PROJECT

WATER MANAGEMENT PLAN
PACIFIC PINES ESTATE
LENNOX HEAD
NEW SOUTH WALES

PREPARED FOR

LEND LEASE PTY LTD

DATE

DECEMBER 2012

GILBERT SUTHERLAND

DOCUMENT CONTROL

DOCUMENT 10734_SZA_RER4F.docx
TITLE Water Management Plan, Pacific Pines Estate, Lennox Head, New South Wales
PROJECT MANAGER P. Matthew
AUTHOR(S) E. Rogers & N. Gifford & E. Holton
CLIENT Lend Lease Pty Ltd
CLIENT CONTACT Eve Monement
CLIENT REFERENCE –

SYNOPSIS This report describes the methods and results of a study undertaken to identify the extent and location of groundwater seepage zones within the proposed Pacific Pines Estate development site, Lennox Head, New South Wales. It presents a landform assessment using indicators including soil, terrain, slope and vegetation and assesses the volume of water needed to recharge the identified seepage zones to maintain the natural hydrological conditions of the freshwater wetland Endangered Environmental Community (EEC) and to ensure the ongoing survival of the endangered Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) post-development.

REVISION HISTORY

REVISION #	DATE	EDITION BY	APPROVED BY
1	3/12	E. Rogers & N. Gifford	P. Matthew & L. Varcoe
2	8/12	E. Holton	C. Anderson & L. Varcoe
3	9/12	E.Holton	C. Anderson
4	12/12	E. Holton	C. Anderson

DISTRIBUTION

	REVISION NUMBER									
Distribution	1	2	3	4	5	6	7	8	9	10
Lend Lease Pty Ltd	1	1	1	1						
G&S library + file	2	2	2	2						

SUMMARY

Lend Lease Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Water Management Plan for the proposed residential development known as 'Pacific Pines Estate' located off Montwood Road and Hutley Road, Lennox Head, New South Wales.

The purpose of the study was 1) to identify the extent and location of groundwater seepage zones occurring within the proposed development site 2) to assess the volume of water needed to recharge the seepage zones and natural hydraulic conditions of the freshwater wetland Endangered Ecological Community (EEC), and 3) to ensure the ongoing survival of the wetland system and vulnerable Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) following development of the site.

An assessment of the distribution of seepage zones throughout the site that contribute to the ecological function of the freshwater wetland EEC was undertaken by way of a landform assessment using soil, terrain, slope and vegetation as indicators. These indicators were mapped as single map overlays and then combined to form Unique Mapping Areas (UMA). The UMAs were then assessed using a set of interpretive rules (as defined in Section 2.4) to ascertain and ultimately map the identified seepage zones.

The MEDLI model was used to estimate the groundwater recharge characteristics of the pre-development landscape. This was then used as the basis for identifying any reduction in recharge that would be likely to occur as a result of the development.

MEDLI was also used to estimate the volume of water that would be required to maintain the saturation level of the seepage zones at field capacity or above.

The MEDLI modelling outcomes were as follows:

- The recharge requirement was statistically assessed and the requirement identified by the 90th percentile as 5.84ML/ha/yr or 27.68ML/yr for the seepage zone.

- The deep drainage deficit resulting from the development of the site was estimated at 211.76ML/yr.

The MUSIC model was used to estimate the reduction in recharge as a result of the development and was also used to estimate the recharge capacity of the infiltration systems as an alternate source of recharge to the seepage zones in order to maintain the existing hydrological regime of the wetlands.

In calculating the volume of water that the bio-retention basins and associated recharge trenches would provide to the seepage zone and freshwater wetland, the MUSIC modelling identified that at the completion of the whole development, a total of approximately 229.06ML/yr would be discharged to the wetland from the bio-retention basins. This exceeds both the recharge requirements of the seepage zone and the deep drainage replacement estimated by MEDLI.

The results of this assessment indicate that the volume of water captured within the bio-retention basins will be sufficient to replace the reduction in groundwater recharge resulting from development of the site, thus maintaining the existing hydrological regime within the identified seepage zone and freshwater wetland EEC. Any surplus water in excess of the recharge requirements will have no deleterious impacts on the ecosystem and will report as runoff discharging westwards towards North Creek and the Ballina Nature Reserve.

CONTENTS

LIST OF DRAWINGS

DRAWING NO.	DESCRIPTION
10734.01	Site Location
10735.02	Borehole Location
10734.03	Pre-developed and post-developed freshwater Wetland location
10734.04	Cross section locations
10734.05	Cross sections, A, B and C
10734.06	Soil landscapes
10734.07	Slope classes
10734.08	Terrain units
10734.09	Soil Classification Map
10734.10	Unique mapping areas
10734.11	Seepage zones and target wetland area for Stage 1 development
10734.12	Freshwater wetland EEC model reporting locations
10734.13	Bioretention basin details
10734.14	Stormwater management measures layout

1 Introduction

1.1 Background and site description

Lend Lease Pty Ltd, on behalf of Petrac Lennox Head Pty Ltd (Receivers and Managers Appointed) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Water Management Plan for the proposed 'Pacific Pines Estate' residential development in Lennox Head, New South Wales.

The site is formally described as part of Lot 234 on DP1104071 and is located off Montwood Drive and Hutley Drive at Lennox Head, New South Wales within the Shire of Ballina. The site location is shown in Drawing No. 10734.01.

The site has an approximate area of 87ha, and is proposed to be developed as a residential estate. Currently, a Construction Certificate (CC) is being sought for Stage 1A of the development. The proposal for Stage 1A includes 51 residential allotments and two open space allotments.

1.2 Objectives

The purpose of the study was to identify the extent and location of groundwater seepage zones occurring within the proposed development.

In the context of this report, a seepage zone is defined as an area exhibiting particular soil, vegetation and topographical features and providing an essential function in maintaining the hydrological regime of the site's identified freshwater wetland Endangered Ecological Community (EEC).

This study assesses the volume of water needed to recharge the identified seepage zones in order to maintain the natural hydraulic conditions of the freshwater wetland EEC to ensure the ongoing survival of the wetland system and vulnerable Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) following development of the site.

1.3 Scope of works

This Water Management Plan is required in order to satisfy the approval conditions issued by the New South Wales Minister for Planning, which state;

> *"(7) A Water Management Plan that addresses the manner in which the hydrological regime of the Freshwater wetlands EEC and associated threatened species will be maintained throughout the life of the project and is to include, but not be limited to:*
>
> *a. An assessment of the pre-development hydrological regime including surface and groundwater inflows and outflows:*
>
> *b. Measures to be implemented to ensure the pre-development hydrological regime is maintained;*

The following summary provides an outline of the scope of works required to satisfy this condition;

- A review of previous assessments conducted for the site.
- A desktop assessment of site features to determine the presence and location of seepage areas, for example geology, topography, vegetation, soil type and slope analysis.
- Field assessments by soil survey methods, soil sampling, and other field determinations.
- The preparation of a report identifying the locations of seepage areas and recommending measures to help maintain the natural hydrological regime and ensure their ongoing protection.

5/232 Robina Town Centre Drive Robina QLD 4230 | PO BOX 4115 Robina QLD 4230
Phone 07 5578 9944 | Email robina@access.gs | www.access.gs

ORIENTATION
NORTH

SCALE
1:10 000 @ A3
100 200 300 400 500
metres

LEGEND

Site boundary

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
DELFIN LEND
LEASE

DRAWING
SITE LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:10 000 @ A3	23/02/2012	DJY	PLM	10734	01

ROBINA
5 / 232 Robina Town Centre Dr.
PO Box 4115
Robina Q4230

Phone 07 5578 9944
Fax 07 5578 9945
robina@access.gs

www.access.gs

CAIRNS
KAWANA
BRISBANE
MELBOURNE

GILBERT SUTHERLAND
AGRICULTURE WATER ENVIRONMENT

2 Methods

2.1 Desktop Assessment

A preliminary assessment of the geology, topography, vegetation, terrain, slope, drainage and soil characteristics of the site was undertaken prior to undertaking a site inspection and soils assessment. Documents reviewed as part of this desktop assessment included:

- geological maps
- soil landscape maps
- topographical maps, and
- an ecologist's report.[1]

The Geological Survey of New South Wales 1:250,000 Geology Series Map Sheet No 53-3 (Tweed Heads) was used to assess the geology underlying the site.

An assessment of the soil classes likely to be encountered within the site was conducted by reviewing the Department of Conservation and Land Management, Lismore-Ballina Soil Landscape Map Series, sheets 9540-9640.

The slope and topography of the site was assessed using contour and slope measurements and information retrieved from the Central Mapping Authority of New South Wales 1:25,000 Ballina Topographic Map, sheet 9640-3-N.

Prior to conducting the site investigation a preliminary assessment of the vegetation types that occur in the area was undertaken. The Central Mapping Authority of New South Wales 1:25,000 Ballina Topographic Map, sheet 9640-3-N was examined to determine vegetation types and communities which exist within and near the site.

An assessment of vegetation at the site was undertaken in conjunction with the soils investigation. The species, location and distribution of the vegetation encountered within the site was noted and described.

2.1.1 Terrain assessment

Aerial map interpretation, a review of topographical maps and field observations were used to undertake a terrain unit assessment of the site. The landscape was divided into:

- Hillcrests that define the top of the hills and ridges (segments 1-2 Dalrymple *et al*. 1968 [2]). This part of the landscape identifies the main recharge zones for groundwater movement.
- Side slopes bulked together as one class of terrain that are either convergent or divergent and linear, concave or convex in nature (segments 3-5 Dalrymple et al. 1968). The side slopes are the transmission zones for shallow interface drainage.
- Footslope and hillwash alluvial areas that define deposition zones within the landscape. Footslopes are landform elements at the base of the side slopes that are waning in slope and leading to lower slope areas (segments 6-7 Dalrymple et al. 1968). This segment identifies the possible effluent zones for groundwater and deposition zones for surface driven sediment.
- Drainage plains that were either:
  - open or closed flow lines carrying the site run-off, or
  - wide open depressions that operate as alluvial plains at the base of catchment areas.

2.1.2 Slope analysis

The slope analysis divided the catchment into slope classes as follows:

- 0-1%
- >1%

The slope analysis was undertaken using Civil CAD 2011. A surface was created using point data provided by the project surveyors Kennedy Surveying Pty Ltd. Contours were then created

[1] Geolink Environmental Management and Design 2008, *Pacific Pines Estate, Lennox Head, Part 3A Application No. MP 07_0026 Environmental Assessment Report*.

[2] Dalrymple J.B., Blong R.J. and Conacher A.J. 1968 A hypothetical nine unit land surface model. Zeitschrift fur Geomorphologie 12, pp60-76.

using the data and compared against existing contour data. The site was then divided into areas of the specified slope limits. The areas of the site with a slope of less than 1% were represented using polygons shaded yellow, while areas with a slope of greater than 1% were represented using polygons shaded red.

2.2 Soil Survey

2.2.1 Survey requirements

A soil-sampling program was undertaken to recover representative soil samples across the site. The site investigation and soil assessment were undertaken in accordance with:

- McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1990) '*Australian Soil and Land Survey Field Handbook', Inkata Press, Melbourne'*.
- Gunn, R.H., Beattie, J.A., Reid, R.A. and van de Graaff, R.H.M., eds. (1988) '*Australian Land and Soil Survey Handbook: Guidelines for conducting surveys'* Inkata Press, Melbourne.
- Isbell, R.F. (1996) *'The Australian Soil Classification (Revised Edition)'.* CSIRO Publishing.

2.2.2 Boreholes

A total of 22 boreholes were constructed at the site to a maximum depth of 2.50m below Natural Surface Level (NSL). This density of boreholes (22 boreholes over 87 ha) is equivalent to one detailed observation per 4ha. An additional 20 soil observations were also conducted on site to give a total density of one observation per 2.07 ha. This constitutes a high intensity investigation. [3]

Boreholes were constructed by qualified G&S staff using a HD10s drill rig fitted with a solid flight auger. The soil profile at each borehole location was described in terms of texture, colour, fabric, soil moisture content and consistence. Where groundwater was intercepted, this was noted on the borelogs. Borehole locations are shown in Drawing No. 10734.02.

2.2.3 Permeability

Soil permeability testing was undertaken at the site in accordance with AS/NZS 1547:2000 *'On-site domestic-wastewater management'*[4] using a Cromer Constant Head Permeameter.

The permeameter consisted of a clear, watertight, graduated, cylindrical water column with a diameter of 85mm and a total volume of 3.75 litres. As water infiltrated from the permeameter into the soil profile the water level was recorded in 30-second to 2-minute intervals. From this information a hydraulic conductivity was calculated.

Soil permeability testing was conducted at five borehole locations (BH5, BH7, BH13, BH20 and BH21), which are shown on Drawing No. 10734.02.

2.3 Unique Mapping Areas (UMA)

The site was divided into a series of Unique Mapping Areas (UMA) to identify areas of land throughout the site with similar soils, terrain, and slope characteristics. Three single-attribute maps were then created depicting soils, terrain and slopes. An additional layer defining the distribution of hydrophytes was added to the mapping to further define the description of the UMAs. The interpretive methods used to establish the UMAs were consistent with Australian Soil and Land Survey Handbook (McDonald et. al., 1990).

2.4 Seepage zone assessment – interpretive rules

Vegetation, slope, soil type and terrain characteristics were used to identify the presence of seepage zones within the site.

2.4.1 Vegetation indicator

The presence of hydrophytes indicates that the soil is regularly saturated or moist (waterlogged). Seepage zones are commonly colonized by plant

[3] Gunn, R.H., Beattie, J.A., Reid, R.A. and van de Graaff, R.H.M., eds. (1988) 'Australian Land and Soil Survey Handbook: Guidelines for conducting surveys' Inkata Press, Melbourne.

[4] Standards Australia/Standards New Zealand, 2000, AS/NZS 1547:2000 *On-site domestic-wastewater management.* Appendix 4.1F, pages 1547-2000.

species that are tolerable of waterlogging, including hydrophytes. The presence of hydrophytes was thus used to identify possible seepage zones throughout the site.

2.4.2 Soil indicator

Hydrosols are soils that are saturated in the major part of the solum for at least 2-3 months of the year and their presence can indicate a seepage zone. The presence of hydrosols was thus used to identify possible seepage zones throughout the site.

2.4.3 Slope indicator

Seepage zones often exist on level to very gently inclined slopes, commonly at the base of moderately inclined to steep slopes. Therefore these areas were mapped as zones likely to exhibit groundwater seepage.

2.4.4 Terrain indicator

Footslope and hillwash areas are recognized as probable groundwater seepage zones. Similarly the wide and open alluvial zones as part of the drainage plains also may be indicative of a seepage area. The terrain units identified in the desktop assessment and confirmed by the site inspection were thus used as part of the base data for the interpretation of the seepage zones.

2.4.5 Integration of indicators

The presence of any one of these factors in isolation does not indicate the occurrence of a groundwater seepage zone. Rather, for the determination of a seepage zone to be definitive, each of the factors outlined above must be present. Consequently, only UMAs identified as hydrosols with hydrophytes in footslope or drainage plain areas and exhibiting slopes of less than 1% are essential seepage zones for the maintenance of the wetland areas.

2.5 Water balance assessment: MEDLI and MUSIC models

The wetland area is dependent on both runoff and seepage from the surrounding catchment to sustain its waterlogged condition. However, permanent waterlogging is not a requirement for most Australian wetlands. Rather, wetlands experience varying periods of wet and dry conditions that are related to the natural fluctuations in rainfall and groundwater at the site.

Modelling of the current soil hydrological regime was undertaken using the MEDLI model. The water management requirements were modeled using the water resources package MUSIC.

The underlying assumptions of the water assessment and management approach were:

- The groundwater regime in the vicinity of the freshwater wetland is dominated by the near surface hydraulic boundary formed by the constructed wetland down stream and the associated bunds, water bodies and drain. The distribution of the wetlands and the position of the near surface hydraulic boundary (or tailwater level) are shown in Drawing No. 10734.04 and 10734.05. The drawing identifies the tailwater level (1.5m AHD contour line), and describes the zone of direct influence of that hydraulic boundary.
- The volume of deep drainage (seepage) from the upper portions of the catchment is additive; i.e. the total seepage to the hydrosols and the wetlands is the sum of all the deep drainage (seepage) of the land up-gradient and adjacent to the wetlands.
- There are no additional groundwater sources other than the catchment itself and its shallow interface drainage; i.e. there is no deep upwelling of groundwater from lower strata.
- The amount of deep drainage (seepage) and run-off is related to a direct proportion between the hardstand and vegetated areas. That is the vegetated areas will continue to contribute to run-off and deep drainage (seepage) as they did predevelopment and the hardstand will contribute to run-off and not contribute to the deep drainage (seepage).
- The impact of the hardstand on the deep drainage may be substituted in total by infiltration devices targeting the wetland area directly, by placing these devices adjacent to, but not within, the wetland.
- The distribution of rainfall and the flow events will be similar between the pre-development

and post development regimes, i.e. run-off events that would occur from rain pre-development will also occur post development and the seepage events predevelopment will still occur post development.
- A measure of the minimum water requirement for the wetland to maintain its integrity is an amount equivalent to maintaining the wetland soil at field capacity or above. The logic of this value as a threshold assessment point is that the wetland requires sufficient water to maintain the hydrologic status of its root system and any excess to this root zone requirement would drain to a level as dictated by the adjacent near surface hydraulic boundary (drain or water body).

2.5.1 MEDLI water balance

This soil hydrological assessment used the water balance model MEDLI to assess the recharge requirements of the existing wetlands onsite. This approach is consistent with the process outlined by Land and Water Australia's April 2007 report titled 'A Frameworks for assessing the Environmental Water Requirements of Groundwater dependent Ecosystems – Report 3, Implementation.

MEDLI is a complex, daily time step, hydrological simulation model that includes the following parameters:

- precipitation
- irrigation (additional water to maintain field capacity or higher)
- evapotranspiration
- percolation
- surface runoff.

The examination of the site's water balance using MEDLI consisted of two components.

Firstly, a MEDLI model was prepared to represent the site in its pre-development condition. MEDLI was used to determine the catchment soil conditions associated with the plant root zone in order to establish the deep drainage (or seepage) characteristics that currently exist at the site in its undeveloped state. The model set-up assumed temperate pastures and used historic daily pan-evaporation and rainfall data for Ballina over a 110-year period.

The water application requirement was then statistically assessed with the value identified by the 90th percentile (i.e. there will be additional water to satisfy or exceed the 90th percentile irrigation requirement) used in the model.

The results of this assessment were then used to assess the impact of the development on the quantity of deep drainage, given that the construction of hard-stand areas throughout the site will decrease infiltration in these areas and may impact upon the wetlands.

The deep drainage was then statistically assessed to describe the distribution of values in relation to the percentile descriptions.

Secondly, MEDLI was used to identify the quantity of groundwater seepage required (in the site's current form) to induce wetland conditions. For this assessment, 'wetland conditions' have been defined as when the soil moisture is estimated to be at field capacity or above on a day-to-day basis. The additional water would be to supplement or replace the reduction in deep drainage and maintain the existing wetlands.

The developed site's stormwater will be captured, stored, treated and then discharged to the wetland via infiltration devices associated with the bio-retention system. This will help to maintain the natural hydrological regime of the freshwater wetland EEC and to help ensure the associated threatened species are protected during construction and following completion of the Pacific Pines Estate development. The MUSIC model was used to assess this as described in the following sections.

2.5.2 MUSIC recharge supplementation assessment

MUSIC is a water resources package with components for generating surface and subsurface runoff, non-point source pollutant export and pollutant transport and routing. It is specifically designed for the analysis of the effects of planned land use changes and for the evaluation of best management practice for stormwater quality improvement devices.

To assess the likely impacts of the proposed development on the hydrological regime within the freshwater wetland EEC, the MUSIC Version 4 computer model was used.

For this assessment daily time-step models were used to provide average daily flows at a number of locations in the mapped freshwater wetland EEC before and after completion of the development.

The MUSIC model input data requirements have been described in Gilbert & Sutherland's Stormwater Assessment & Management Plan for the Pacific Pines Estate[5]. However, for the purposes of the hydrological regime assessment, daily rainfall data (as opposed to time-step data) was obtained from the Bureau of Meteorology website for Ballina Airport weather station No. 58198 and used to create continuous model simulations from 1 December 1992 until 26 October 2011, a period of almost 19 years. The Ballina Airport station (58198) was used within this hydrological assessment due to the close proximity to the site and the availability of daily rainfall data. All other model inputs and parameters (described in the stormwater quality assessment sections) were unchanged.

The average monthly potential areal evapotranspiration values (supplied by the Bureau of Meteorology) were also required in the MUSIC model set-up and are provided below in Table 2.1.

Table 2.1 Evapotranspiration data

Month	Evapotranspiration (mm)
January	199
February	168
March	156
April	107
May	71
June	52
July	55
August	69
September	102
October	152
November	177
December	207

Relevant runoff parameters for the site land uses were sourced from the Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WbD, 2010) Table 3.7 and are presented in Table 2.2.

Table 2.2 Runoff Parameters

Parameter	Rural Land use	Urban Land use
Impervious Area Properties		
Rainfall threshold (mm)	1	1
Pervious Area Properties		
Soil storage capacity (mm)	98	500
Initial storage (%)	10	10
Field capacity (mm)	80	200
Infiltration coefficient	84	211
Infiltration exponent	3.3	5.0
Groundwater Properties		
Initial depth (mm)	50	50
Daily recharge rate (%)	100	28
Daily baseflow rate (%)	22	27
Daily deep seepage rate (%)	0	0

Three scenarios listed below have been modelled:

- Base Case – Site in its present state.
- Developed Case – Ultimate development over the whole site without mitigation measures.
- Mitigated Case – Ultimate development over the site with measures to mitigate the development's impacts.

[5] Gilbert & Sutherland January 2021. *Stormwater Assessment and Management Plan, Pacific Pines Estate, Montwood Drive & Hutley Drive, Lennox head, New South Wales*.

ORIENTATION
NORTH

SCALE
1:3 200 @ A3
40 80 120 160
metres

LEGEND

BH# Borehole

BH# Borehole & groundwater sample location

BH# Borehole & permeability test location

PROJECT	CLIENT	DRAWING
PACIFIC PINES LENNOX HEAD NSW	LEND LEASE	BOREHOLE LOCATIONS

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:3 200 @ A3	10/09/2012	DJY/KLS	PLM	10734	02

ROBINA
5 / 232 Robina Town Centre Dr.
PO Box 4115
Robina Q4230

Phone 07 5578 9944
Fax 07 5578 9945
robina@access.gs

www.access.gs

CAIRNS
KAWANA
BRISBANE
MELBOURNE

GILBERT SUTHERLAND
AGRICULTURE WATER ENVIRONMENT

Catchment	Size
1	7.72ha
2	12.91ha
3	9.08ha
4	1.71ha
5	8.77ha
6	3.89ha
7a	0.86ha
7b	1.52ha
7c	2.10ha
7d	1.10ha
8	12.18ha
9a	2.81ha
9b	1.33ha
10	5.22ha
11	6.09ha
12	8.27ha
13	5.42ha

ORIENTATION
NORTH

SCALE
50 100 150 200 250 300
metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- Pre-developed Wetland Area (5.2ha)
- Post-developed Residual Wetland Area (4.6ha)
- Catchment Boundaries (91ha)

SOURCES

Image base: Google Earth Pro 2012

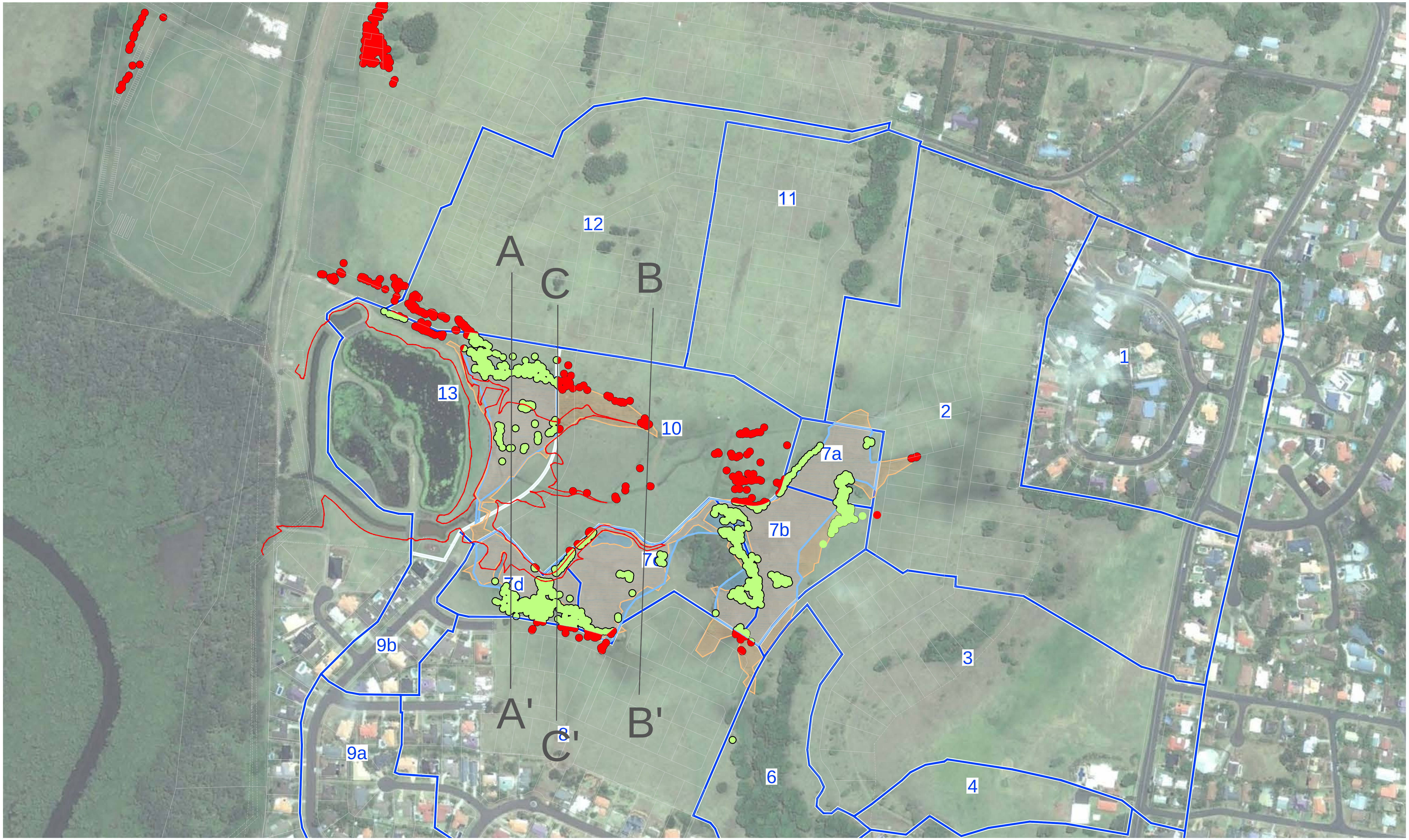
PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
DELFIN LEND
LEASE

DRAWING
PRE-DEVELOPED &
POST-DEVELOPED
FRESHWATER
WETLAND LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250@A3	18/12/2012	BWS	PLM	10734	03

Brisbane Sydney Melbourne and regions
GILBERT SUTHERLAND
Agriculture. Water. Environment.



ORIENTATION NORTH

SCALE 40 80 120 160 200 metres

LEGEND

- Pre-developed Wetland Area (5.2ha)
- Post-developed Residual Wetland Area (4.6ha)
- Catchment Boundaries (91ha)
- Undisturbed Hairy Joint Grass
- Removed Hairy Joint Grass
- Section Location
- Tailwater level

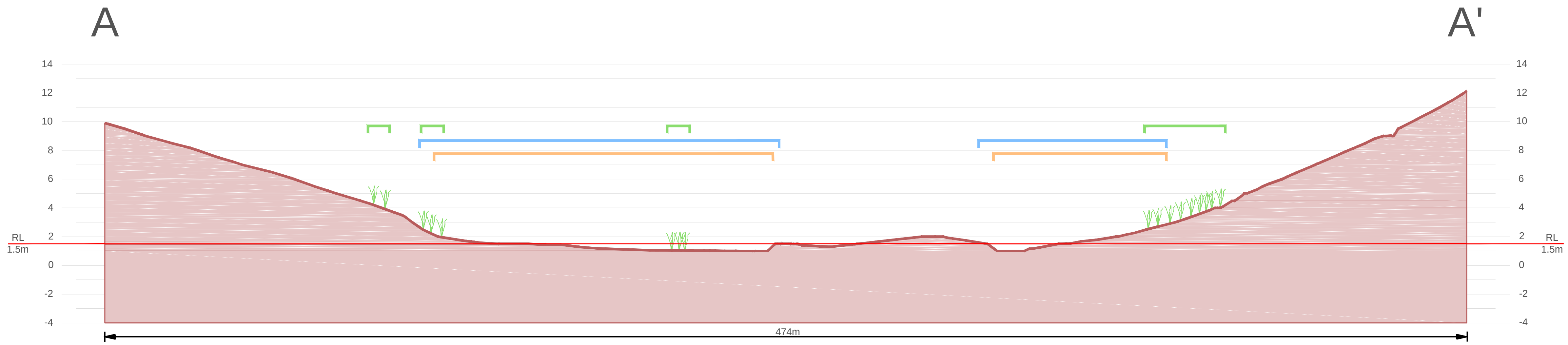
SOURCES Image base: Google Earth Pro 2012

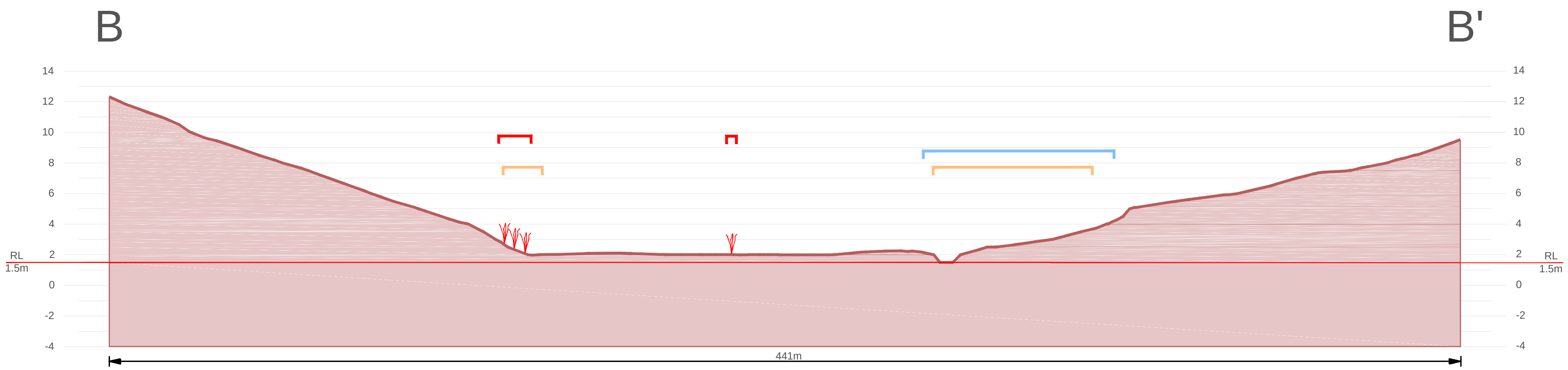
PROJECT	CLIENT	DRAWING
PACIFIC PINES LENNOX HEAD NSW	DELFIN LEND LEASE	CROSS SECTION LOCATIONS

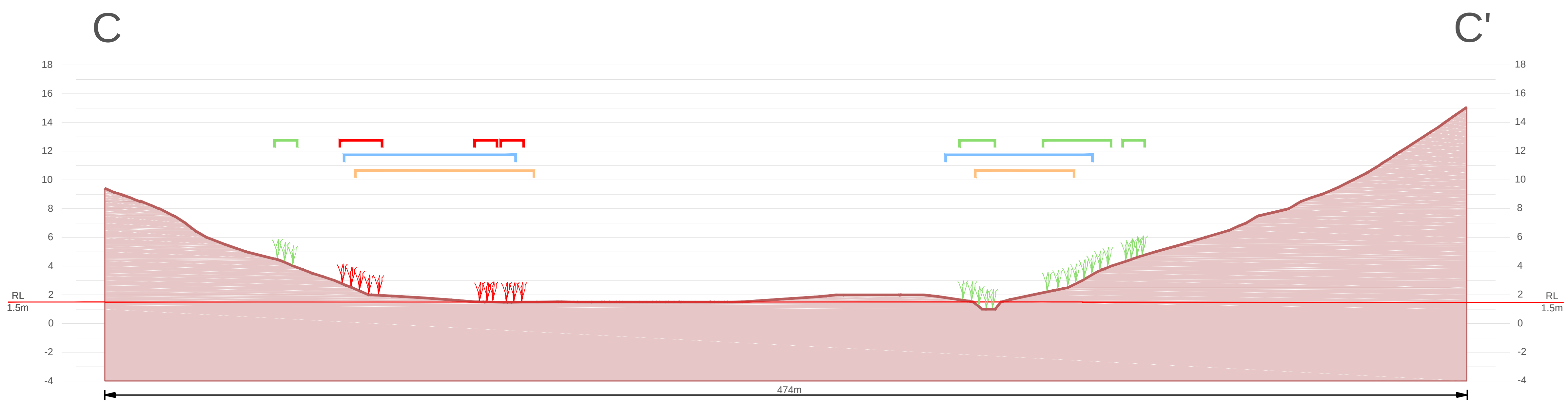
SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:4 000@A3	18/12/2012	BWS	PLM	10734	04

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

Brisbane Sydney Melbourne and regions
GILBERT SUTHERLAND
Agriculture. Water. Environment.







ORIENTATION
NORTH

SCALE
50 100 150 200 250 300
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- Pre-developed Wetland Area
- Post-developed Residual Wetland Area
- Undisturbed Hairy Joint Grass Area
- Removed Hairy Joint Grass Area
- Tailwater level

SOURCES

Image base: Google Earth Pro 2012

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
DELFIN LEND
LEASE

DRAWING
CROSS SECTION
A, B & C

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250@A3	17/12/2012	BWS	PLM	10734	05

Brisbane Sydney Melbourne and regions

GILBERT SUTHERLAND
Agriculture. Water. Environment.

3 Results and outcomes

3.1 Desktop assessment

3.1.1 Geology

A review of the Geological Survey of New South Wales 1:250,000 Geology Series Map Sheet No 53-3 (Tweed Heads) indicates that the site is underlain by Palaezoic era undifferentiated Narenleigh-Fernvale beds of Greywacke, Slate, Phyllite and Quartzite. The underlying Narenleigh-Fernvale beds are overlain by Tertiary era Lamington Volcanic Basalt associated with the Tweed Shield Volcano.

3.1.2 Topography

The site lies to the west of North Creek Road (which generally follows a ridge line) and is situated in the bowl of a natural amphitheatre formed by spurs in the north, east and south that follow Stoneyhurst Drive, North Creek Road and Montwood Drive, respectively. It ranges in elevation from below RL 1.0m Australian Height Datum (AHD) to RL 51.0m.

3.1.3 Drainage

Runoff flows towards the lower lying central portion of the site, then in a generally westerly direction through the Ballina Nature Reserve before discharging to the tidal zone of North Creek. Stage 1a lies in the southern portion of the site and falls in a generally northerly direction.

3.1.4 Vegetation

Vegetation within the investigation area generally consists of pasture grass species with scattered soft wood and Camphor Laurel (*Cinnamomum camphora*) trees. A freshwater wetland EEC exists within the central conservation zone. Hydrophyte species dominate the freshwater wetland and other low-lying areas in the site. Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*), which are vulnerable and endangered species respectively, are known to occur within the wetland and were observed by G&S staff. The location of the freshwater wetland both pre and post developed is shown in Drawing No. 10734.03.

3.1.5 Land use on site

Although the bulk of the site has been cleared and used for grazing purposes, small patches of scattered isolated trees remain. A number of agricultural drains have been historically excavated through the lower portions of the site in order to facilitate grazing. The site was purchased for residential subdivision in the late 1990s and the first four stages have since been constructed.

3.1.6 Adjacent land use

The land to the south-west and south-east of the site has previously been developed as residential allotments and is zoned as low to medium density residential in Ballina City Council's Local Environment Plan 2011, Land Zoning Map – Sheet LZN-012. The Ballina Nature Reserve and North Creek are located to the west of the site.

3.1.7 Soils

A review of the Department of Conservation and Land Management, Lismore-Ballina Soil Landscape Map Series (sheet numbers 9540 to 9640) indicates that Bangalow Transferal Landscapes and Disputed Plains are the predominant soil landscapes most likely to occur within the site. Drawing 10734.06 depicts the distribution of the soil landscapes on the site.

Bangalow transferal landscapes are described as low rolling hills on basalt with slopes ranging between 15% and 25%. Krasnozems are the dominant soil class existing within Bangalow transferal landscapes. Krasnozems are defined as red brown, well-structured clay soils, often ranging from 1m to 7m deep and are classified as Ferrosols under the Australian Soil Classification.

Disputed Plains are basalt derived valley in-fills and alluvial fans forming gently inclined slopes of 1% to 3%. Poorly-drained black earths and dense clays are the dominant soil type of Disputed Plains.

3.1.8 Slope analysis

The site slope analysis indicates that gradients at the site range between 0% and 23%. The lower slope gradients exist within the freshwater wetland

EEC in the southern portion of the site. The higher slope gradients exist towards the east and the north of the site on the sideslopes grading towards the freshwater wetland.

Results of the site slope analysis are shown in Drawing No. 10734.07 and indicate that 7.2 hectares of the site are characterised by slopes of 0-1% with the remaining 79.8 hectares exhibiting slopes of less than 1%.

3.1.9 Terrain assessment

The distribution of the terrain units on site is shown in Drawing No. 10734.08.

The freshwater wetland and low-lying southern portion of the site (approximately 29.4ha) has been classified as drainage plain. Dalrymple et al, (1968) describes a drainage plain as being either open or closed flow lines that carry runoff, or wide, open depressions that operate as alluvial plains at the base of catchment areas.

The high point located to the north-east of the site was classified as Hillcrest (or Hilltop) (approximately 0.6ha). Hillcrest is defined as smoothly convex with very gently inclined to steep crests.

The slopes grading towards the freshwater wetland have been classified as side slope (approximately 39.5ha) and foot slope/hillwash (approximately 17.4ha). Side slopes are defined as gently inclined to precipitous slopes that are convergent or divergent and linear, concave or convex in nature. Foot slopes/hillwash are landform elements that are at the base of the side slopes but are waning in slope and lead to lower slope areas.[6]

3.2 Soil Survey

3.2.1 Soil types

The soils encountered at the site were classified, in accordance with the Australian Soils Classification (Isbell, 1996), as hydrosols and ferrosols. The location of these soils is shown on the Soils Classification Map, Drawing No. 10734.09. The borelogs for the site are provided in Appendix 1.

The soils encountered within the freshwater wetland EEC were classified as Extratidal Hydrosols. Hydrosols are defined as soils that are saturated in the major part of the solum for at least 2-3 months in most years.

The soils encountered on the side slopes and hillcrests surrounding the freshwater wetland were classified as Brown Ferrosols. Ferrosols are defined as soils with B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine earth fraction (less than 2mm).

3.2.2 Permeability

Soil permeability results are provided in Appendix 2 and are summarised below in Table 3.1.

Table 3.1 Soil permeability results

Borehole	Permeability (m/day)	Soil type
BH5	0.026	Ferrosol
BH7	0.25	Ferrosol
BH13	0.10	Ferrosol
BH20	0.42	Ferrosol
BH21	0.73	Ferrosol

The results show that the soils at the site are very poorly drained to imperfectly drained. The most rapid permeability was recorded at BH21 (0.73m/day), which is located on the side slope to the north of the site. The slowest permeability was recorded at BH5 (0.026m/day), which is also located on the side slope to the north of the site.

3.2.3 Water table

The groundwater table was encountered at BH2, BH3, BH7, BH8, BH9, BH10, BH11, BH12, BH14, BH15, BH16, BH18 and BH19. The depth below the natural surface level (NSL) of the groundwater table at each borehole is given in Table 3.2 (next page).

[6] Dalrymple J.B., Blong R.J. and Conacher A.J. 1968 A hypothetical nine unit land surface model. Zeitschrift fur Geomorphologie 12, pp60-76.

Table 3.2 Borehole, water table depth and soil type associations on site.

Borehole	Groundwater table depth (metres below NSL)	Soil type
BH2	0.85	Ferrosol
BH3	0.56	Ferrosol
BH7	0.90	Ferrosol
BH8	0.22	Hydrosol
BH9	0.58	Hydrosol
BH10	0.33	Hydrosol
BH11	0.32	Hydrosol
BH12	0.18	Hydrosol
BH14	0.35	Hydrosol
BH15	0.40	Hydrosol
BH16	0.20	Hydrosol
BH18	0.25	Hydrosol
BH19	0.40	Hydrosol

3.3 UMA distribution

The distribution of the UMAs based on the four seepage zone indicators (vegetation, soils, slope and terrain) is shown in Drawing No. 10734.10.

3.4 Seepage Zones

Based on our assessment of the four seepage zone indicators (vegetation, soils, slope and terrain), one seepage zone was identified at the site. The seepage zone was identified at the base of the hill side slope, within a depositional zone as shown on Drawing No. 10734.11. The presence of hydrophytes including Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) indicate that the soil is moist to saturated and is receiving groundwater seepage. A review of aerial imagery of the site was used to identify saturated and moist zones, particularly those evident in periods of low rainfall. The soils within the seepage zone and low-lying areas of the site were identified as hydrosols.

As the development will be completed in stages, the water collected from development areas will be irrigated into targeted sections of the seepage zone to compensate for the recharge lost as each stage undergoes development. The section of the seepage zone to receive irrigation from surface water run-off collected in Stage 1a (the first stage to be constructed) is shown in Drawing No. 10734.11.

3.5 Water balance – MEDLI model

The MEDLI deep-drainage results for the existing/pre-developed site are detailed in Appendix 3. A summary of the deep drainage estimates is shown in Table 3.3.

Table 3.3 Summary of deep drainage estimates (mm/ha/yr)

Statistic	Result
Mean	265.20
Standard Error	7.24
Confidence Level (95.0%)	262.70
Median	294.90
Standard Deviation	73.50
Skewness	5402.34
Range	-0.26
Minimum	-0.11
Maximum	366.90
Count	57.00
Decile	
0	57.00
0.1	180.36
0.2	205.52
0.3	219.34
0.4	245.38
0.5	262.70
0.6	287.02
0.7	310.02
0.8	330.52
0.9	358.60
1	423.90

The MEDLI results indicate the volume of water required to maintain soil moisture at field capacity (or higher). Full results are detailed in Appendix 3, a summary of results is provided in Table 3.4.

Table 3.4 Summary of irrigation (mm/ha/year) outputs from MEDLI Water Balance

Parameter	Result

5/232 Robina Town Centre Drive Robina QLD 4230 | PO BOX 4115 Robina QLD 4230
Phone 07 5578 9944 | Email robina@access.gs | www.access.gs

Mean	458.05
Standard Error	9.51
Confidence Level (95.0%)	18.86
Median	453.10
Standard Deviation	96.52
Skewness	0.25
Range	486.30
Minimum	240.00
Maximum	726.30
Count	103.00
Decile	
0	240.00
0.1	335.30
0.2	378.84
0.3	404.44
0.4	431.88
0.5	453.10
0.6	484.24
0.7	503.80
0.8	534.78
0.9	584.92
1	726.30

3.6 MUSIC recharge supplementation assessment

The stormwater runoff captured from impervious surfaces within the Pacific Pines Estate development will be captured and stored in bio-retention basins. The water stored in the basins will then be discharged via infiltration devices into the freshwater seepage zone to maintain the natural hydrological regime of the freshwater wetland.

To assess the likely impacts of the proposed development on the hydrological regime within the freshwater wetland and to calculate an approximate volume of water likely to be returned to the freshwater wetland by the bio-retention basins and associated infiltration systems, the MUSIC Version 4 computer model was used. The MUSIC results indicate that at the completion of the development the bio-retention basins would capture approximately 229.06 ML/yr from the impervious surfaces within the development. Following treatment in the bio-retention basin this water would be returned to the freshwater wetland via infiltration devices. The complete Stormwater Assessment and Management Plan for the site is Attached in Appendix 6. A summary of the relevant components of the report is provided in the following sub-sections.

3.6.1 Base case

The MUSIC modeling software was used to create a model of the freshwater wetland EEC in its present state. A daily time-step model was run for the period from 1/12/1992 until 26/10/2011 to obtain a statistically valid data-set. From this model, average daily flows were extracted at the three locations as shown on Drawing No. 107234.12. These average daily flow frequencies are presented in tabular format in Appendix 4.

3.6.2 Developed case

A model of the freshwater wetland EEC, including the proposed residential development on the site, was created and the results were extracted. A comparison of the Base Case and Developed Case results provides an indication of the potential impacts on the hydrological regime of the proposed development. These average daily flow frequencies are presented in tabular format in Appendix 4.

3.6.3 Developed mitigated case

This model is essentially the same as the Developed Case model but measures have been added to mitigate the impacts of the proposed development. The results of the Developed Mitigated Case are presented in tabular format in Appendix 4.

The measures added to the model to mitigate the impacts of development included rainwater tanks and bio-retention basins. It is intended that the bio-retention basins would provide treatment of the stormwater runoff to a standard acceptable for addition to the groundwater by means of exfiltration from the infiltration trenches.

The properties of the bio-retention basins are provided in Appendix 4 whilst the locations are shown on Drawing No. 10734.13 and 10734.14 (indicative locations for the whole of site). An exfiltration rate of 100mm/hour has been used for the soils under the bio-retention basins and the resulting outflows from the basins have been assessed using the MUSIC models. This exfiltration rate would be verified by field measurement and the basin designs adjusted if necessary. The sizes of the proposed bio-retention basins were assessed by using multiple model runs to derive an acceptable solution.

To assist in a visualization of the meaning of these results, two sets of graphs have been prepared. The first set of graphs (presented in Appendix 4) shows the number of times that flows of a particular magnitude have occurred during the 19-year model runs (a flow frequency analysis). These graphs show that for the Base Case, the majority of the average daily flows through all three assessment locations in the wetland are less than 0.1m^3/sec and that flows greater than 0.3m3/sec occur infrequently.

In the Developed Case (unmitigated), there would be a significant increase in the frequency of the flows less than 0.3m3/sec. It is assumed that the low flows are an important component of the hydrologic regime and should be maintained at present levels to protect the EEC.

The graphs also show that the Developed Mitigated Case flows would be restored to levels close to those of the Base Case.

In summary, the flow frequency analysis shows the distribution of discharges from the site and indicates that the change between the pre and the mitigated post development state is minimal. This is most important and evident for the lower peak and volume events. Any differences are within the normal variation of catchment responses to rainfall and run-off generation and of no consequence to the hydrology of the wetland.

The second set of graphs (also in Appendix 4) show the magnitude of the average daily flows for a calendar year (in this case 2010, which was selected as being representative of current climatic conditions). These graphs show that the bulk of rainfall events produce small surface flows and that the magnitude of the flows during heavy rainfall events would increase marginally. It is the contention of this assessment that the marginal increases to these infrequent larger flows are inconsequential as they generally lie within the range of flows normally occurring during rainfall periods.

3.7 Seepage water balance assessment

A water balance table comparing the estimated volume of water to be captured by the bio-retention basins, the estimated deep drainage loss caused by the hard stand areas of the development and the calculated recharge requirement for the freshwater wetland is shown in Table 3.5 (below).

At the completion of the Pacific Pines Estate development, the volume of water captured in the bio-retention basins (229.06ML/yr) will exceed the estimated deep drainage loss caused by the hard stand of the development (211.76ML/yr). Both values are in surplus of the estimated average yearly irrigation requirement for the seepage zone and freshwater wetland (27.68ML/yr). The volume of water captured within the bio-retention basins will be sufficient to replace the deep drainage loss caused by the development and to maintain wetland conditions within the seepage zone and

Table 3.5 Whole of site water balance

Bio-retention basin recharge contribution (ML/yr)	Reduction in deep drainage caused by hardstand (ML/ /yr)	Seepage zone irrigation requirement (ML/yr)	Bio-retention surplus to seepage replacement ML/yr
229.06	211.76	27.68[7]	17 (surplus)

Note: Seepage zone irrigation requirement calculated using seepage zone area (4.74ha).

[7] Estimate of irrigation requirement per hectare based on 5.84 ML/ha multiplied by the area of 4.74 ha = 27.68 ML/yr. The figure of 5.84ML/ha is an estimate of the annual water requirement to maintain the wetland at field capacity or higher (high soil moisture status) for 90% of years (refer to Table 3.4, decile 9, being 584.92mm per hectare per year, or 5.84ML/ha/yr.)

freshwater wetland EEC. Any surplus water in excess of the irrigation requirement or the seepage replacement will have no deleterious impacts on the ecosystem. Excess flows will discharge westwards towards North Creek and the Ballina Nature Reserve.