.391
MB02	0.011	0.161	0.321	0.191	0.001	0.111	0.391
MB03	0.621	0.801	0.921	0.801	0.611	0.711	1.001
MB04	0.014	0.164	0.334	0.154	0.004	0.104	0.404
MB05	0.036	0.176	0.336	0.046	0.016	0.116	0.406
MB06	0.044	0.194	0.354	0.224	0.034	0.134	0.424


Depth to groundwater (m)
8
7
6
5
4
3
2
1
0
1/04/2010
1/05/2010
1/06/2010
1/07/2010
1/08/2010
1/09/2010
1/10/2010
1/11/2010
1/12/2010
1/01/2011
1/02/2011
1/03/2011
1/04/2011
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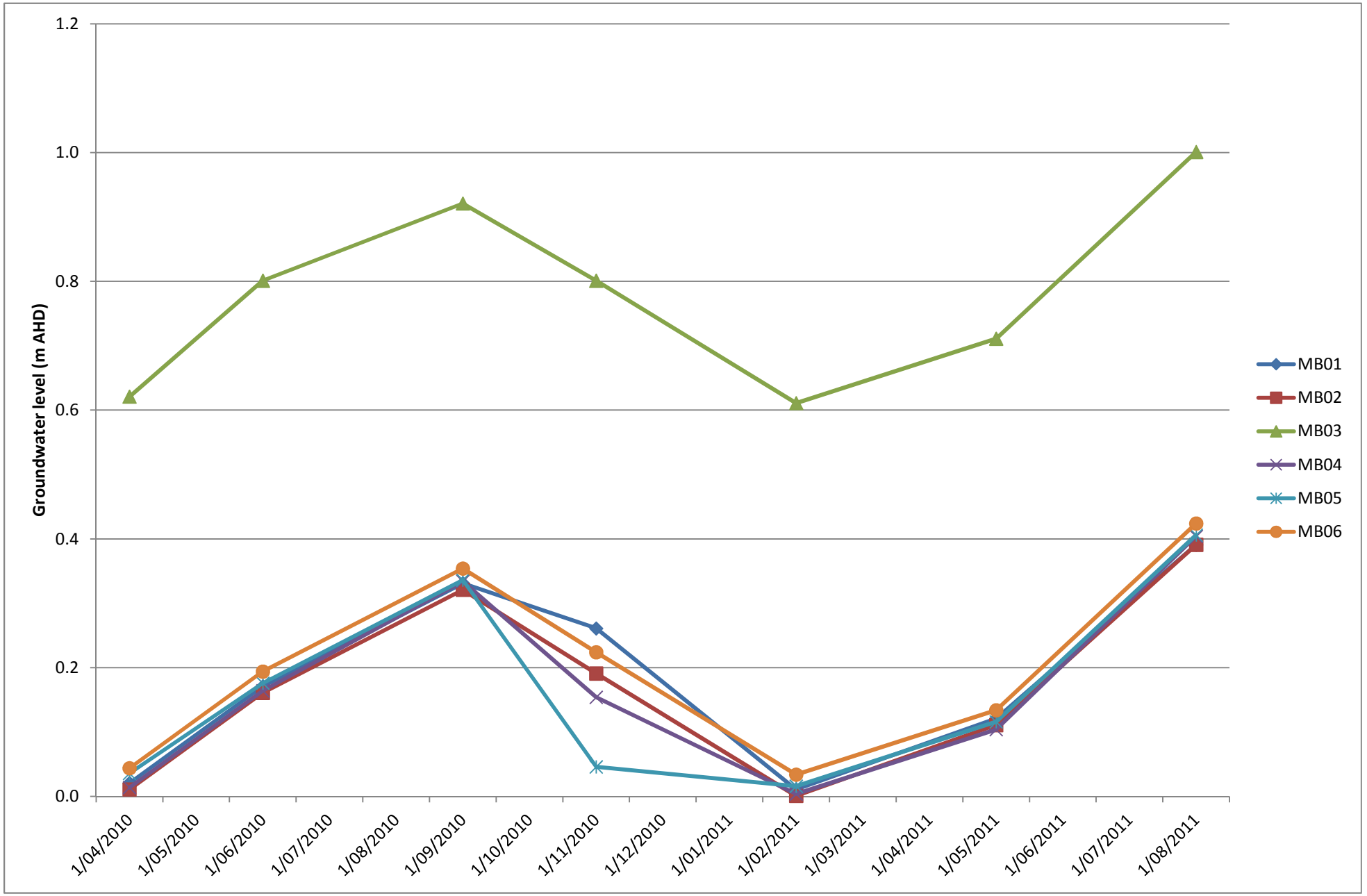
1/08/2011
MB01
MB02
MB03
MB04
MB05
MB06

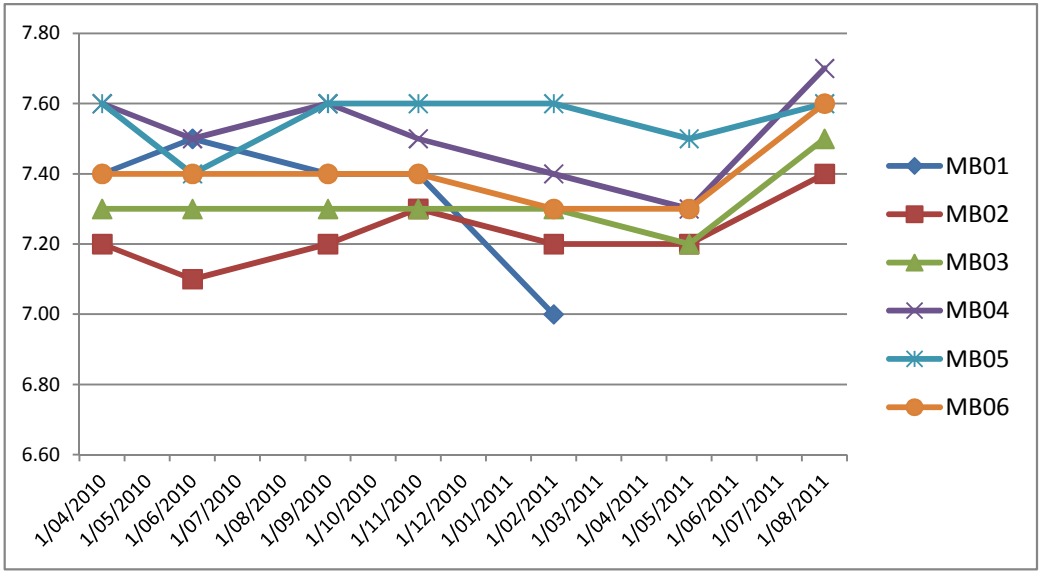

Groundwater level (m AHD)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1/04/2010
1/05/2010
1/06/2010
1/07/2010
1/08/2010
1/09/2010
1/10/2010
1/11/2010
1/12/2010
1/01/2011
1/02/2011
1/03/2011
1/04/2011
1/05/2011
1/06/2011
1/07/2011
1/08/2011
MB01
MB02
MB03
MB04
MB05
MB06

Surveyed bore locations and heights

			GDA94 (MGA50)										
Location	**ID**	**Description**	**Easting (m)**	**Horizontal Accuracy (m)**	**Northing (m)**	**Horizontal Accuracy (m)**	**Vertical Accuracy (m)**	**AHD (m) T.O.C.**	**Height Pipe A.G.L. (m)**	**Surface Elevation (m)**	**SWL (m)**	**RWL (m)**	**Notes**
Lake Clifton	MB01	Piezometer	375483.683	0.010	6371635.304	0.010	0.010	5.071	0.600	4.471		5.071	
Lake Clifton	MB02	Piezometer	375534.000	5.000	6371459.000	5.000	0.010	3.441	0.600	2.841		3.441	Spirit Levelled. XY = Handheld.
Lake Clifton	MB03	Piezometer	375604.389	0.010	6371323.061	0.010	0.010	7.151	0.600	6.551		7.151	
Lake Clifton	MB04	Piezometer	375836.090	0.010	6371243.177	0.010	0.010	3.104	0.600	2.504		3.104	
Lake Clifton	MB05	Piezometer	375751.155	0.010	6371541.084	0.010	0.010	4.226	0.600	3.626		4.226	
Lake Clifton	MB06	Piezometer	375710.093	0.010	6371676.233	0.010	0.010	3.614	0.600	3.014		3.614	

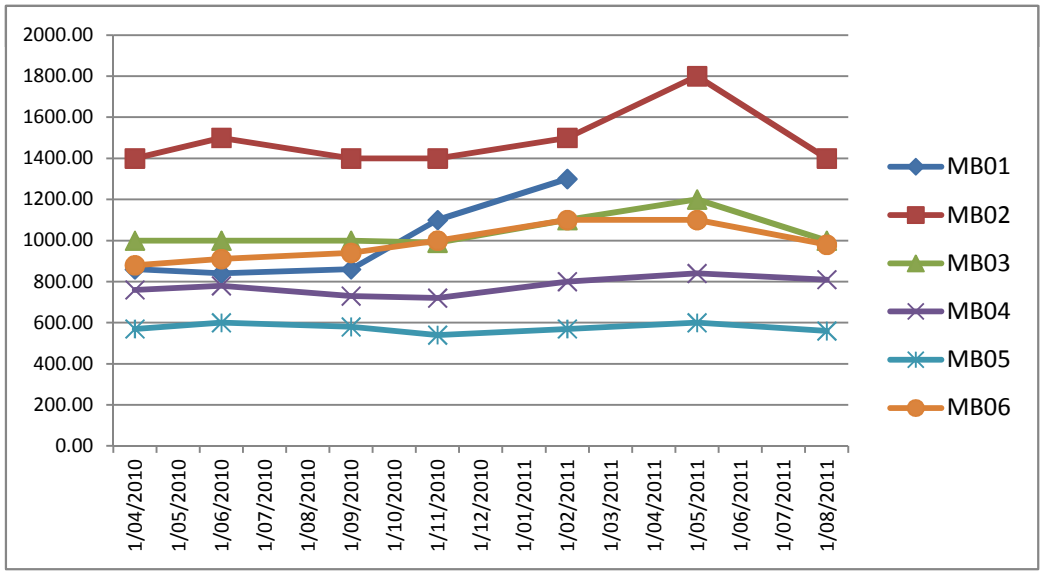
pH

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	7.40	7.20	7.30	7.60	7.60	7.40
25/06/2010	7.50	7.10	7.30	7.50	7.40	7.40
2/09/2010	7.40	7.2	7.3	7.6	7.6	7.4
18/11/2010	7.4	7.3	7.3	7.5	7.6	7.4
24/02/2011	7	7.2	7.3	7.4	7.6	7.3
1/05/2011		7.2	7.2	7.3	7.5	7.3
31/08/2011		7.4	7.5	7.7	7.6	7.6
Max	7.50	7.40	7.50	7.70	7.60	7.60
Min	7.00	7.10	7.20	7.30	7.40	7.30
Median	7.40	7.20	7.30	7.50	7.60	7.40



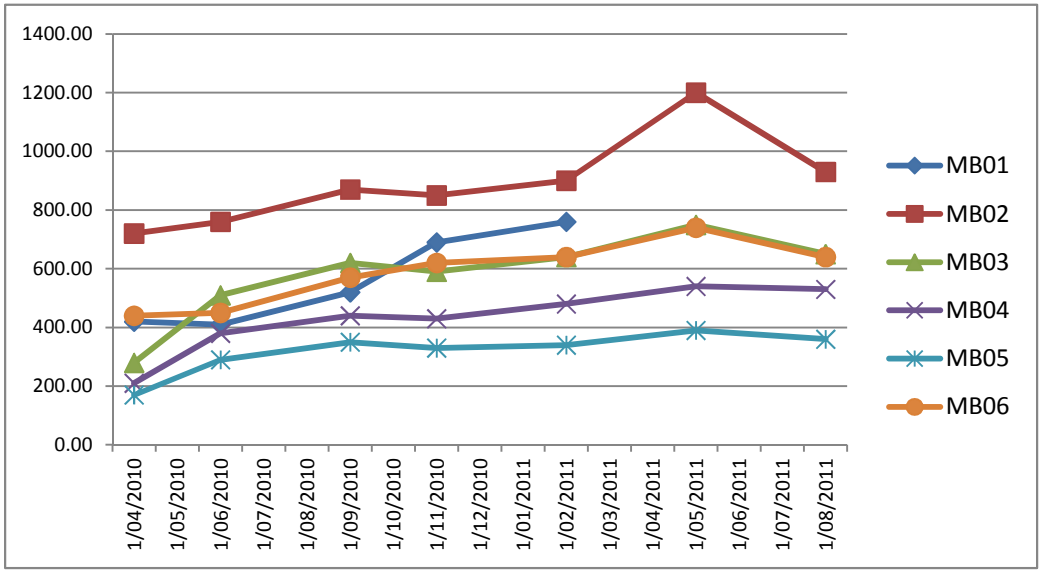
Conductivity (us/cm)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	860.00	1400.00	1000.00	760.00	570.00	880.00
25/06/2010	840.00	1500.00	1000.00	780.00	600.00	910.00
2/09/2010	860.00	1400	1000	730	580	940
18/11/2010	1100	1400	990	720	540	1000
24/02/2011	1300	1500	1100	800	570	1100
1/05/2011		1800	1200	840	600	1100
31/08/2011		1400	1000	810	560	980
Max	1300	1800	1200	840	600	1100
Min	840	1400	990	720	540	880
Median	860	1400	1000	780	570	980



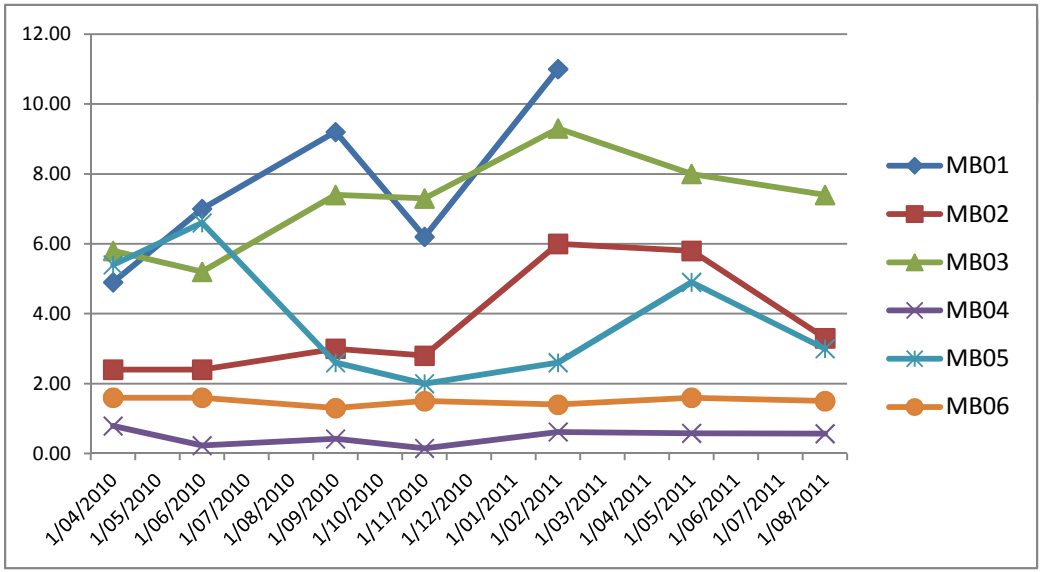
TDS (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	420.00	720.00	280.00	210.00	170.00	440.00
25/06/2010	410.00	760.00	510.00	380.00	290.00	450.00
2/09/2010	520.00	870	620	440	350	570
18/11/2010	690	850	590	430	330	620
24/02/2011	760	900	640	480	340	640
1/05/2011		1200	750	540	390	740
31/08/2011		930	650	530	360	640
Max	760	1200	750	540	390	740
Min	410	720	280	210	170	440
Median	520	870	620	440	340	620



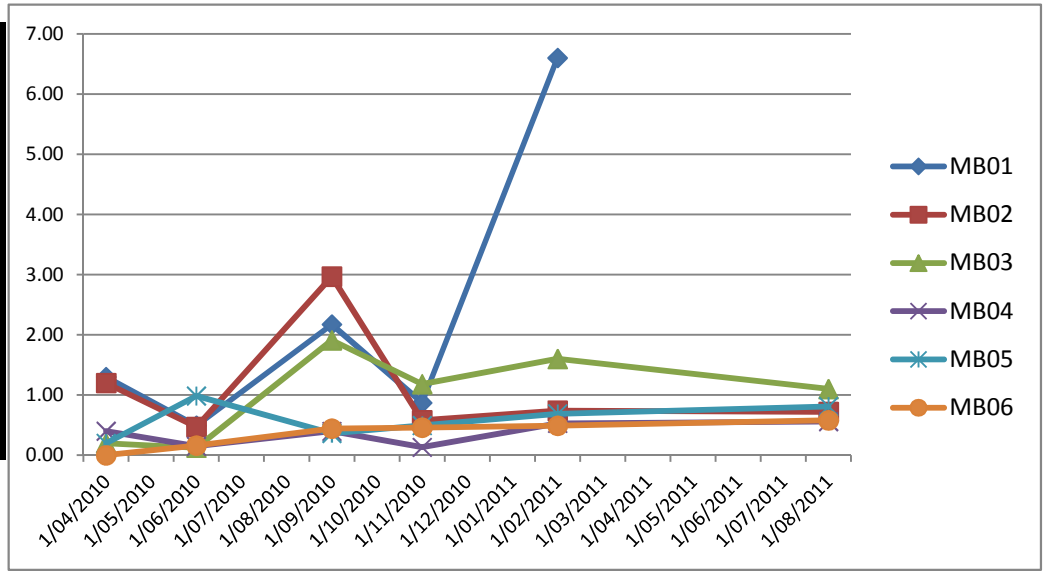
Total Nitrogen (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	4.90	2.40	5.80	0.79	5.40	1.60
25/06/2010	7.00	2.40	5.20	0.23	6.60	1.60
2/09/2010	9.20	3	7.4	0.42	2.6	1.3
18/11/2010	6.2	2.8	7.3	0.15	2	1.5
24/02/2011	11	6	9.3	0.62	2.6	1.4
1/05/2011		5.8	8	0.58	4.9	1.6
31/08/2011		3.3	7.4	0.57	3	1.5
Max	11	6	9.3	0.79	6.6	1.6
Min	4.9	2.4	5.2	0.15	2	1.3
Median	7	3	7.4	0.57	3	1.5



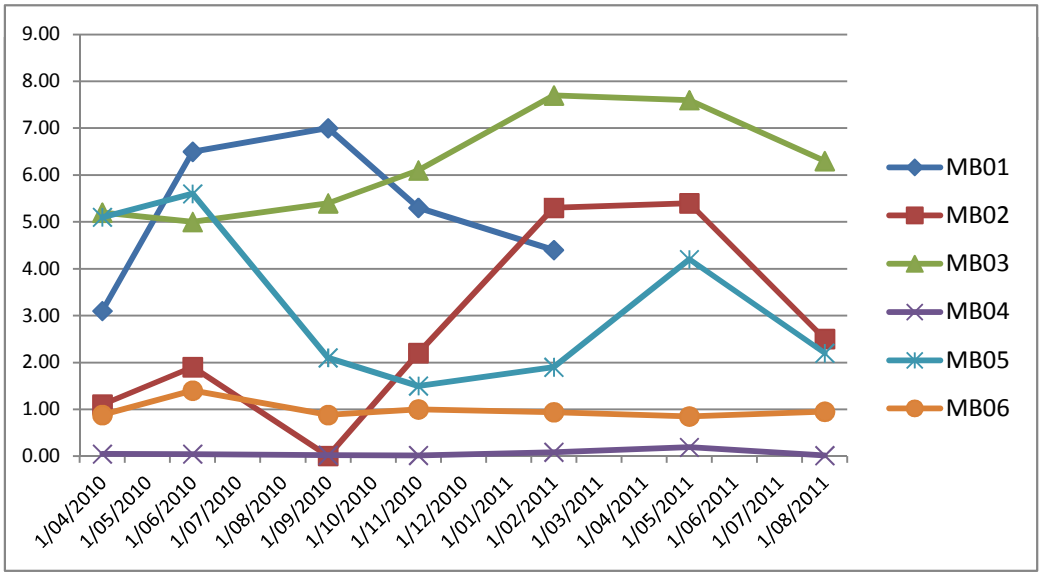
Organic Nitrogen (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	1.30	1.20	0.20	0.40	0.20	<0.2
25/06/2010	0.49	0.47	0.13	0.15	0.99	0.16
2/09/2010	2.17	2.968	1.91	0.398	0.364	0.443
18/11/2010	0.872	0.581	1.181	0.132	0.494	0.459
24/02/2011	6.6	0.74	1.6	0.53	0.69	0.49
31/08/2011		0.72	1.1	0.56	0.81	0.58
Max	6.6	2.968	1.91	0.56	0.985	0.58
Min	0.492	0.47	0.126	0.132	0.2	0.162
Median	1.3	0.73	1.1405	0.399	0.592	0.459



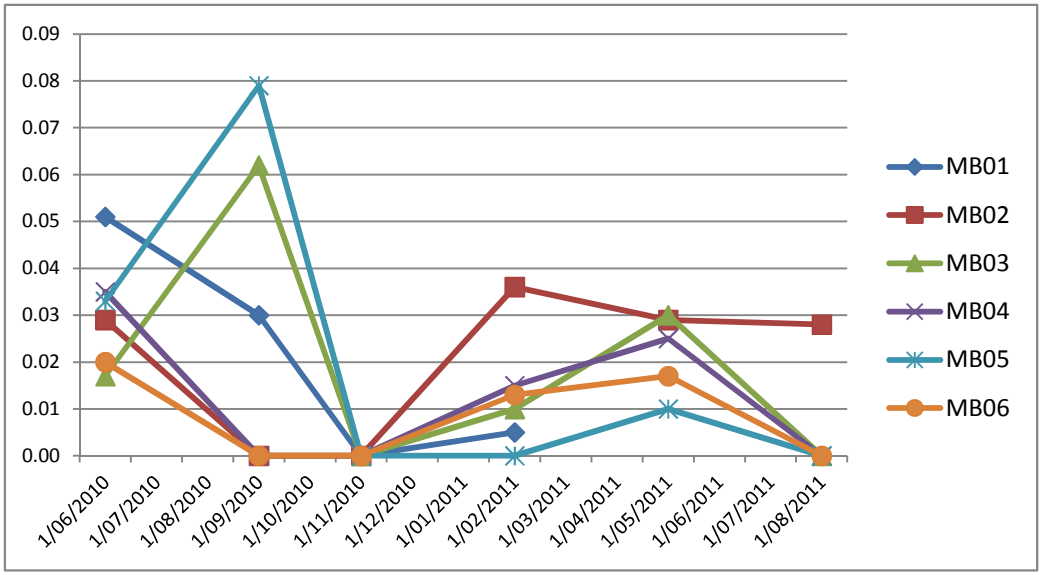
Nitrate/Nitrite Nitrogen, NOx as N (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	3.10	1.10	5.20	0.05	5.10	0.88
25/06/2010	6.50	1.90	5.00	0.05	5.60	1.40
2/09/2010	7.00	0.005	5.4	0.022	2.1	0.88
18/11/2010	5.3	2.2	6.1	0.018	1.5	1
24/02/2011	4.4	5.3	7.7	0.085	1.9	0.94
1/05/2011		5.4	7.6	0.19	4.2	0.85
31/08/2011		2.5	6.3	0.014	2.2	0.95
Max	7	5.4	7.7	0.19	5.6	1.4
Min	3.1	0.005	5	0.014	1.5	0.85
Median	5.3	2.2	6.1	0.046	2.2	0.94



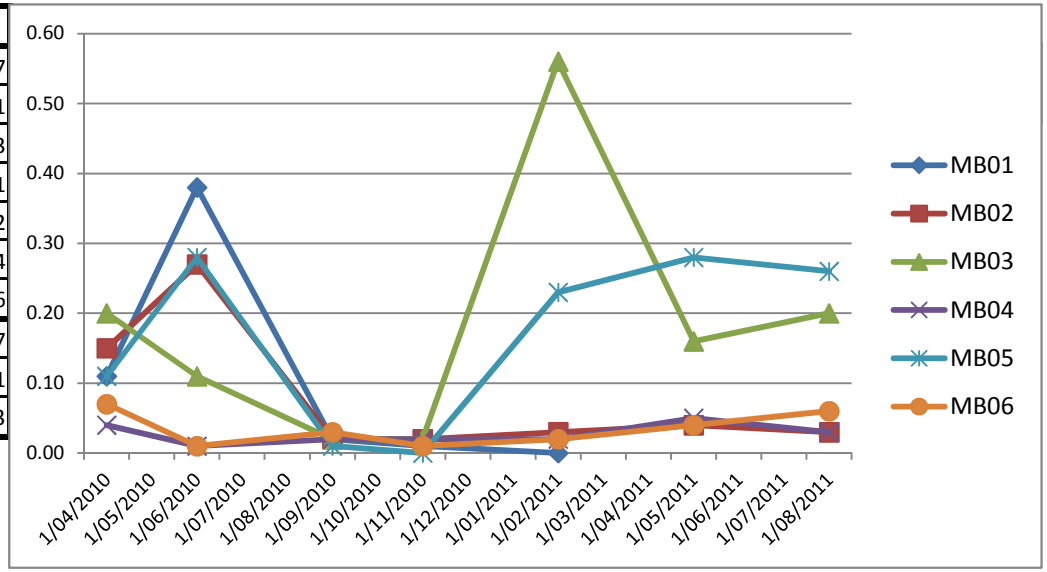
Ammonia Nitorgen, NH_3 as N (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	0.50	0.10	0.30	0.30	0.10	0.60
25/06/2010	0.05	0.03	0.02	0.04	0.03	0.02
2/09/2010	0.03	<0.005	0.062	<0.005	0.079	<0.005
18/11/2010	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
24/02/2011	0.005	0.036	0.01	0.015	<0.005	0.013
1/05/2011		0.029	0.03	0.025	0.01	0.017
31/08/2011		0.028	<0.005	<0.005	<0.005	<0.005
Max	0.5	0.1	0.3	0.3	0.1	0.6
Min	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Median	0.03	0.028	0.02	0.025	0.01	0.013



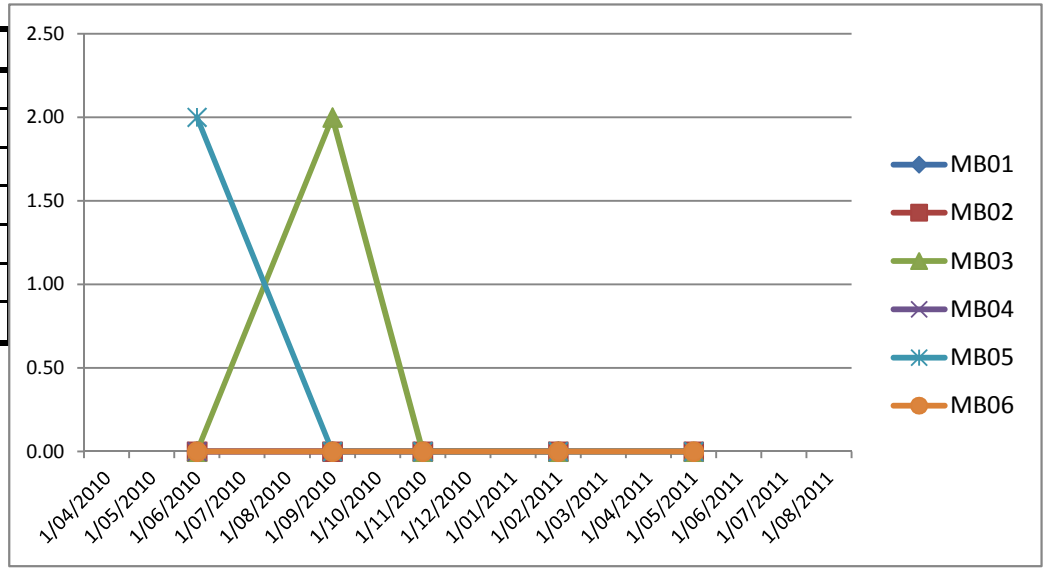
Total Phosphorus (mg/L)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010	0.11	0.15	0.20	0.04	0.11	0.07
25/06/2010	0.38	0.27	0.11	0.01	0.28	0.01
2/09/2010	0.02	0.02	0.02	0.02	0.01	0.03
18/11/2010	0.01	0.02	0.02	0.02	<0.01	0.01
24/02/2011	-	0.03	0.56	0.02	0.23	0.02
1/05/2011		0.04	0.16	0.05	0.28	0.04
31/08/2011		0.03	0.2	0.03	0.26	0.06
Max	0.38	0.27	0.56	0.05	0.28	0.07
Min	0.01	0.02	0.02	0.01	<0.01	0.01
Median	0.065	0.03	0.16	0.02	0.25	0.03



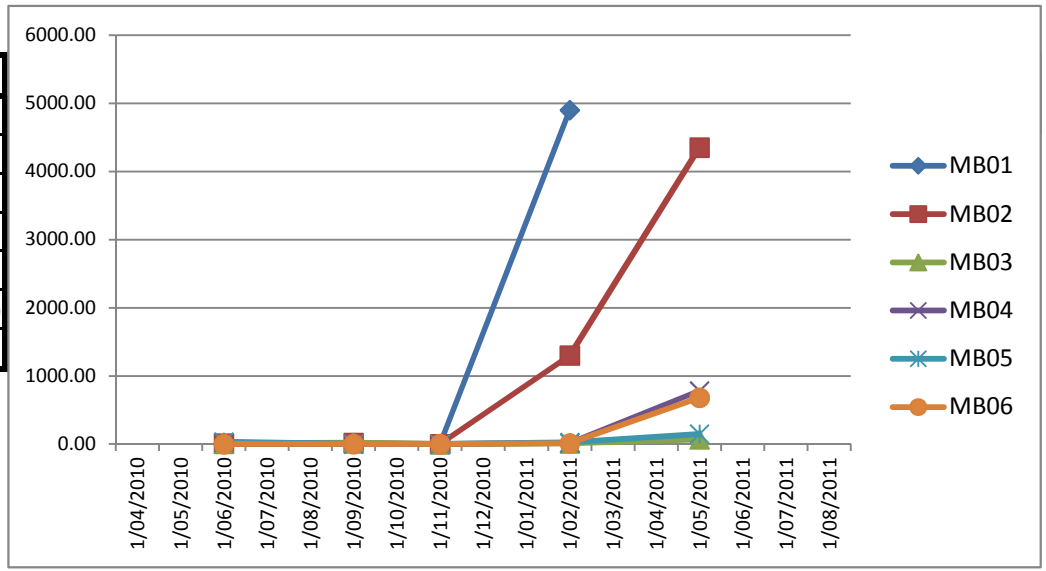
EColi in Water (MPN/100 mL)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010						
25/06/2010	<2	<2	<2	<2	2.00	<2
2/09/2010	<2	<2	2	<2	<2	<2
18/11/2010	<1	N.A.	<1	N.A.	<1	N.A.
24/02/2011	<1	<1	<1	<1	<1	<1
1/05/2011		<10	<10	<10	<10	<10
31/08/2011						



Total Coliforms in Water (MPN/100 mL)

Date	MB01	MB02	MB03	MB04	MB05	MB06
9/04/2010						
25/06/2010	<2	8.00	11.00	23.00	33.00	<2
2/09/2010	<2	17.00	22	<2	<2	<2
18/11/2010	3.10	N.A.	3.10	N.A.	<1	N.A.
24/02/2011	4900	1300	11	16	25	11
1/05/2011		4350.00	70.00	780.00	150.00	680.00
31/08/2011						



Heavy Metals (mg/L)

	MB01		MB02		MB03		MB04		MB05		MB06	
	9/04/2010	31/08/2011	9/04/2010	31/08/2011	9/04/2010	31/08/2011	9/04/2010	31/08/2011	9/04/2010	31/08/2011	9/04/2010	31/08/2011
Total Arsenic	0.1	-	<0.02	<0.02	0.029	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Cadmium	0.001	-	<0.001	<0.005	<0.001	<0.005	<0.001	<0.005	<0.001	<0.005	<0.001	<0.005
Total Chromium	0.58	-	0.009	<0.005	0.14	<0.005	0.04	<0.005	0.06	<0.005	0.05	<0.005
Total Copper	0.13	-	0.07	0.006	0.064	<0.005	0.015	<0.005	0.032	<0.005	0.04	<0.005
Total Lead	0.059	-	0.005	<0.005	0.056	<0.005	0.054	<0.005	0.047	<0.005	0.084	<0.005
Total Nickel	0.02	-	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005
Total Zinc	0.06	-	0.02	0.02	0.04	<0.01	0.01	<0.01	0.03	<0.01	0.02	<0.01
Mercury	<0.0005	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Appendix 4 Lake Clifton Caravan Park Wastewater Treatment and Disposal

From: Ramakrishnan, Parusu (Perth) [Parusu.Ramakrishnan@WorleyParsons.com]
Sent: Tuesday, 4 September 2012 8:38 AM
To: Margaret Dunlop
Subject: RE: Final Invoice

Hi Margaret,

It would have an impact on the overall price. Since it increase the max design by 33% I would think the price would increase by about 25% (approx.). Is there a reason behind DoH's requirement?
I am not sure if we have an environmental health expert in WP. If you have a specific question I may be able to ask around. Thanks.

Regards,

Parusu Ramakrishnan
Lead Water/Wastewater Engineer – Power, Infrastructure & Environment
Tel: +61 (08) 6311 6270 | Mobile: 0405542789 | Fax: +61 (0)8 9278 8110 | GMT +8 |
QV1, 250 St Georges Terrace, Level 4 | Perth WA 6000 | WorleyParsons Services Pty Ltd | ABN 61 001 279 812
www.worleyparsons.com

From: Margaret Dunlop [mailto:m.dunlop@strategen.com.au]
Sent: Friday, 31 August 2012 9:11 AM
To: Ramakrishnan, Parusu (Perth)
Subject: RE: Final Invoice

Thanks Parusu,

I've organised payment of that.

I've had a chat with the DoH and they want us to use a higher rate of flow than what was previously estimated – about 60 kL/day. Would that make a difference to the wastewater system costing?

Do you have any environmental health experts in your team? We may possibly need some assistance with the Health Department in future.

Regards,

Margaret

Margaret Dunlop
Senior Consultant

STRATEGEN
environmental consultants

Ph 9380 3100 Fax 9380 4606
Email M.Dunlop@strategen.com.au
Web www.strategen.com.au
Level 2, 322 Hay St Subiaco WA 6008
PO Box 243 Subiaco WA 6904

From: Ramakrishnan, Parusu (Perth) [mailto:Parusu.Ramakrishnan@WorleyParsons.com]
Sent: Wednesday, 29 August 2012 9:33 AM
To: Margaret Dunlop
Subject: Final Invoice

Hi Margaret,

We have sent out the final invoice. If you have not received it yet, you should be receiving it soon.

Regards,

Parusu Ramakrishnan
Lead Water/Wastewater Engineer – Power, Infrastructure & Environment
Tel: +61 (08) 6311 6270 | Mobile: 0405542789 | Fax: +61 (0)8 9278 8110 | GMT +8 |
QV1, 250 St Georges Terrace, Level 4 | Perth WA 6000 | WorleyParsons Services Pty Ltd | ABN 61 001 279 812
www.worleyparsons.com

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WorleyParsons
resources & energy

EcoNomics

TECHNICAL MEMORANDUM

DATE	1 August 2012
TO	Margaret Dunlop
FROM	Parusu Ramakrishnan
COPY	
PROJECT	301012-01587
SUBJECT	Lake Clifton Caravan Park Wastewater Treatment and Disposal
DOC NO	
FILE LOC	

1 BACKGROUND

A new 129 lot Park Home Site i.e. Caravan Park, is proposed to be developed at Lot 21 Old Coast Road in Lake Clifton, Western Australia (refer to Appendix A for the Amended Park Home Site Plan).

WorleyParsons has been appointed to recommend a suitable method for domestic wastewater treatment and disposal of treated effluent and sludge.

This technical memorandum documents the wastewater treatment and disposal options for the new Park Home Site.

2 SCOPE

- Recommend suitable option(s) for wastewater treatment
- Investigate option(s) for treated wastewater effluent and sludge disposal
- Provide a budget cost estimate for the wastewater treatment plant

3 DESIGN DATA

The source of wastewater is from cooking, laundry, shower facilities and toilet flushing. As such the wastewater generated is considered domestic in nature. No industrial waste is expected to be produced from the site.

Table 1 shows the expected raw wastewater quality.

Table 1: Design Raw Wastewater Quality (indicative)

Description	Quantity	Unit
Biological Oxygen Demand (BOD_5)	75	g/person/day
Total Suspended Solids (TSS)	70	g/person/day
Total Nitrogen (TN)	14	g/person/day
Total Phosphorus (TP)	5	g/person/day
pH	6.5 – 8.5	-
Faecal coliforms	50 x 10^6 / 100mL	-
Temperature	10 -30	°C

Table 2 highlights the proposed treated effluent quality.

Table 2: Required Treated Effluent Quality

Parameter	Required value
BOD_5	< 10mg/L
TSS	< 10mg/L
TN	< 5 mg/L
TP	< 1 mg/L
pH	6.5 – 8.5
Turbidity	< 5 NTU (95%tile)
E.Coli	< 10 cfu/100mL
Residual total chlorine	0.2 – 2.0 mg/L

The site's occupancy rate is made of the following:

- 20% permanent residents
- 40% used infrequently up to 12 times/year for up to 3 days
- 40% used 5 days/week for 6 months/year

Table 3 shows the design influent flow rates.

Table 3: Design Influent Flowrates

Description	Range (kL/day)
Design Flow	8.6 to 45

Appendix B shows how this flow range was calculated.

4 SITE CONSIDERATIONS

The Lake Clifton area has generally been classified as an environmentally sensitive area. It has been identified as having geoheritage features of international significance, ecological communities, flora and fauna species of national significance (listed under the Environment Protection and Biodiversity Conservation Act 1999) and regionally significant vegetation, flora and fauna (Wildlife Conservation Act 1956) as well as significant coastal and landscape values.

As such the proposed wastewater treatment facility and effluent disposal should take this into consideration.

5 WASTEWATER TREATMENT PLANT SELECTION

A centralised wastewater treatment plant is proposed.

Option 1: Conventional activated sludge treatment plant using membrane ultrafiltration (also known as a membrane biological reactor) and effluent disinfection using liquid sodium hypochlorite and ultraviolet radiation.

Option 2: BIOMAX type conventional activated sludge treatment plant (using clarifiers instead of membrane filtration).

The treated effluent is of a quality that can be reused for onsite irrigation in an environmentally safe manner.

6 OTHER TYPES OF WASTEWATER TREATMENT

Aeration Treatment Units (or ATU's) have not been considered in this study as they will not produce consistently good quality effluent suitable for reuse for this site and the ATU's will be decentralised throughout the site making it difficult to monitor and control. A large number of ATU's will also be required which does not make it economical.

7 WASTEWATER TREATMENT PROCESS

The general steps involved in the MBR wastewater plant process are as follows:

- Flow Equalisation: This acts as a buffer tank that will apply only during peak season where the flow is above plant design capacity. It helps to equalise the flow and distributes it during the off peak times of the day for treatment i.e. night time.
- Screening : Using automatic bar screens to remove or screen material detrimental to the biological process and membrane filtration
- Biological Treatment: Consists of an anoxic and aerobic zone both serving different functions. The anoxic zone is primarily for denitrification and aerobic zone for removal of carbonaceous material using fine air bubble diffusers
- Ultrafiltration : Occurs through a special membrane of microscopic pores that prevents particles, bacteria and viruses from passing through. The membranes are cleaned by air scouring and chemicals.
- Chlorination disinfection: Effluent disinfection using liquid sodium hypochlorite
- Treated Effluent Storage: This tank serves to store 2 to 3 days' worth of treated effluent in case irrigation is not possible due to wet weather or process upset.
- Sludge storage: Treated sludge is stored in a covered tank for disposal. As amount of sludge produced is small this tank needs to be emptied once every 3 to 6 months.

For the BIOMAX system the ultrafiltration step is replaced by a clarification process.

8 EFFLUENT AND SLUDGE DISPOSAL

The treated effluent is proposed to be disposed off via two methods.

Effluent Disposal Method 1: Subsurface irrigation is recommended for garden beds within the lots.

Effluent Disposal Method 2: Surface irrigation is recommended for large landscaped areas, shrubs and trees.

Irrigation could be extended to the existing caravan site if it is not possible to irrigate all of the treated effluent within the new site.

In accordance to the draft guidelines for the *Guidelines for Non-Potable Uses of Recycled Water in WA, August 2011,* sub-surface irrigation is considered low risk and surface irrigation is considered medium risk. Restricted public access to irrigation areas is required during surface irrigation periods.

Other forms of wastewater reuse like toilet flushing has not been recommended at this stage until discussions have commenced with the Local Shire and relevant regulatory authorities.

Sludge Disposal Method: The volume of sludge produced from an MBR type plant is minimal. The sludge storage tank is expected to be emptied once every 3 to 6 months. The sludge can be transported to the nearest centralised wastewater treatment plant.

The sludge generated from the Biomax type plant is slightly more and it is expected to be transported to the nearest treatment plant once every 1 to 2 months.

9 BUDGET COST ESTIMATES

Quotes were obtained from two wastewater treatment vendors.

Quote 1: Membrane Biological Reactor Type Wastewater Treatment Plant by Aquacell

Budget Cost: $687,000 (excluding GST)

See Appendix C for the detailed quote. Budget cost includes cost of effluent storage tanks and phosphorus precipitant dosing system. It does not include supply and laying of subsurface dripper effluent disposal system.

Quote 2: Biomax Type Conventional Activated Sludge Plant by Biomax

Budget Cost: $369,000 (excluding GST)

See Appendix D for the email quote. The price includes delivery, installation, training, performance testing, commissioning, supply of O&M manuals including the supply and laying of subsurface dripper effluent disposal system and the phosphorus precipitant dosing system. The quote does not include the equalisation tank, 24 hr effluent storage tanks, earthworks, crane hire, plumbing and electrical connections. It is envisaged that if these costs were included Biomax budget cost would be close to $460,000.

10 OPERATIONAL COSTS

This includes annual chemical, utilities, laboratory water analysis tests and routine maintenance costs only. Major equipment servicing costs have not been accounted for. In addition, replacement of membranes for the MBR plant which usually occurs once every 5 years has not been included.

The annual operational cost for the MBR plant is $30,000 i.e. this includes the cost of plant remote monitoring, technical support and annual major servicing by Aquacell which is estimated at $16,000.

The annual operational cost for the Biomax plant is estimated to be $7,000.

11 PLANT OPERATOR EFFICIENCY

Both vendors have advised that the on-site training provided will be sufficient for the nominated person to operate the plant and perform minor maintenance work. It is also recommended that the designated operator needs to have a basic understanding of general mechanical equipment i.e. pumps.

In the case of the MBR plant quoted by Aquacell the training provided will be sufficient as long as Aquacell is engaged on a service contract to undertake the remote monitoring and operation component. This way the site operator is not involved in any of the more complicated operation activities and an Aquacell operator is able to be in control of the system. Aquacell will also provide technical support to the site operator on a 24hour basis.

12 CONCLUSIONS AND RECOMMENDATIONS

The types of wastewater treatment recommended are:

1. Membrane Biological Reactor or
2. Biomax type wastewater treatment plant

With the MBR type plant effluent can be disposed off on site using a combination of subsurface irrigation for garden beds within lots. Surface irrigation is recommended for large landscaped areas, shrubs and trees. Other forms of wastewater reuse like toilet flushing is also possible.

With the Biomax type plant, effluent disposal via both subsurface irrigation and surface irrigation is possible. However, for surface irrigation enhanced restricted access controls need to be put in place i.e. restricted public access when area is wet, spray drift controls etc (refer to Table 8 of WA *Guidelines for Non-Potable Uses of Recycled Water in WA, August 2011*)

Sludge will be transported to the nearest local wastewater treatment plant.

The use of MBR type plant is more expensive but yields a much higher quality of effluent which is suitable for a wider range of reuse.

13 ASSUMPTIONS

The following assumptions have been made:

- Wastewater reticulation system i.e. collection and pumping, will be done by others

- Major civil works (if required) and electrical work will be carried out by others and has not been factored into the budget cost.
- Wastewater treatment and effluent disposal options were made without liaising with local Shire and DEC. They were based on site conditions, input from Strategen representative and documentation provided.

14 AFTER NOTE

After this tech memo was produced Wastewater Services (WWS) were approached to provide a quote for a membrane bioreactor (MBR) type plant. A verbal quote of $420,000 (excluding GST) was provided for a plant similar to the one quoted by Aquacell.

Wastewater Services are a reputable company and have supplied a large number of wastewater treatment plants throughout WA. WWS could be approached for a firm quote if the MBR plant is being considered as a treatment option.

APPENDIX

A. AMENDED PARK HOME SITE PLAN
B. DESIGN FLOW CALCULATIONS
C. QUOTE FROM AQUACELL
D. QUOTE FROM BIOMAX

APPENDIX A

296.15 M BOUNDARY

19.56 M

40 M

NEW LANDSCAPING

ESA BUFFER BOUNDARY

ALL PEPPERMINT TREES TO BE RETAINED IN THIS AREA

NATURAL LANDSCAPE TO REMAIN

246.08 M BOUNDARY

ONE PEPPERMINT TREE TO BE REMOVED

6 M ALL ROADWAYS 6000 WIDE

10 M

LOT 19

R.O.W.

TWO PEPPERMINT TREES TO BE REMOVED

PEDESTRIAN LINKS

LOTS 19 & 20 TO BE AMALGAMATED

LOT 20

93.45m

72.45m

20 M

15 M

61.31M

WATER FEATURE

BBQ AREA

LOT 21

25 M

LANDSCAPED AREA WITH SIMILAR TREES AND SHRUBS ON SITE (NATIVES)

141.08 M BOUNDARY

13.92 M

15 M

ALL EXISTING TUART TREES TO BE RETAINED

ALL EXISTING TUART TREES TO BE RETAINED

OLD COAST ROAD (TO BECOME LOCAL ROAD ON COMPLETION OF BUNBARY BY PASS)

NOTES:

1. THIS AMENDED PROPOSAL CONTAINS 129 LOTS, INSTEAD OF PREVIOUS 142 LOTS, A REDUCTION OF 13.

2. WESTERN LOTS HAVE BEEN FURTHER SET BACK TO 40 METRES FROM THE SITE BOUNDARY

3. ALL EXISTING HEALTHY TUART TREES (T.T.) TO BE RETAINED.

4. ONLY 3 SINGLE STAND PEPPERMINT TREES TO BE REMOVED.

5. LANDSCAPED BUFFER AREAS TO BOUNDARIES TO BE EXTENSIVELY PLANTED WITH SPECIES CURRENTLY ON SITE.

6. PEDESTRIAN LINKAGES HAVE BEEN INCORPORATED TO ALLOW SAFE CIRCULATION AND ACCESS TO OPEN SPACE AREAS SHOWN

DOEPEL MARSH architects

Beck Advisory
Level 3, 190 St George's Terrace,
Perth - WA

AMENDED PARK HOME SITE PLAN

SCALE 1:500

LAKE CLIFTON DEVELOPMENT

LOT 21 OLD COAST ROAD, LAKE CLIFTON

JOB NO. 28.31

DATE: 01 APR 11

APPENDIX B

Design Flow calculations for the new 129 lot Home Site:

1. 20% full time residents
Flow = 129 lots x 2 persons/lot x 20% x 166 l/day = 8,566 L/day or 8.6 kL/day

2. 40% used infrequently i.e. 12 times/yr for up to 3 days/occasion
Flow = 129 lots x 2 persons/lot x 4 % x 166 l/day = 17,132 L/day or 17.1 kL/day

3. 40% of site used 5 days/week for 6 months/year
Flow = 129 lots x 2 persons/lot x 40% x 166 l/day = 17,132 L/day or 17.1 kL/day

Due to the transient nature of the caravan park the treatment plant must be designed to cater to a range of flow.

Low Flow = 8.6 kL/day

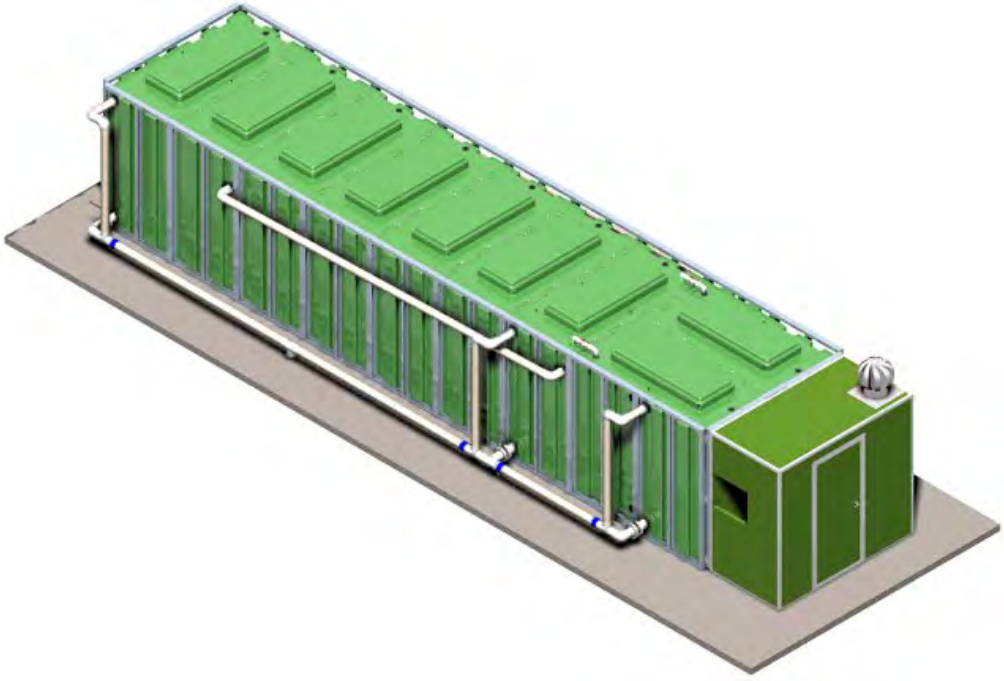
Peak Flow = 8.6 + 17.1 +17.1 = 42.8 kL/day (approximately 45 kL/day)

Due to the inclusion of a 24hour equalisation tank at the head of the plant a peaking factor need not be factored into the flow calculations.

APPENDIX C

Aquacell Wastewater Blackwater Recycling System
Budget Proposal

Project:	**Lake Clifton Caravan Park**
Consultant:	**Worley Parsons**
Location:	**Lake Clifton**
Proposal no:	**12-5045**
Date:	**24th July 2012**



Prepared by: *Michael Conciatore - phone 0409 018 383*
Email: *michaelc@aquacell.com.au*

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ABN 79 072 487 015

CONTENTS

Proposal Introduction

We are pleased to provide a budget proposal for a 50kL/day Blackwater plant for the Lake Clifton Caravan Park.

Aquacell are specialists in commercial blackwater and greywater treatment and reuse schemes (see experience on p4), having established numerous commercial schemes across Australia, including in NSW, VIC, ACT, QLD and WA. We therefore have the knowledge and experience to confidently deliver a successful blackwater scheme for this project.

The blackwater solution offered is based on Membrane Bioreactor (MBR) technology; a process that is fast becoming a treatment technology of choice for commercial facilities desiring to achieve a high quality effluent that can be safely reused.

The treatment system is capable of dealing with fluctuating site flow which is perfectly suited to a caravan park with a season site population. The Aquacell is able to be sustained with as little as 10% of its design flow, which preliminary water balance calculations show the caravan park produces more than this figure during off peak periods. Due to the nature of this site which has no main sewer to fall back onto, all critical pumps and blowers require redundancy in design and have been designed in a duty standby arrangement.

In this proposal we have included pricing for recirculation pumps, buffer and storage tanks and concrete slabs for this equipment. With this in mind we are offering a complete end to end solution including design, regulatory approvals, manufacturing, delivery to site, installation commissioning and ongoing operation and training. As this is a preliminary investigation this proposal is of a budgetary nature only.

I hope that this proposal will provide you with sufficient technical and budgetary information to support you with this stage of the project development. Please don't hesitate to call me if you require any further information.

Sincerely

Michael Conciatore
Technical Sales Engineer
m) 0409 018 383
e) michaelc@aquacell.com.au

Aquacell Experience

Blackwater Experience

We have a number of blackwater reuse Plants operating and under construction ranging from 5kL/day to 130kL/day in capacity. These include:

Blackwater Plant	Model	Location	Type of Facility
Blacktown Workers Club (100kL/day)	S100	Blacktown, Sydney, NSW	Sports/workers club, irrigation of sports field
Liverpool Catholic Club (100kL/day) (including Mecure Hotel at Liverpool)	S100	Liverpool, Sydney, NSW	Sports club + Hotel, irrigation of sports field
RMIT (6kL/day)	S5	Melbourne	University
PACE farms (20kL/day)	S20	Western NSW	poultry farm wastewater treatment
1 Bligh St (130kL/day)	S100	CBD Sydney, NSW	6 star green star building, sewer mining for cooling tower reuse
Brindabella – Canberra Airport (50kL/day)	S50	Canberra, ACT	Airport business park
Joalah (20kL/day)	S20	south coast NSW	Beachside Holiday Caravan Park in sensitive environment
Australian National University (90kL/day)	S100	ACT	University
Acton Nishi	S50	ACT	Offices

Greywater Experience

In addition to the blackwater experience already mentioned, Aquacell's experience in commercial grey water treatment makes us one of the leading companies in Australia for delivering greywater solutions. We have a number of Greywater Plants in various stages of construction, approval and operation around Australia. The Table below lists our current contracts.

Greywater Plant	Model	Location	Type of Facility
K2	G10	Windsor (Melbourne), VIC	Public Housing – Residential apartments
Birrigai	G5	Tidbinbilla, ACT	School outdoor education centre
Pinctada	G20	Broome, WA	Resort
Lot 6, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Lot 7, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Lot 11, Prince Henry at Little Bay Development	G20	Sydney, NSW	Green star, residential apartment block
Lot 13, Prince Henry at Little Bay Development	G20	Sydney, NSW	Green star, residential apartment block
Lot 18, Prince Henry at Little Bay Development	G10	Sydney, NSW	Green star, residential apartment block
Childers Square	G5	ACT	Commercial Offices
City West	G20	ACT	Commercial Offices
40 Mount St (ARK)	G10	North Sydney, NSW	Commercial Offices
RSL Care	G20	Rockhampton, QLD	Aged Care
King George Central	G10	Brisbane, QLD	Commercial Offices
Star City Casino	G100	Sydney, NSW	Casino
111 Eagle St	G10	Brisbane, QLD	Commercial Offices
Hamilton Harbour	G20	Brisbane, QLD	Residential, Commercial development

Note G5~5kL/day; G10~10kL/day; G20~20kL/day.

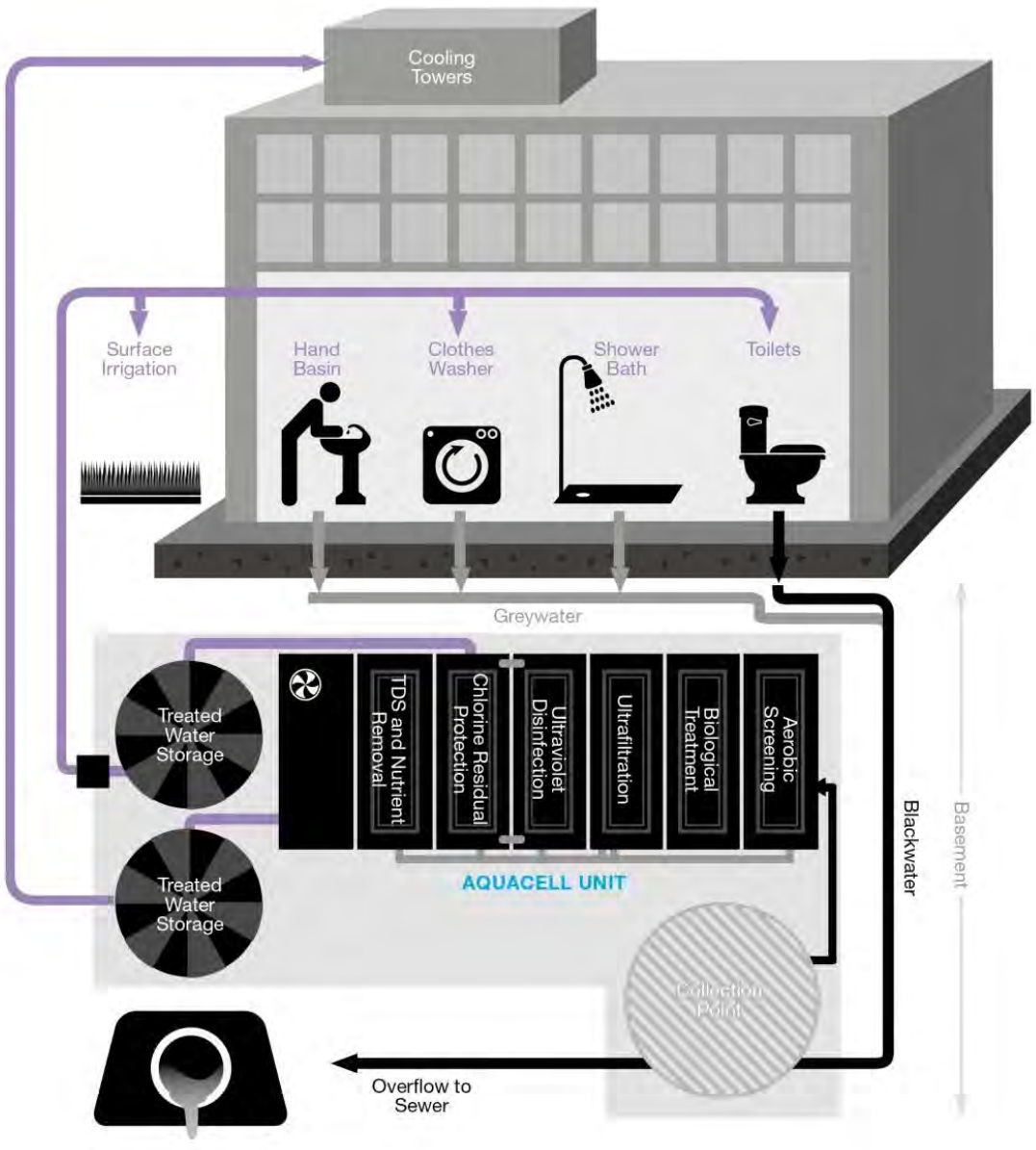
Regulatory Requirements

Aquacell has already obtained approval to operate and reuse wastewater from a 20kL/day Greywater Plant at a resort in Cable Beach, Western Australia. We are therefore able to bring a wealth of local experience to the project in terms of negotiating with Western Australian regulators. Aquacell has had preliminary discussions with WA Health and they have confirmed Blackwater recycling is permitted in WA. Recently WA Health has released a set of guidelines covering the use of recycled water in WA.

Due to Lake Clifton being an environmentally sensitive area further approvals may be required for the onsite water recycling system. Further investigations into the required approvals will need to be undertaken. Aquacell specialises in gaining regulatory approvals, having gained approvals for many varying projects all over Australia including a number in similar environmentally sensitive areas.

Aquacell – Blackwater Recycling Process Summary

A high level schematic showing a typical set up of an Aquacell system for both on-site blackwater and greywater reuse is provided below. Each Plant is site specific and will need to be customised to meet the clients needs and situation.



Schematic of Blackwater Recycling

Blackwater Recycling General Process Features

Some of the key features of the Aquacell Plant to note are:

- The Treatment Plant is based on Membrane Biological Reactor technology; an internationally proven technology that is able to offer a low footprint, high quality final effluent suitable for on-site reuse.

- Aquacell Plants use Ultrafiltration membranes (0.04micron) that are air scoured; No Backwash is Produced (further reducing on site wastewater production). Clean permeate is pushed through the membranes under the normal hydrostatic pressure in the MBR tank.

- Approximate power use of the Aquacell MBR Plant is about 3-3.5kWh/kL for Blackwater, but efficiencies are dependent on how effectively the Plant is utilised.

- The Aquacell Plants have a very high water recovery yield ~99.5%. i.e. 100L of wastewater into the system produces 99.5L of treated A+ effluent.

- Aquacell Plants are modular and skid mounted, therefore minimising on-site installation time and reducing impact on business activities.

- The effluent quality from the MBR Plant will achieve a minimum of log 4-5 removal of pathogens with BOD's <5mg/L. See typical water quality specification.

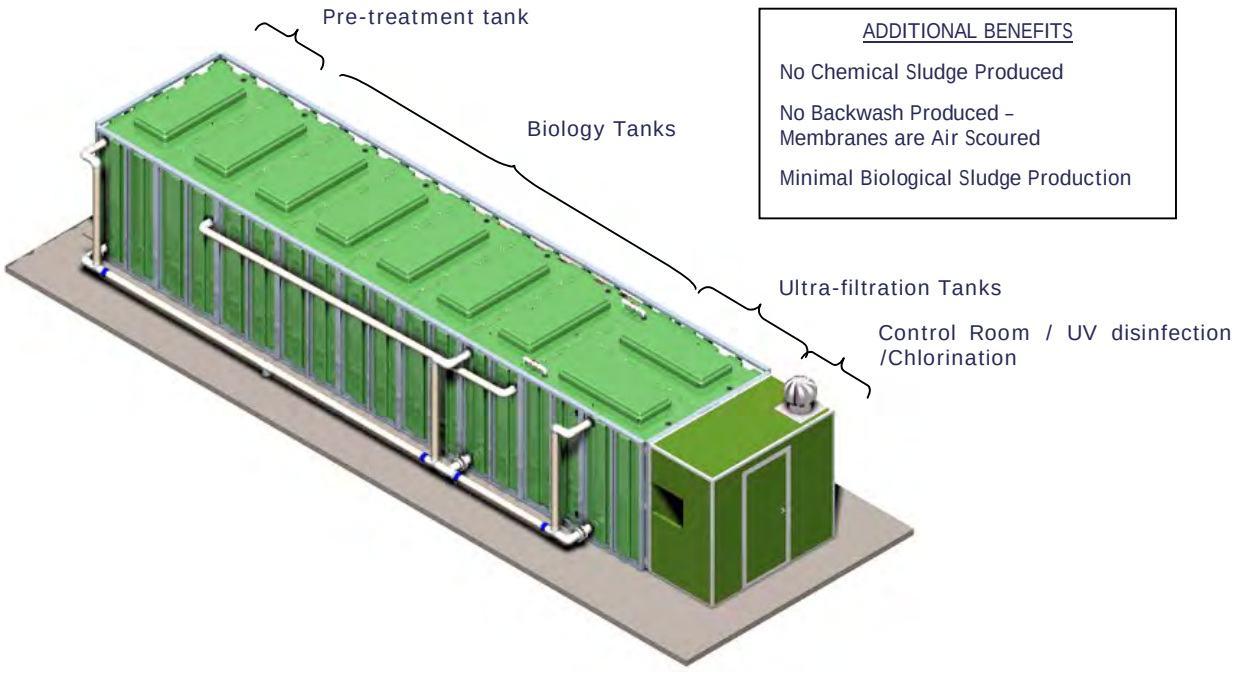
- Very little sludge is produced from the Aquacell system, except for a few cubic meters of biological sludge every 3 months. The sludge waste can be easily removed by a local waste contractor.

- Aquacell Plants are remotely monitored via the internet. Aquacell has the capability to change operational parameters remotely and maintain the ongoing optimisation of the Plant.

Aquacell Process Summary

The Aquacell Plant comprises five main processes:

1. **Pre-treatment**: effluent is pumped from a collection point into the pre-treatment chamber where large solids are screened and separated by a mechanical fine screen. Screenings are dewatered and compacted and deposited by a hygienic bagging system into a bin for removal
2. **Biological Reactors**: Air is diffused into the wastewater to maintain oxygenated conditions to support the growth of aerobic bacteria. These bacteria efficiently break down the organic matter in the effluent. Dissolved oxygen probes ensure that a consistent environment is maintained in the tank to maximise microbial activity.
3. **Ultra-Filtration**: Submersed flat sheet membranes with a pore size several hundredths the thickness of a human hair are used to separate the effluent, without bacteria or virus passing through. These membranes are regularly scoured with air to ensure constant flow rates. Effluent flows through the membranes under the hydraulic head difference between the tank and the outlet.
4. **Ultra Violet Disinfection**: Although the effluent passing through the membranes doesn't contain bacteria/virus', all effluent is passed through UV disinfection to provide additional confidence in the system. ***Potentially this process could be removed from the system since subsurface irrigation is the only intended treated water reuse application, investigations into the relevant regulatory framework are needed to clarify if this is acceptable.***
5. **Chlorine Disinfection**: A chlorine residual is applied as a final disinfection barrier and to combat any microbial contamination that may occur in reticulation lines and effluent storage tanks. ***Potentially this process could be removed from the system since subsurface irrigation is the only intended treated water reuse application, investigations into the relevant regulatory framework are needed to clarify if this is acceptable.***
6. Treated Water is then ready for re-use.



S50 Aquacell Product Specification - Summary

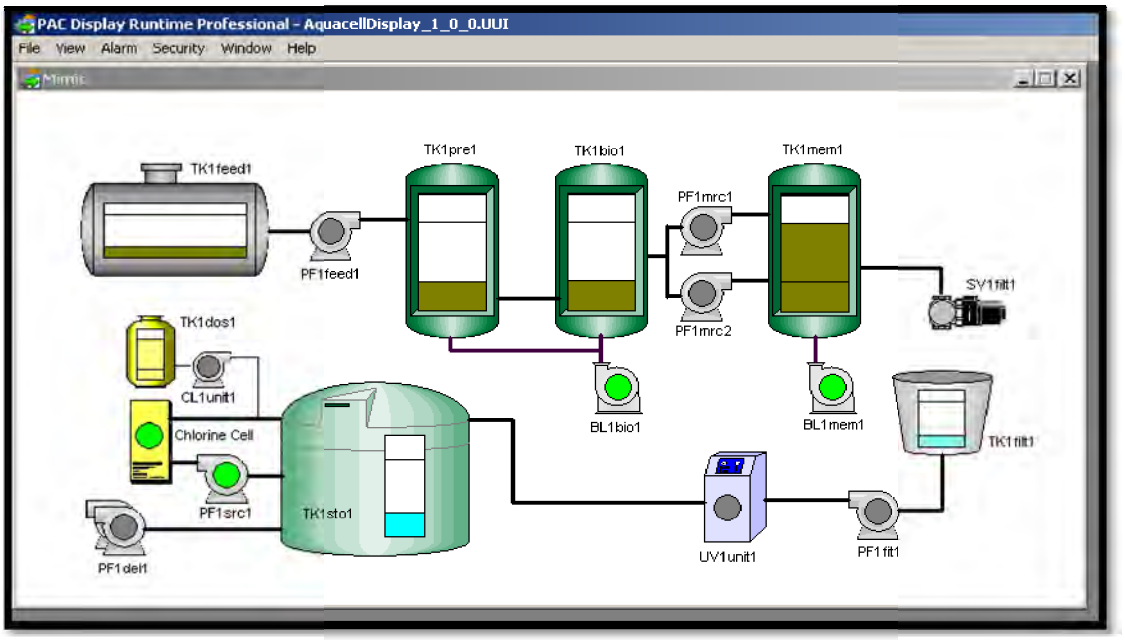
Aspect	Aquacell S50 Specifications
Influent	Blackwater
Design Hydraulic throughput	0 – 50kL/day of blackwater
Final Treated Water Quality	See Effluent Quality Specification
Feed Method	Pump
Tank Description	Enclosed custom moulded polyethylene
Pre-treatment screening	2mm mechanical fine screen
Biology Tank Aeration	Dissolved oxygen controlled, fine bubble aeration
Membranes	Flat Sheet – Ultra-filtration. Nominal pore size 0.04micron.
Membrane operation	Flux through membranes produced by hydraulic head in the membrane tank (i.e. no membrane pumps required). Membranes are air scoured to maintain flux. Chemical clean required infrequently (~3-12 monthly depending on water quality).
Primary Disinfection	UV Treatment: The system will deliver a minimum UV dose of 40mJ/cm^2 at maximum design flow.
Residual Disinfection:	Chlorine dosing post UV treatment. Free Chlorine residual in treated effluent storage tank to be Cl: 0.2-1.0mg/L
Control System and alarms	Integrated Programmable Automation Controller with remote monitoring control. A touch screen on the face of the panel will provide a visible display of plant status, motor manual/off/auto, critical control point status. The plant will be able to operate via the touch-screen interface without remote operation in the event of communications failure. The system will include an ethernet-based web-based human interface with real-time remote operation and control via web-connected PC, and alarming function systems via email and SMS.
Monitoring instrumentation	Continuous on-line monitoring of turbidity, pH of influent and treated water, free chlorine residual in effluent storage tank, Dissolved Oxygen in bioreactor, and total treated water processed.

Remote Monitoring & Controls

A Motor Control Centre and Programmable Automation Controller will be provided. A touch screen on the face of the panel provides a visible display of plant status, motor manual/off/auto, critical control point status. The plant will be able to operate via the touch-screen interface without remote operation in the event of communications failure.

A remote monitoring and data acquisition system will be provided as part of the system to monitor all process variables and critical control points. It will include an ethernet-based web-based human interface with real-time remote operation and control via web-connected PC, and alarming function systems via email and SMS. The system can also be integrated with the Building Management System.

Example of remote monitoring control interface from one of Aquacell's Plants.



The plant will monitor the following parameters and use controls to ensure reliable and safe recycled water supply is available at all times.

Parameter	Monitoring & Control
Level	• MBR Tank levels
	• Recycled water storage tank level
	• High level Alarms
Status or Condition	• Flow
	• Level Sensors
	• Pumps on/off
	• Blowers on/off
	• Filtration
	• Aeration cycle
UV Disinfection	• UV Lamp on/off
	• UVI
Dissolved Oxygen	• Online DOx monitoring
Turbidity	• Online turbidity monitoring
pH	• Online pH monitoring
Chlorine	• Online chlorine monitoring
	•

The recycled water scheme has remote monitoring in place for critical process parameters. For example, turbidity of the recycled water will be monitored online using a turbidity meter. If the turbidity value exceeds 0.5 NTU due to membrane rupture or plant malfunction, recycle water supply will be stopped, and an alarm will be raised and directed to the remote monitor.

Effluent Quality Produced from the Aquacell Plant

The effluent produced from the Plant will be equivalent to A+ quality. Typical effluent quality is shown below. Potentially less stringent requirements may be required due to sub-surface irrigation being the only intended reuse application.

Blackwater Effluent Quality Specifications

Parameter	Influent Water quality	Typical Treated Water quality
Biochemical Oxygen demand (BOD), mg/l	300-600mg/L for blackwater	< 5.0
Suspended solids, mg/l	200-400	<1
pH	6.5-8.5	6.5-8.5
Oil and grease	<50mg/l	<1mg/l
Total Nitrogen, mg/l	85mg/l	<15 mg/l *
Total phosphorous	20mg/l	<10 mg/l *
Faecal coliforms cfu/100ml	$10^6 – 10^8$	<1
E. Coli, organisms/100ml	10^6-10^8	<1
Turbidity, NTU		<2
Viruses		99.9999% removal

Proposal Offer

The following Aquacell components/activities will be supplied under this proposal:

- Process Design customisation of the Treatment Plant – including system management Plan and risk assessment
- Secure the necessary regulatory approvals (WA Health approval only, however we are able to add any other required approvals to our scope of supply)
- Concrete slab for treatment works – we are assuming no excessive excavation will be required.
- In ground concrete 50kL collection/equalisation tank (excavation not included)
- Treated water storage tanks proposed as additional options.
- Delivery pumps (duty/standby) from blackwater collection tank/buffer tank to the S50 Aquacell. (pipe work and tank included)
- Reticulation pump set to supply treated water to the intended reuse application
- Aquacell Treatment Plant Equipment Supplied
    - S50 Aquacell Membrane Bioreactor (MBR) Module. This comprises a Biological Reactor with 0.04micron Ultrafiltration membranes.
    - Mechanical Fine Screen
    - UV disinfection
    - Residual Chlorination dosing equipment to achieve final effluent residual chlorine of 0.2mg/L-1mg/L.
    - Control Panel (total integrated wastewater system control)
    - Remote monitoring unit (Internet control)
    - Delivery of all equipment to site
    - Pre-commissioning of plant prior to leaving factory. Installation and commissioning are included on site. (including travel expenses)
    - Training of local building services staff.
    - Operation Manuals and System Management Plan

Items Not Included in Proposal Offer

In addition to these budget costs, these additional costs should be considered, but are not included:

- Civil/mech/elec design
- Site preparation / excavation
- Plumbing and pipework connecting the Aquacell into the surrounding development.
- Plumbing and irrigation network post treatment Plant.
- 415V Power supply and phone line to Aquacell Control Panel
- Backup Power

Project Scope

Preliminaries

Item		Description	Supplied by	Price for Aquacell-supplied items
1.1	Site survey	Assessment of recycled water demand	Existing	
		Site and Soil Survey	Existing	
1.2	Approvals	Regulatory Approvals – WA Health approval	Aquacell	15,000
1.3	Design	Concrete slab design	Aquacell	3,200
		Detailed Design (Aquacell – process Plant)	Aquacell	12,500
		Irrigation/reticulation	Other	

Treatment Plant

Item		Description	Supplied by	Price for Aquacell-supplied items
2.0	Delivery Pump set	For receiving wastewater from the collection pit and delivering to Aquacell – Includes floats, rising main, guide rails and installation into tank.	Aquacell	7,813
2.1	Emergency overflow	150 NB to sewer	N/A	
2.2	Aquacell	Above ground system including the following major components: • Inlet screening/pre-treatment zone • bioreactor system • blowers • submerged ultrafiltration membranes and housings • Aeration diffusers for air scour of membranes • Aeration diffusers for biological treatment • Level controls and on-line instruments; • Permeate and transfer pumps within Aquacell and to storage tank • Air scour blowers • Bioreactor blowers • UV/chlorine dosing • Control Panel for all Aquacell supply drives and controls • Remote monitoring unit • Factory assembly and testing	Aquacell	318,800
2.3	Buffer Tank	In ground Concrete tank supplied and installed	Aquacell	75,000
		Recommended buffer tank volume:	50kl	
	Treated water storage tank	Please see Aquacell storage tank options below.	Other	
		Recommended storage tank volume:	2 days	
2.4	Reticulation pump-set	Supplying recycled water to re-use points	Aquacell	7,000
2.5	Delivery to site	Aquacell-supplied items	Aquacell	18,800

Site Works

Item		Description	Supplied by	Price for Aquacell-supplied items
3.1	Civil and mechanical works	Concrete slab for treatment works	Aquacell	86,000
3.2		Recommended plant room size (for indoor installation)	N/A	
3.3		Recommended slab size (for outdoor installation)	See Attached GA Drawing	
3.4		Site installation of Aquacell	Aquacell	56,600
3.5	Plumbing and drainage	Internal plumbing of Aquacell into package unit.		**Included in item 2.2**
3.6		Overflows, drains to floor waste		**Included in item 2.2**
3.7		Rising main from buffer tank to Aquacell	Aquacell	**Included in item 2.3**
3.8		Drainage from plant via relief gully trap or reflux valve to sewer	Other	
3.9		Plumbing from Aquacell to treated water storage tank	Aquacell	**Included in item 2.2**
3.10		Vent to stack/mechanical ventilation	N/A	
3.11		Plumbing from treated water storage tank to reticulation pumps and to re-use points (lilac coloured pipes and taps to plumbing codes)	Other	
3.12		Mains water backup supply (via RPZ or physical air gap) to storage tank and plant room if applicable	Other	
3.13		RPZ at property boundary	Other	
3.14		Recycled water signage (plant only)	Aquacell	700
3.15	Electrical and utilities	Incoming 415V power supply to control panel	Other	
3.16		Phone line and internet connection to control panel	Other	
3.17		Electrical conduits from pump station, storage tank and reticulation pumps to panel	Aquacell	**Included in item 3.1**
3.18		Wiring from control panel to Aquacell		Included in 3.4
3.19		Backup power	Other	
3.20	Commissioning	Start-up – mechanical and biological commissioning	Aquacell	26,100
3.21		Performance testing to statutory guidelines – NATA chemical analysis, sampling	Aquacell	18,800
3.22		Operations Manuals	Aquacell	4,700
3.23	Operation	System Management Plan – HACCP Analysis / risk analysis	**Aquacell**	**9,400**

TOTAL FOR AQUACELL SUPPLIED ITEMS – Budget Price $660,413

Alterative price for sub surface irrigation system as per above scope excluding UV Disinfection, Cl Dosing and Turbidity probe

- Budget Price $625,000

Storage Tank Options

Aquacell can offer a range of storage tank solutions for this project. The most cost effective option is to utilise poly round above ground tanks. Below are options for a range of different storage capacities. There may be a regulatory requirement to have wet weather storage available. Price includes delivery and installation.

Component	Dimensions	Cost
20kl Storage using two 10kl round poly tanks.	Each tank is 2510D x 2300H	$7,833
68kl Storage using two 34kl round poly tanks.	Each tank is 4180D x 3050H	$16,667
102kl Storage using three 34kl round poly tanks.	Each tank is 4180D x 3050H	$25,417

Summary of Annual Operational Costs

A service contract will need to be in place prior to the system becoming operational. The first 12 months will be added to the final sale price. Aquacell tailors each service contract to the customer's needs and technical skills. We can offer a complete service contract including all the components below, or we can train site staff to undertake the majority of the components and only look after remote monitoring, technical support, regulatory compliance and annual service

Maintenance Component	Detail	Annual Price
Remote Monitoring & Technical support	• Project Management • Remote monitoring of Plant for alarms and general operational health • Notify client of any emergency alarms • Plant optimisation when required • Brief Quarterly report on Plant operation e.g. amount of water processed, general issues • Maintenance scheduling • Response to client queries	~$9,000
Monthly Servicing	• Monthly general inspection and calibration of instruments • Monthly collection of regulatory water quality samples	~$9,600
Six Monthly Full Technical Servicing	• Full technical inspection • Membrane cleans when required • Replacement of ph Probes (6 monthly) • Replacement of UV tubes (12 monthly)	~$5,000
Consumables	• pH probe – 2 probes replaced 6 monthly • UV tube – replaced 12 monthly • Chlorine (12.5% sodium hypochlorite) • CIP Chemicals	~$4,000
Regulatory Compliance	• Chemical Analysis • Licence fees • Regulatory reports • Ongoing regulatory management of documentation • Independent audits	~$8,000
Power	• 3.5kW/kL for blackwater, based on $0.3/kWh; 52 weeks, 7 days a week	~$3,500

NOTE: A further 2.5% of the Capex value should be allocated per year for ongoing asset replacement at the end of component engineering life e.g. pumps replaced every 3-7 years, membranes replaced 5-7 years, valves replaced 3-5 years etc.

Standard Terms of Offer:

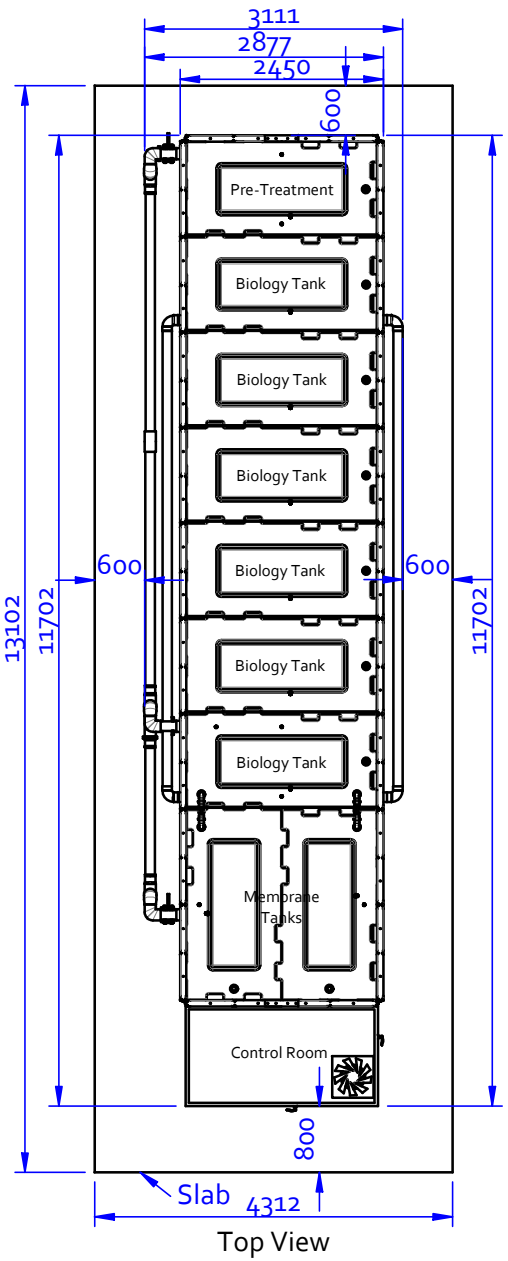
- Price excludes taxes
- Budgetary proposal
- Schedule:
  - Regulatory approval – 2-4 months
  - Design & risk assessment: 1-2 months
  - Equipment procurement and Manufacture: 16-18 working weeks from sign off of detailed design
  - Installation and Commissioning: ~8-12 weeks
  - Post Commissioning regulatory validation: 4-6 weeks
- Validity: 60 days
- Payment terms:
  - To be discussed
- Warranty: 12 months after commissioning, or 18 months after delivery, whichever is earlier
- Our standard terms and conditions of sale apply- copy available on request

APPENDIX A – AQUACELL GENERAL DRAWING

Note that the actual module may differ slightly dependant on site specific design

PRINT MAY BE REDUCED - DO NOT SCALE.

NOT FOR CONSTRUCTION

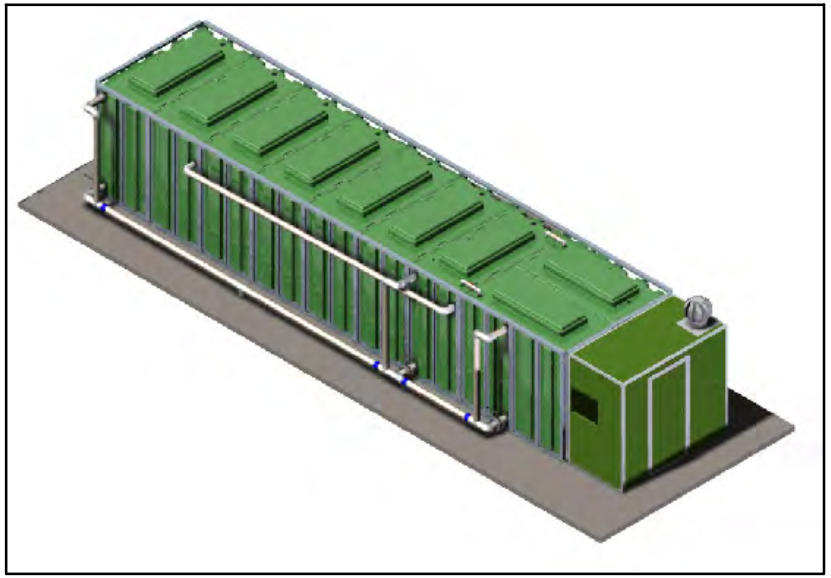


Top View

Aquacell S50

Right hand configuration shown

Iso View



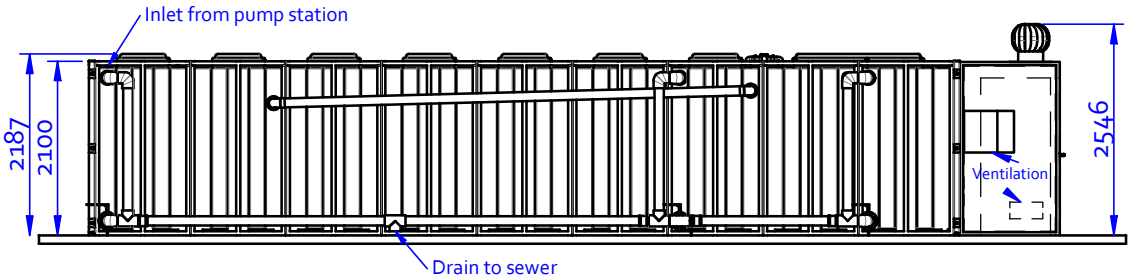
Notes:

Pump station and storage tanks not shown, refer to G50 page 2

Dry weight: 4500 Kg

Wet weight: 52000 Kg

Side View



 email: info@clearwatertechnology.com.au

REV.	DATE	DESCRIPTION	DRN:

GENERAL TOLERANCES (Unless otherwise noted):

Whole:	± 1.0mm
Decimal:	± 0.5mm
Angular:	± 0.5 deg.

Break ALL sharp corners and remove burrs & swarf.
All machining & fabrication to meet MIL-TFD-1111

Clearwater Technology aquacell

1/26 Megalong St. Katoomba NSW 2780 Australia
PO Box 7091 Leura NSW 2780 Australia
Ph : +61 2 4782 3300, Fax : + 61 2 4782 3211

DRN BR DATE
CKD DATE
MACHINED FINISH: 3.2 UON

All dimensions in mm unless otherwise noted
Third Angle Projection - AS 1100

TITLE Aquacell S50

A3

DWG No: CWT S50

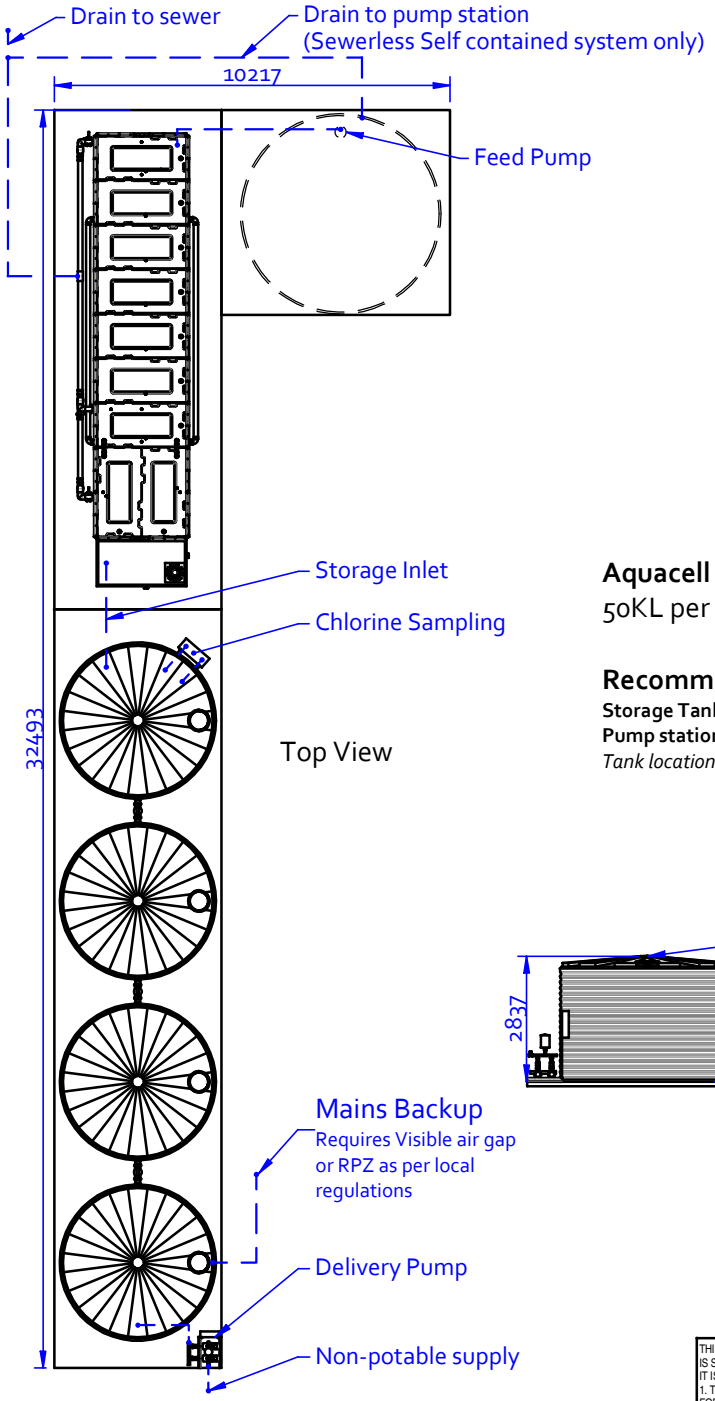
REV No:

SCALE: Noted

SHEET 1 of 1

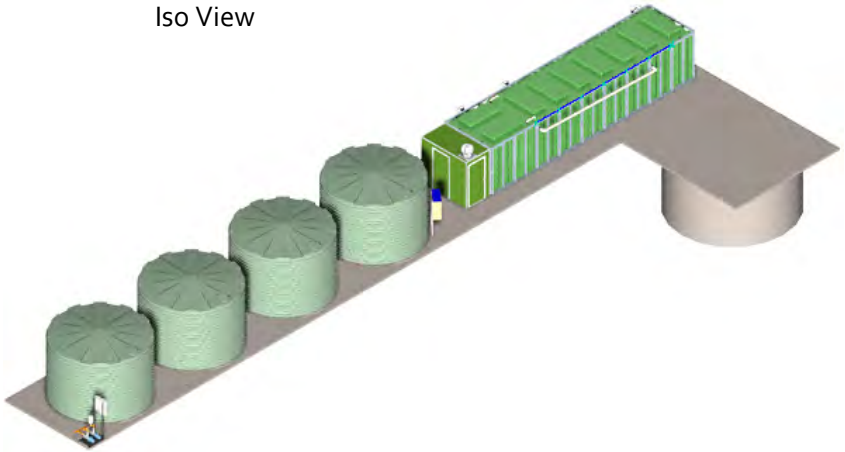
PRINT MAY BE REDUCED - DO NOT SCALE.

NOT FOR CONSTRUCTION



Top View

Iso View



Aquacell G50

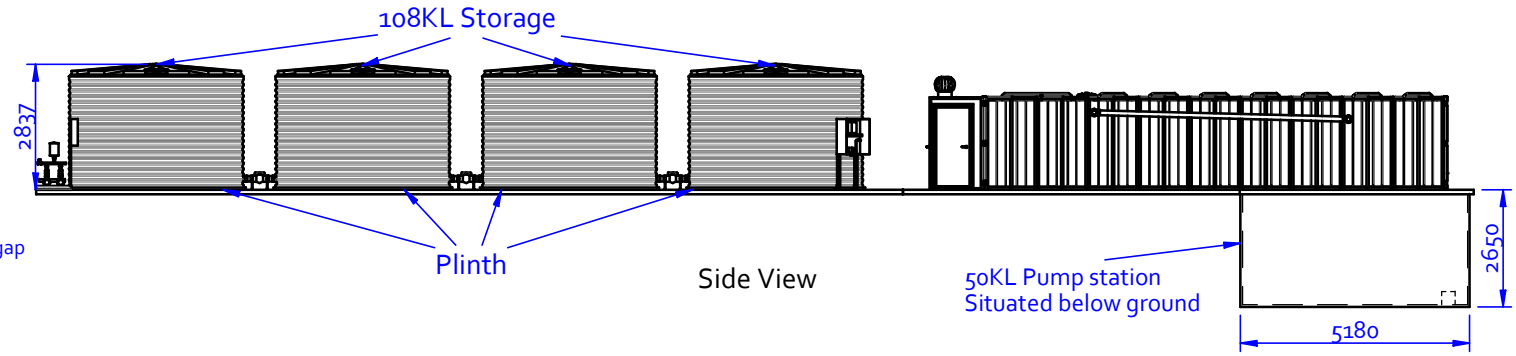
50KL per day Treatment plant

Recommended tank sizing

Storage Tank: 108KL

Pump station: 50KL

Tank locations optional



Side View

GENERAL TOLERANCES (Unless otherwise noted):
Whole: ± 1.0mm
Decimal: ± 0.5mm
Angular: ± 0.5 deg.
Break ALL sharp corners and remove burrs & swarf.
All machining & fabrication to meet MIL-TFD-1111

Clearwater Technology aquacell

1/26 Megalong St. Katoomba NSW 2780 Australia
PO Box 7091 Leura NSW 2780 Australia
Ph : +61 2 4782 3300, Fax : + 61 2 4782 3211

DRN	BR	DATE
CKD		DATE

MACHINED FINISH: 3.2 UON

All dimensions in mm unless otherwise noted

Third Angle Projection - AS 1100

TITLE Aquacell G50

A3

DWG No: CWT G50

REV No:

SCALE: Noted

SHEET 2 of 2

REV.	DATE	DESCRIPTION	DRN:

APPENDIX B – JOALAH HOLIDAY PARK CASE STUDY

consulting systems projects operations

Aquacell® SRN20

Joalah Holiday Park, NSW

Location: Durras North, NSW

Client: Joalah Holiday Park

Capacity: 20,000L/day

Source: Wastewater from toilet, showers and laundry

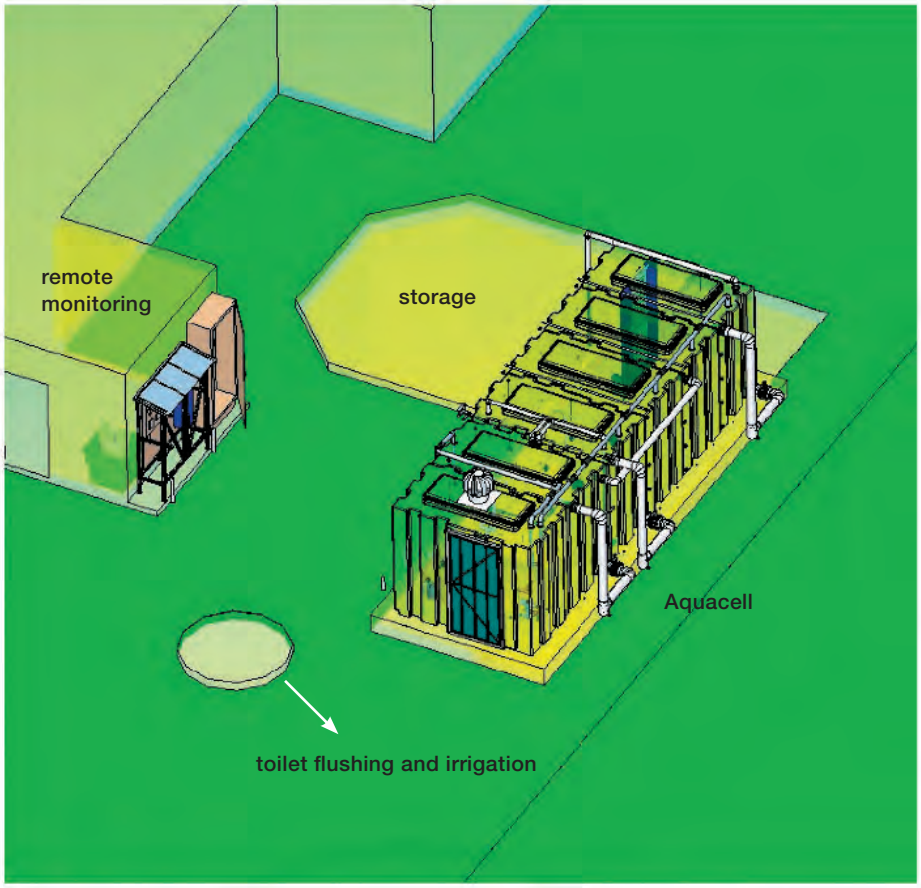
Recycled Use: Toilet flushing and irrigation

Commissioned: November 2007

aquacell
water recycling solutions

www.aquacell.com.au

consulting systems projects operations



One recycling solution

Helping small businesses expand with eco-friendly solutions

On the beautiful South Coast of NSW, Joalah Holiday Park is in a pristine environment; adjacent to Murramarang National Park, an estuary, the Pacific Ocean, a migratory bird nesting site, and an abundance of sensitive flora and fauna.

The owners chose to install waterfront cabins with ensuites, and expand the park occupancy rates, which would increase wastewater load. In such a constrained site without a sewer connection, the only option was to recycle water for toilet flushing and irrigation. In conjunction with Dr. Peter Bacon, of Woodlots and Wetlands, a detailed land capability assessment was performed. The result of this study showed the recycled water needed to be low in nutrients, have no odour and create no noise. The solution was Aquacell's SRN20.

By recycling onsite the owners of the park are able to increase occupancy and therefore generate better returns from their resort, without adversely impacting the environment. They are able to offer a better standard of accommodation, to meet the demands of their customers in a truly eco-friendly way.

For further information:

Please contact Aquacell Head Office on 02 4782 3300 or email sales@aquacell.com.au

aquacell water recycling solutions

www.aquacell.com.au

APPENDIX D

Ramakrishnan, Parusu (Perth)

From: Campbell Durrant <campbell@biomax.com.au>
Sent: Tuesday, 24 July 2012 3:01 PM
To: Ramakrishnan, Parusu (Perth)
Subject: RE: Biomax Model for Lake Clifton Caravan Park

Hi Parusu,

Thankyou for your email.

The price includes delivery and installation by our hiab truck, training, performance testing, commissioning and handover, O&M manual and the supply and laying of the sub-strata dripper disposal system.

The price excludes all earthworks, crane hire (if required) and plumbing and electrical connections.

Best wishes

Campbell

From: Ramakrishnan, Parusu (Perth) [mailto:Parusu.Ramakrishnan@WorleyParsons.com]
Sent: Tuesday, 24 July 2012 2:51 PM
To: Campbell Durrant
Subject: RE: Biomax Model for Lake Clifton Caravan Park

Hi Campbell,

Thanks for the quote. May I know if the price includes the following and if not will you be able to provide a budget cost for these items:

- Minor civil and electrical works
- Installation
- Training
- Performance testing to WA effluent guidelines
- Commissioning and Hand over
- O&M manual
- Rate for supply and installation of sub surface and surface irrigation poly pipes i.e. $/meter

Regards,

Parusu Ramakrishnan
Lead Water/Wastewater Engineer – Power, Infrastructure & Environment
Tel: +61 (08) 6311 6270 | Mobile: 0405542789 | Fax: +61 (0)8 9278 8110 | GMT +8 |
QV1, 250 St Georges Terrace, Level 4 | Perth WA 6000 | WorleyParsons Services Pty Ltd | ABN 61 001 279 812
www.worleyparsons.com

-----Original Message-----
From: Campbell Durrant [mailto:campbell@biomax.com.au]
Sent: Tuesday, 24 July 2012 11:13 AM
To: Ramakrishnan, Parusu (Perth)
Subject: RE: Biomax Model for Lake Clifton Caravan Park

Hi Parusu,

Thankyou for your email.

The most suitable Biomax system to treat flows from 8000L/day to 45000L/day is the Biomax Model C50K.

The Model C50K can treat flows from 5000L/day to 50000L/day.

The footprint for the Model C50K is 10m x 20m x 2.8m deep.

The price for the Model C50K is $359 000 plus GST, delivered by our hiab truck.

The quality of effluent from the Model C50K is a Class B which is suitable for irrigation purposes.

Please let me know if you require additional information.

Best wishes

Campbell

-----Original Message-----
From: Ramakrishnan, Parusu (Perth)
[mailto:Parusu.Ramakrishnan@WorleyParsons.com]
Sent: Monday, 23 July 2012 4:24 PM
To: Campbell Durrant
Subject: RE: Biomax Model for Lake Clifton Caravan Park

Hi Campbell,

We spoke. I am after a price for a system that can treat flows from 8kl/day up to 45kl/day. Would you be able to price it up and let me know what quality of effluent we can get from it. Thanks.

Regards,

Parusu Ramakrishnan
Lead Water/Wastewater Engineer - Power, Infrastructure & Environment
Tel: +61 (08) 6311 6270 | Mobile: 0405542789 | Fax: +61 (0)8 9278 8110 | GMT +8 | QV1, 250 St Georges Terrace, Level 4 | Perth WA 6000 | WorleyParsons Services Pty Ltd | ABN 61 001 279 812 www.worleyparsons.com

*** WORLEYPARSONS GROUP NOTICE *** "This email is confidential. If you are not the intended

Appendix 5: Nutrient Balance Model

Lake Clifton
Post-development Scenario
Total Nitrogen

All assumptions regarding non-wastewater nutrient input rates and removal rates, are based on
Water and Rivers Commission 2002, *Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy* , Water and Rivers Commission, Perth.
Effluent assumptions are as per the Effluent management sheet

Area breakdown

Lots	Lots	22800	m2	
	Roofed/paved	14400	m2	
	Garden	4200	m2	Assumes half of remainder is lawn, other half garden.
	Lawn	4200	m2	
Open Space	Open space - lawn/garden	18065	m2	
	Effleunt Irrigation area	8300	m2	
	Road reserve	11335	m2	
	Total area	60500	m2	

Nutrient Input Without WSUD		**kg/m2/yr**	**Total area**	**Kg/Yr**	**Percentage**	
Lots	Garden	0.059	2100	123.90	33.73%	Assumes half lawn, half garden
	Lawn	0.033	2100	69.30	18.87%	Assumes half lawn, half garden
	Pet Waste	0	4200	0.00	0.00%	Assumes no pets allowed
	Car Wash			0.10	0.03%	Assumes cars washed monthly, one car per permanently occupied unit, 0.33 g per wash
	sub-total			193.30	52.63%	
POS	Garden/Lawn	0.00734	18065	132.60	36.10%	
	Pet Waste	0	18065	0.00	0.00%	Assumes no pets allowed
	Sub-total			132.60	36.10%	
Road Reserve	Major Roads	0	11335	0.00	0.00%	Road reserves not fertilised
	Minor Roads	0	11335	0.00	0.00%	Road reserves not fertilised
	Sub-total			0.00	0.00%	
Wastewater disposal	As per effluent management sheet			41.40	11.27%	
	Total			**367**	**kg/yr**	

Development Nutrient Removal via Source Control

Education effectiveness:		20%					
			Removal	Total area	Removal	removal	
	% Area of influence		KG/m2/yr		KG/yr	%	
Native Gardens (Lots-Garden)		20%	0.059	2100	24.78	6.75%	Assumes 20% native planting
Native Gardens (Lots-Lawn)		20%	0.033	2100	13.86	3.77%	Assumes 20% native planting
Native Gardens (POS)		50%	0.00734	18065	66.29855	18.05%	Assumes 50% native planting
Community Education (Lawn)		80%	0.049	2100	82.32	22.41%	Lowers use in non-native planting areas
Community Education (Garden)		80%	0.024	2100	40.32	10.98%	Lowers use in non-native planting areas
Totals					**227.57855**	**61.96%**	

Development Nutrient Removal via In transit control

			%Removal	Removal	removal	
	% Area of influence		KG/gross/yr	KG/yr	%	
Gross Pollutant Traps		0.00%	50%	0	0.00%	
Water Pollution Control Ponds		0.00%	50%	0	0.00%	
Totals				**0**	**0.00%**	

Net Nutrient Input	**140**	**kg/yr N**
	61.96	**% N removal compared to no WSUD**

Lake Clifton
Pre-development Scenario
Total Nitrogen

All assumptions regarding non-wastewater nutrient input rates and removal rates, are based on
Water and Rivers Commission 2002, *Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy* , Water and Rivers Commission, Perth.
Effluent assumptions are as per the Effluent management sheet

Area breakdown

Lots	Lots	4000	m2	40 permanent caravans
	Roofed/paved	1600	m2	4 by 10 m on average, with 60 m2 garden
	Garden	1200	m2	Assume half lawn, half garden
	Lawn	1200	m2	
Open Space	Open space - lawn/garden	23000	m2	
	Non-irrigated pasture/fallow	33500	m2	Assumed not to be fertilised
	Road reserve	0	m2	
	Total area	60500	m2	

Nutrient Input Without WSUD		**kg/m2/yr**	**Total area**	**Kg/Yr**	**Percentage**	
Lots	Garden	0.059	600	35.40	6.07%	Assumes half lawn, half garden
	Lawn	0.033	600	19.80	3.40%	Assumes half lawn, half garden
	Pet Waste	0	1200	0.00	0.00%	Assumes no pets allowed
	Car Wash			0.10	0.02%	Assumes cars washed monthly, one car per permanently occupied unit, 0.33 g per wash
	sub-total			55.30	9.49%	
POS	Garden/Lawn	0.00734	23000	168.82	28.97%	
	Pet Waste	0	23000	0.00	0.00%	Assumes no pets allowed
	Sub-total			168.82	28.97%	
Road Reserve	Major Roads	0	0	0.00	0.00%	Road reserves not fertilised
	Minor Roads	0	0	0.00	0.00%	Road reserves not fertilised
	Sub-total			0.00	0.00%	
Wastewater disposal	As per effluent management sheet			358.72	61.55%	
	Total			**583**	**kg/yr**	

Development Nutrient Removal via Source Control

Education effectiveness: 20%

			Removal	Total area	Removal	removal	
	% Area of influence		KG/m2/yr		KG/yr	%	
Native Gardens (Lots-Garden)		0%	0.059	600	0	0.00%	Assumes 20% native planting
Native Gardens (Lots-Lawn)		0%	0.033	600	0	0.00%	Assumes 20% native planting
Native Gardens (POS)		0%	0.00734	23000	0	0.00%	Assumes 50% native planting
Community Education (Lawn)		0%	0.049	600	0	0.00%	Lowers use in non-native planting areas
Community Education (Garden)		0%	0.024	600	0	0.00%	Lowers use in non-native planting areas
Totals					**0**	**0.00%**	

Development Nutrient Removal via In transit control

			%Removal	Removal	removal	
	% Area of influence		KG/gross/yr	KG/yr	%	
Gross Pollutant Traps		0.00%	50%	0	0.00%	
Water Pollution Control Ponds		0.00%	50%	0	0.00%	
Totals				**0**	**0.00%**	

Net Nutrient Input **583 kg/yr N**
0.00 % N removal compared to no WSUD

Lake Clifton
Post-development Scenario
Total Phosphorus

All assumptions regarding non-wastewater nutrient input rates and removal rates, are based on
Water and Rivers Commission 2002, *Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy* , Water and Rivers Commission, Perth.
Effluent assumptions are as per the Effluent management sheet

Area breakdown

Lots	Lots	22800	m2	
	Roofed/paved	14400	m2	
	Garden	4200	m2	Assumes half of remainder is lawn, other half garden.
	Lawn	4200	m2	
Open Space	Open space - lawn/garde	18065	m2	
	Effluent Irrigation area	8300	m2	
	Road reserve	11335	m2	
	Total area	60500	m2	

Nutrient Input Without WSUD		**kg/m2/yr**	**Total area**	**Kg/Yr**	**Percentage**	
Lots	Garden	0.027	4200	113.40	76.90%	Assumes half lawn, half garden
	Lawn	0.005	4200	21.00	14.24%	Assumes half lawn, half garden
	Pet Waste	0	8400	0.00	0.00%	Assumes no pets allowed
	Car Wash			0.10	0.06%	Assumes cars washed monthly, one car per permanently occupied unit, 0.33 g per wash
	sub-total			134.50	91.20%	
POS	Garden/Lawn	0.00026	18065	4.70	3.18%	
	Pet Waste	0	18065	0.00	0.00%	Assumes no pets allowed
	Sub-total			4.70	3.18%	
Road Reserve	Major Roads	0	11335	0.00	0.00%	Road reserves not fertilised
	Minor Roads	0	11335	0.00	0.00%	Road reserves not fertilised
	Sub-total			0.00	0.00%	
Wastewater disposal	As per effluent management sheet			8.28	5.61%	
	Total			**147**	**kg/yr**	

Development Nutrient Removal via Source Control

Education effectiveness:		20%				
		Removal	Total area	Removal	removal	
	% Area of influence	KG/m2/yr		KG/yr	%	
Native Gardens (Lots-Garden)	20%	0.027	4200	22.68	15.38%	Assumes 20% native planting
Native Gardens (Lots-Lawn)	20%	0.005	4200	4.2	2.85%	Assumes 20% native planting
Native Gardens (POS)	50%	0.00026	18065	2.34845	1.59%	Assumes 50% native planting
Community Education (Lawn)	80%	0.024	4200	80.64	54.68%	Lowers use in non-native planting areas
Community Education (Garden)	80%	0.004	4200	13.44	9.11%	Lowers use in non-native planting areas
Totals				**123.30845**	**83.61%**	

Development Nutrient Removal via In transit control

		%Removal	Removal	removal	
	% Area of influence	KG/gross/yr	KG/yr	%	
Gross Pollutant Traps	0.00%	50%	0	0.00%	
Water Pollution Control Ponds	0.00%	50%	0	0.00%	
Totals			**0**	**0.00%**	

Net Nutrient Input **24 kg/yr P**

83.61 % P removal compared to no WSUD

Lake Clifton
Pre-development Scenario
Total Phosphorus

All assumptions regarding non-wastewater nutrient input rates and removal rates, are based on
Water and Rivers Commission 2002, *Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy*, Water and Rivers Commission, Perth.
Effluent assumptions are as per the Effluent management sheet

Area breakdown

Lots	Lots	4000	m2	40 permanent caravans	
	Roofed/paved	1600	m2	4 by 10 m on average, with 60 m2 garden	
	Garden	1200	m2	Assume half lawn, half garden	Think this is overestimate of actual garden areas
	Lawn	1200	m2		
Open Space	Open space - lawn/garden	23000	m2		
	Non-irrigated pasture/fallow	32500	m2	Assumed not to be fertilised	
	Road reserve	1000	m2		
	Total area	60500	m2		

Nutrient Input Without WSUD		**kg/m2/yr**	**Total area**	**Kg/Yr**	**Percentage**	
Lots	Garden	0.027	600	16.20	28.52%	Assumes half lawn, half garden
	Lawn	0.005	600	3.00	5.28%	Assumes half lawn, half garden
	Pet Waste	0	1200	0.00	0.00%	Assumes no pets allowed
	Car Wash			0.10	0.17%	Assumes cars washed monthly, one car per permanently occupied unit, 0.33 g per wash
	sub-total			19.30	33.96%	
POS	Garden/Lawn	0.00026	23000	5.98	10.53%	
	Pet Waste	0	23000	0.00	0.00%	Assumes no pets allowed
	Sub-total			5.98	10.53%	
Road Reserve	Major Roads	0	1000	0.00	0.00%	Road reserves not fertilised
	Minor Roads	0	1000	0.00	0.00%	Road reserves not fertilised
	Sub-total			0.00	0.00%	
Wastewater disposal	As per effluent management sheet			31.54	55.51%	
	Total			**57**	**kg/yr**	

Development Nutrient Removal via Source Control

Education effectiveness:		20%					
			Removal	Total area	Removal	removal	
	% Area of influence		KG/m2/yr		KG/yr	%	
Native Gardens (Lots-Garden)		0%	0.027	600	0	0.00%	Assumes 20% native planting
Native Gardens (Lots-Lawn)		0%	0.005	600	0	0.00%	Assumes 20% native planting
Native Gardens (POS)		0%	0.00026	23000	0	0.00%	Assumes 50% native planting
Community Education (Lawn)		0%	0.024	600	0	0.00%	Lowers use in non-native planting areas
Community Education (Garden)		0%	0.004	600	0	0.00%	Lowers use in non-native planting areas
Totals					**0**	**0.00%**	

Development Nutrient Removal via In transit control

			%Removal	Removal	removal	
	% Area of influence		KG/gross/yr	KG/yr	%	
Gross Pollutant Traps		0.00%	50%	0	0.00%	
Water Pollution Control Ponds		0.00%	50%	0	0.00%	
Totals				**0**	**0.00%**	

Net Nutrient Input	**57**	**kg/yr P**
	0.00	**% P removal compared to no WSUD**

Lake Clifton - effluent management

Calculations to determine loading rates and areas required for effluent management

Volume calculations

No of units	120		
No of bedrooms per site	1.8333333		20 at 1 bedroom, balance at 2 bedroom
Peak use of site per day at 0.27 KL/bedroom/day	59.4	kL/day	

Total effluent disposal area to meet DEC/DoW guidelines for effluent disposal

Assume 40% used frequently (36 days/yr), 40% at five days per week, 26 weeks per year (130 days/yr), 20% full time (365 days/yr)

Unit days of use per year	16728		if full time then	43800
Annual water use	8.28036	ML/yr		
Assumed TN concentration	5	mg/L	Based on Worley Parsons spec	
Assumed TP concentration	1	mg/L	Based on Worley Parsons spec	

Annual TN load	41.4018	kg/yr	Guideline	140	kg/ha/yr	Based on Water Quality Protection Note 22
Annual TP load	8.28036	kg/yr	Guideline	10	kg/ha/yr	Based on Water Quality Protection Note 22

Total area for TN to meet above guideline	0.2957271	ha	
Total area for TP to meet above guideline	0.828036	ha	
Max irrigation rate	50	mm/day	Based on DoH draft country sewage policy
	0.05	kL/m2	
Total area required (m2) on DoH country sewage policy	0.1188	m2	
Area required	**0.828036**	**ha**	Maximum of three areas given above

Estimate of current wastewater effluent loads

Assumed TN concentration	91	mg/L	Based on Strategen sampling
Assumed TP concentration	8	mg/L	Based on Strategen sampling
Total no of units	60		
Assumed use per unit	0.27	kL/day	Based on DoH estimates
Assumed to be used all year			
Total use days per year	14600		Assume units used for two thirds of the year on average
Total annual volume	3.942	ML/yr	
Annual TN load	358.722	kg/yr	
Annual TP load	31.536	kg/yr	

Appendix 6: Drainage Calculations

CONSULTING CIVIL & TRAFFIC ENGINEERS, RISK MANAGERS.

Project:	Lake Clifton UWMP
Client:	Strategen
Job Number:	1208004
Author:	Ryan Needham
Signature:	
Date:	17-10-12

1 ST. FLOOR, 908 ALBANY HIGHWAY, EAST VICTORIA PARK WA 6101.

PHONE	+61 8 9355 1300
FACSIMILE	+61 8 9355 1922
EMAIL	rneedham@shawmac.com.au

Document Status

Version No.	Author	Reviewed by	Date	Document status	Signature	Date
1	R.Needham	B.Garton	17-10-12	Client Review		17-10-12

SHAWMAC PTY LTD

ABN 51 828 614 001

PO BOX 937

SOUTH PERTH WA 6951

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E: rneedham@shawmac.com.au

Drainage Summary.docx

Contents

1. 1 YEAR EVENT

1 year 1 hour event – road runoff

Catchment	Road Area (m^2)	Max Flow (L/s)	Inflow Volume (m^3)	Water level (m AHD)	Stored Area (m^2)	Stored Volume (m^3)
1	3,795	13.5	48.6	2.36	510	26.5
2	4,341	15.5	55.6	2.41	300	31.6
3	3,199	11.4	41.0	2.40	375	34.1
Total	11,335	40.4	145.2			

1. All stormwater from lot areas retained within lots in soakwells
2. Road C = 0.8, POS C = 0.15
3. Stored depths, areas and volumes shown include runoff from POS areas
4. Infiltration rate assumed 1m/day

Lot Soakwell Sizing

Duration (mins)	5	6	10	20	30	60	120	180	360	720	1440	2880	4320
Inflow Volume (m^3)	0.59	0..66	0.88	1.23	1.46	1.92	2.47	2.85	3.64	4.68	5.99	7.51	8.30
Storage + Infil. Volume (m^3)	2.84	2.84	2.85	2.88	2.91	2.98	3.14	3.30	3.77	4.71	6.60	10.39	14.14
Excess capacity (m^3)	2.25	2.18	1.97	1.65	1.44	1.06	0.67	0.45	0.13	0.03	0.61	2.88	5.83

1. Sizing based on lot size of 200m^2 and roofed/paved area of 120m^2
2. Figures shown represent 2x 1.2dia. x 1.5m deep soakwells
3. Infiltration rate assumed 1m.day

2. 10 YEAR EVENT

Catchment Area	Road Area (m^2)	Lot Area(m^2)	POS (m^2)	10 yr Peak Inflow to Basin (L/s)
1	3,795	7,313	13,696	213
2	4,341	9,319	4,129	109
3	3,199	5,709	3,053	101

1. tc = 50min Lots, 6 min roads, POS varies
2. Road C = 0.8, Residential C = 0.25, POS C = 0.2
3. Coefficient of Runoff and tc from Lot areas reflects storage in soakwells
4. Storage in road/drainage pits excluded
5. Storage in Lot soakwells included

Basin	Top Level (mAHD)	Base Level (mAHD)	Top Area (m^2)	Base Area (m^2)	Total Vol (m^3)	Critical Storm Duration (hrs)	10 Year Water Level (mAHD)	10 Year Area (m^2)	10 Year Vol (m^3)
1	3.00	2.30	1,660	510	817	2	2.69	1,549	242
2	3.00	2.30	1,286	300	604	3	2.65	817	118
3	3.20	2.30	1,210	375	838	3	2.65	811	142

1. Infiltration rate assumed 1m/day

3. 100 YEAR EVENT

Catchment Area	Road Area (m^2)	Lot Area(m^2)	POS (m^2)	100yr Peak inflow to Basin (L/s)
1	3,795	7,313	13,696	431
2	4,341	9,319	4,129	385
3	3,199	5,709	3,053	276

1. tc = 20min Lots, 6 min roads, POS varies
2. Road C = 1.0, Residential C = 0.6, 4 POS C = 0.4
3. Storage in road, drainage pits excluded
4. Storage in Lot soakwells included

Basin	Top Level (mAHD)	Base Level (mAHD)	Top Area (m^2)	Base Area (m^2)	Total Vol (m^3)	Critical Storm Duration (hrs)	100 Water Level (mAHD)	100 Year Area (m^2)	100 Year Vol (m^3)
1	3.20	2.30	1,660	510	817	3	2.87	1,660	538
2	3.00	2.30	1,286	300	604	3	2.85	1,286	364
3	3.20	2.30	1,210	375	838	3	2.85	1,210	375

1. Infiltration rate assumed 1m/day