PROJECT

SEEPAGE ZONE ASSESSMENT REPORT PACIFIC PINES ESTATE LENNOX HEAD NEW SOUTH WALES

PREPARED FOR

LEND LEASE PTY LTD

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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

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SUMMARY

Lend Lease Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to undertake a Seepage Zone Assessment 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 Environmental Community (EEC), and 3) to ensure the ongoing survival of the endangered 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 recharge capacity of the bio-retention 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 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.

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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 undertake a Seepage Zone Assessment 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 endangered Hairy Joint Grass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) following development of the site.

1.3 Scope of works

The scope of works required to achieve the assessment objectives includes:

- 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.

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

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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.

2.5.1 MEDLI water balance

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.

A MEDLI model was prepared to represent the site in its pre-development condition. 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 will be statistically assessed and the requirement identified by the 9th decile (90th percentile) i.e. there will be additional water to satisfy or exceed the 90th percentile irrigation requirement.

The examination of the site's water balance using MEDLI consisted of two components. First, MEDLI was used to inform an assessment of deep drainage under pre-development conditions. 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 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.

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

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

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.

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

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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 to the north of the site. 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 EEC 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. The remaining undeveloped portion of the site was purchased during 2007 by Petrac Lennox Head Pty Ltd.

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 10734.04 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. 10734.05 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. 10734.06.

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 (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. 10734.07. 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. 10734.08.

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. 10734.09. 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. 10734.09.

3.5 Water balance – MEDLI model

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.

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
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

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.

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. 107234.10. 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 bio-retention basins.

The properties of the bio-retention basins are provided in Appendix 4 whilst the locations are shown on Drawing No. 10734.11. 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 0.3m^3/sec occur infrequently.

In the Developed Case (unmitigated), there would be a significant increase in the frequency of the flows less than 0.3m^3/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.

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 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.

Table 3.5 Water balance table

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 (i.e. 5.84 ML/ha multiplied by the area of 4.74 ha = 27.68 ML/yr).

ORIENTATION
NORTH

SCALE
1:2 500 @ A3

25 50 75 100 125
metres

LEGEND

Wetland Boundary

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
LEND LEASE

DRAWING
FRESHWATER
WETLAND
LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:2 500 @ A3	10/09/2012	DJY/KLS	PLM	10734	03

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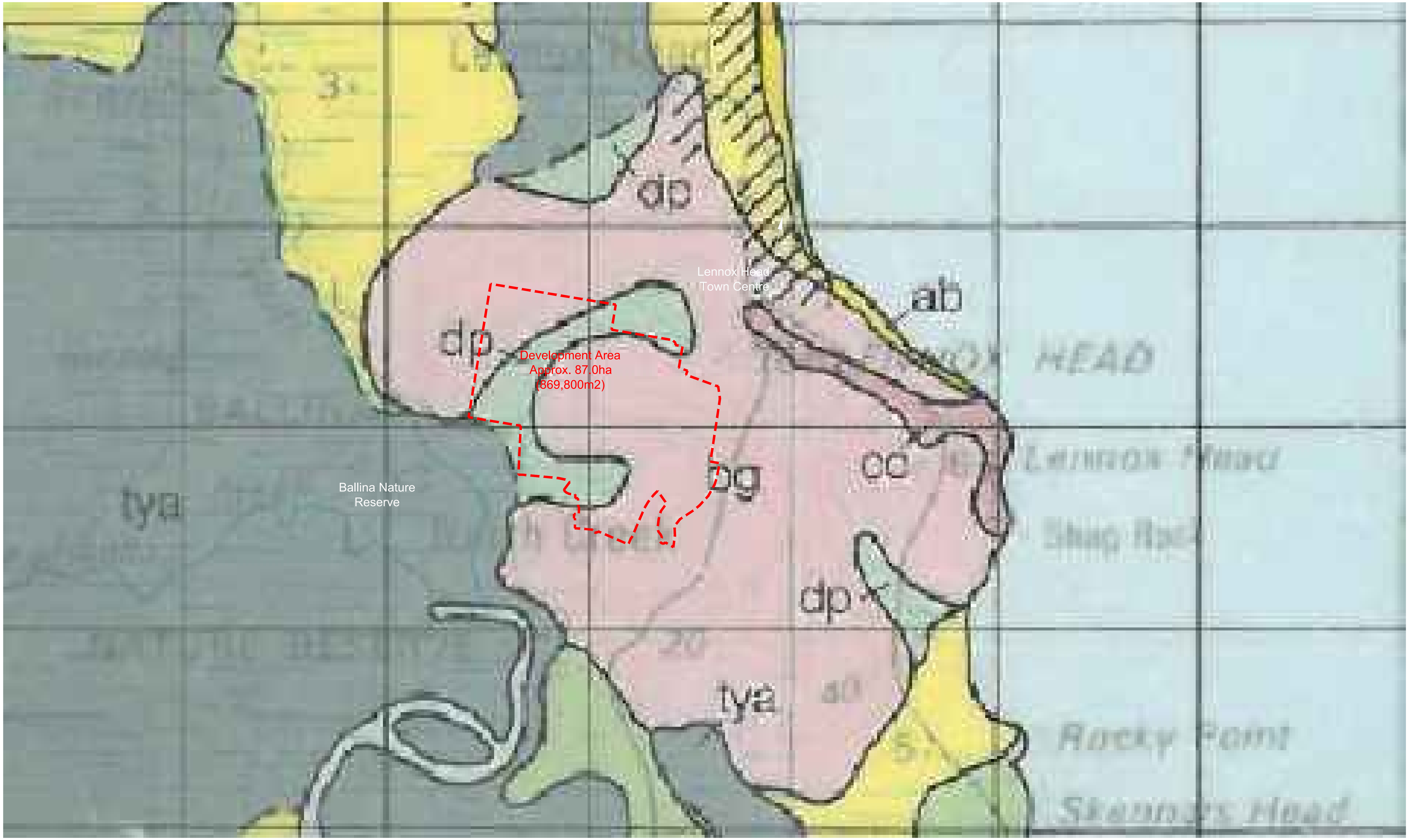

ORIENTATION
NORTH

SCALE
1:16 000 @ A3
200 400 600 800
metres

LEGEND

- - - - Site boundary

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
LEND LEASE

DRAWING
SOIL LANDSCAPE
MAP

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:16 000 @ A3	10/09/2012	DJY/KLS	PLM	10734	04

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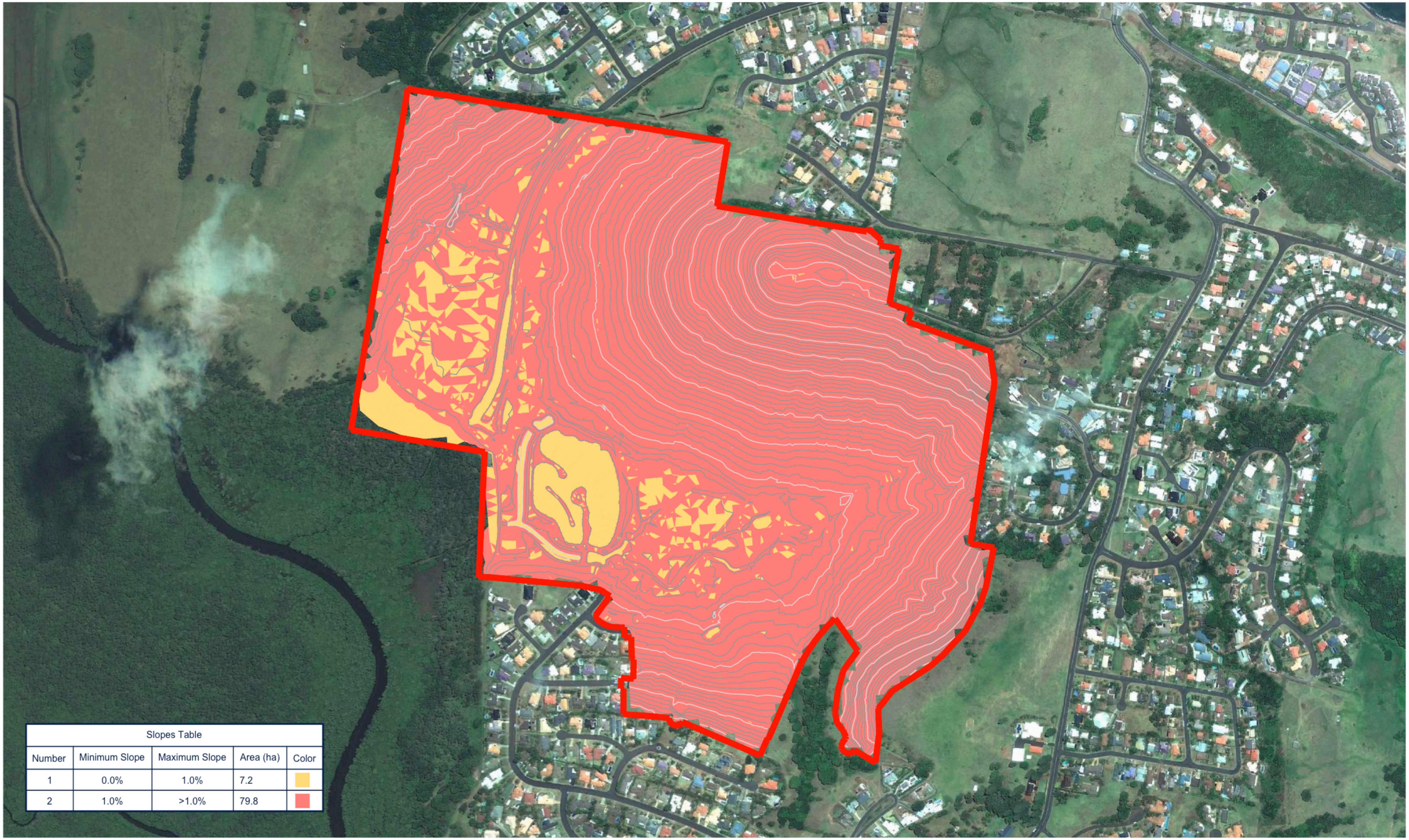

Slopes Table				
Number	Minimum Slope	Maximum Slope	Area (ha)	Color
1	0.0%	1.0%	7.2	
2	1.0%	>1.0%	79.8	

ORIENTATION
NORTH

SCALE
1:6 250 @ A3
50 100 150 200 250 300
metres

LEGEND
Site boundary
Major contours (5m intervals)
Minor contours (1m intervals)

SOURCES
Base Image: Google Earth Pro, 2012

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
LEND LEASE

DRAWING
SLOPE CLASSES

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250 @ A3	10/09/2012	DJY	PLM	10734	05

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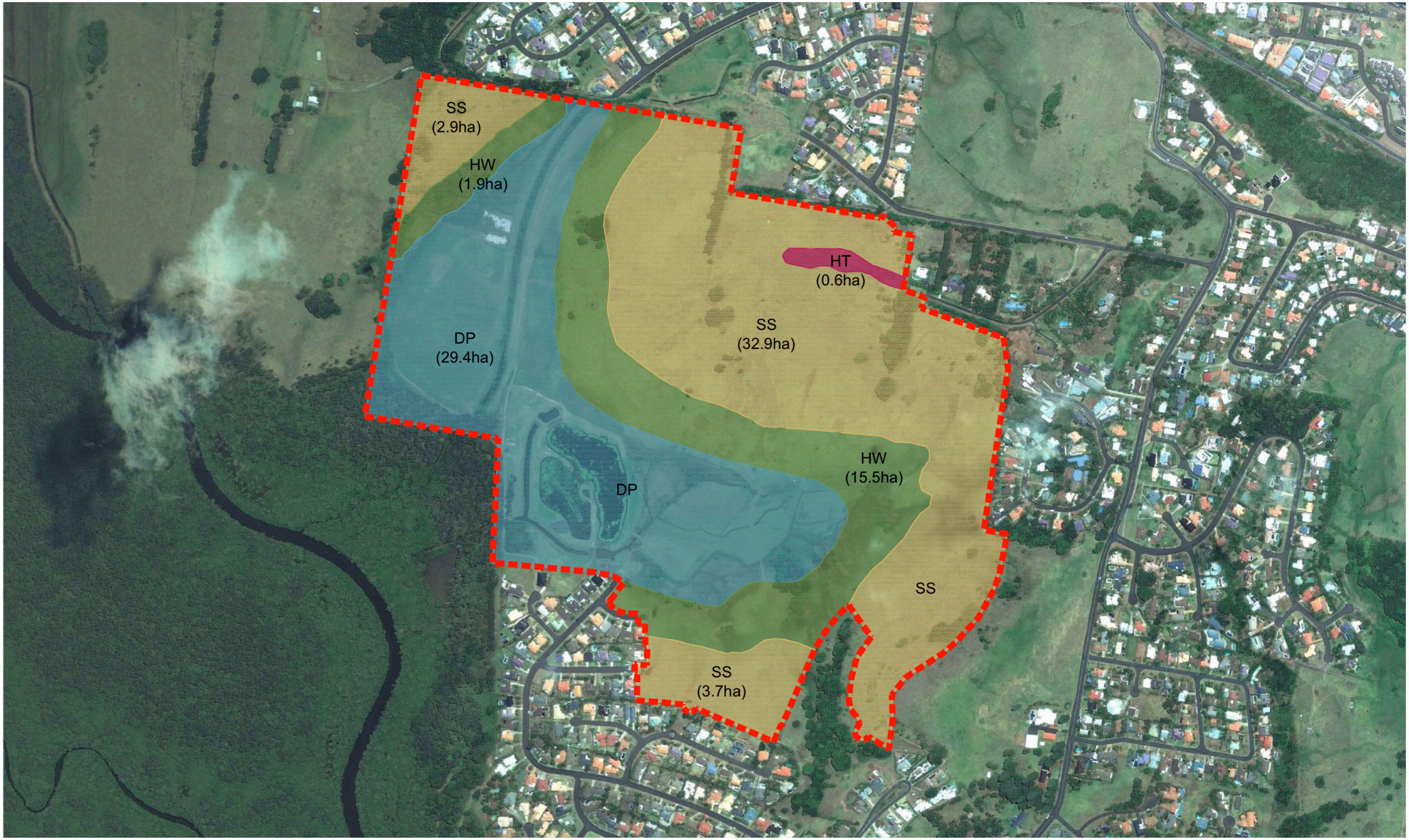

ORIENTATION
NORTH

SCALE
1:6 250 @ A3
50 100 150 200 250 300
metres

LEGEND

Site boundary	
SS	Side slope
HS	Hillwash/ foot slope
DP	Drainage path
HT	Hilltop

SOURCES
Google Earth Pro, 2012

PROJECT
PACIFIC PINES
LENNOX HEAD
NSW

CLIENT
LEND LEASE

DRAWING
TERRAIN UNITS

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250 @ A3	10/09/2012	DJY	PLM	10734	06

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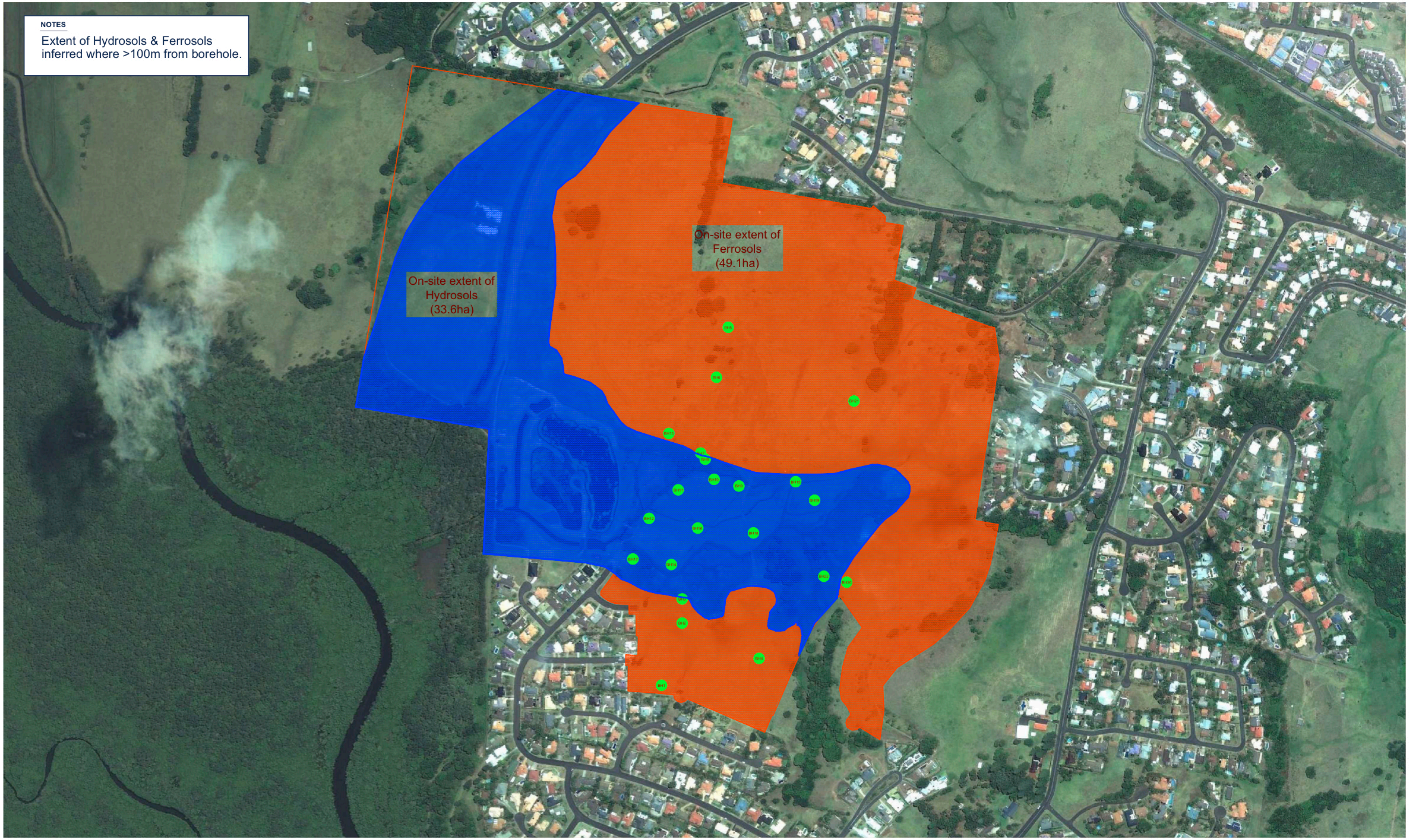

ORIENTATION
NORTH

SCALE
1:6 250 @ A3
50 100 150 200 250 300
metres

LEGEND

- Hydrosol/Ferrosol boundary
- Site boundary
- Borehole
- Extent of Hydrosols
- Extent of Ferrosols

SOURCE
Google Earth Pro, 2012

PROJECT	CLIENT	DRAWING
PACIFIC PINES LENNOX HEAD NSW	LEND LEASE	SOIL CLASSIFICATION

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250 @ A3	10/09/2012	DJY	PLM	10734	07

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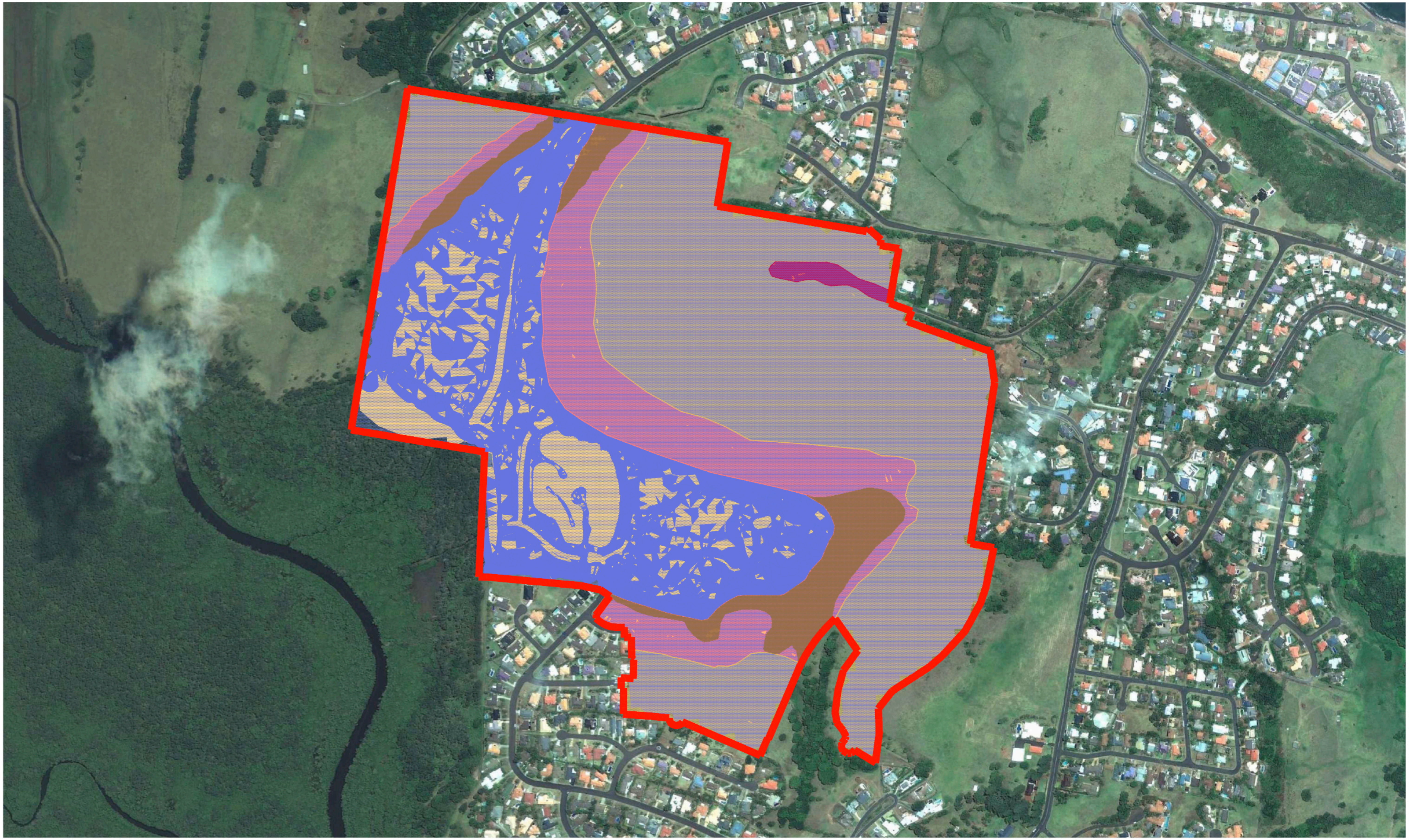

ORIENTATION
NORTH

SCALE
1:6 250 @ A3
50 100 150 200 250 300
metres

LEGEND

UMA 1	UMA 4
UMA 2	UMA 5
UMA 3	UMA 6

Site boundary

SOURCES
Google Earth Pro, 2012

PROJECT	CLIENT	DRAWING
PACIFIC PINES LENNOX HEAD NSW	LEND LEASE	Unique Mapping Areas (UMA)

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:6 250 @ A3	10/09/2012	DJY	PLM	10734	08

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ORIENTATION
NORTH

SCALE
1:2 500 @ A3
25 50 75 100 125
metres

LEGEND

- Seepage Zone Boundary
- Dam Inundation Zone Boundary
- Development stage 1A
- Target seepage area for 1A

PROJECT	CLIENT	DRAWING
PACIFIC PINES LENNOX HEAD NSW	DELFIN LEND LEASE	GROUNDWATER SEEPAGE ZONE

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:2 500 @ A3	14/02/2012	DJY	PLM	10734	09

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50 100 150 200 250
metres

SCALE
1:5 000

ORIENTATION
NORTH

LEGEND

- Pacific Pines Estate Balance Boundary
- WBNM developed case catchment boundary
- Freshwater EEC model reporting location

SOURCES

Contours and proposed layout supplied by Kennedy Surveying and SMEC Urban

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PROJECT
PACIFIC PINES ESTATE
LENNOX HEAD, NSW

CLIENT
LEND LEASE

DRAWING
FRESHWATER EEC MODEL
REPORTING LOCATIONS

DATE	DRAWN
24/09/2012	BWS
SCALE	CHECKED
1:5 000	CMA

PROJECT NO	DRAWING NO	REVISION
10734	1.10	B

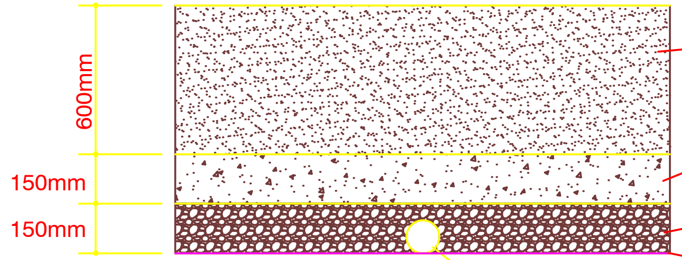
SCALE
Basin plan 1:1 250
Location plan and detail NTS

ORIENTATION
NORTH

LEGEND

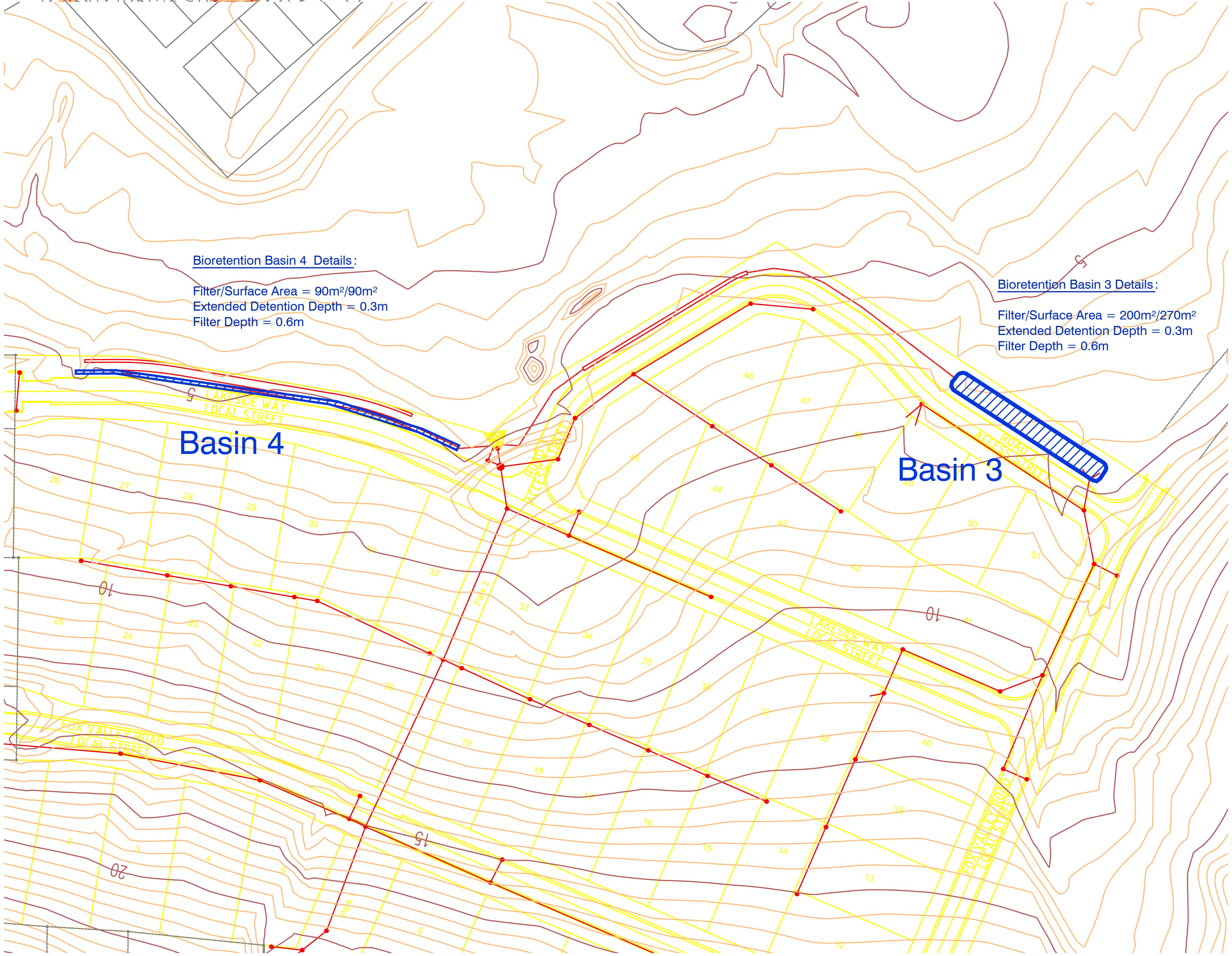
Pacific Pine Estate Balance boundary

SOURCES
Contours and proposed layout supplied by Kennedy Surveying and SMEC Urban



Notes
Filter conductivity to be measured in accordance with AS4419:2003.
Filter organic content to be measured in accordance with AS1289 4.1.1.

TYPICAL BIORETENTION BASIN FILTER ZONE DETAIL



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PROJECT
PACIFIC PINES ESTATE
LENNOX HEAD, NSW

CLIENT
LEND LEASE

DRAWING
BIORETENTION BASIN DETAILS

DATE 24/09/2012	**DRAWN** BWS
SCALE 1:1 250 & NTS	**CHECKED** CMA

PROJECT NO	**DRAWING NO**	**REVISION**
10734	11	B

4 Conclusions and recommendations

The site slope, terrain, soil and vegetation characteristics were used to help identify the location of groundwater seepage zones at the proposed Pacific Pines Estate development site. One seepage zone of 4.74 hectares was identified towards the south of the site, north of the stage 1a residential development and south of the stage 1b retirement community.

To maintain the natural hydrological regime of the freshwater wetland EEC it is recommended that runoff be captured from within the development, stored and treated in bio-retention basins. This water should then be discharged to the nominated target seepage area, via the infiltration trenches associated with the bio-retention systems.

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 volumes are in surplus of the estimated average yearly recharge requirement for the seepage zone and freshwater wetland (27.68ML/yr) thus ensuring that the water requirements of these areas can be met.

The bio-retention and infiltration system as described in Appendix 4 and detailed on SMEC Urban Consulting Drawings contained in Appendix 5 would provide an acceptable solution in that the stormwater inflow would be appropriately treated before it flows into the infiltration trenches. The infiltration trenches have been designed to exfiltrate the entire volume held in the basin within 24 hours.

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

5 Limitations of reporting

Gilbert & Sutherland Pty Ltd has made every effort to ensure that the information provided in this report is accurate. The interpretation of scientific data, however, involves professional judgement and as such is open to error.

In recognising the potential for errors in scientific interpretation, Gilbert & Sutherland Pty Ltd does not guarantee that the information is totally accurate or complete and clients are advised not to rely solely on this information when making commercial decisions. Any representation, statement, opinion or advice, expressed or implied is made in good faith and on the basis that the authors, Gilbert & Sutherland Pty Ltd, their agents or employees are not liable (whether by reason of lack of care or otherwise) to any person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any representation, statement or advice referred to above.

Furthermore, this information should not be relied upon by any persons other than the client for whom it has been compiled. This information reflects the specific brief and the budget of the client concerned, who enjoys an individual tolerance of risk.

6 Appendix 1 – Borelogs

Borehole: **BH1**

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557016
Depth (m):	0.60	**Northing:**	6812616
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Dark brown (7.5yr3/3), weak to moderate polyhedral (5-10mm) structure, earthy fabric, weak to firm consistence, common fine to medium roots, moist;
		CLAY LOAM, Dark brown (7.5yr3/4), moderate polyhedral (5-10mm) structure, rough ped fabric, weak to firm consistence, moist;
		CLAY LOAM, Very dark brown (7.5yr2.5/3), very few small pebbles, weak polyhedral (5-10mm) structure, earthy fabric, weak to firm consistence, common very fine to fine roots, moist;
.5		LIGHT CLAY, Dark reddish brown (5yr3/4), very few small pebbles, moderate subangular blocky (5-10mm) structure, rough ped fabric, weak to firm consistence, moist, borehole refusal at 2m below NSL (only 0.00-0.60m sample depth available).
1.0		
1.5		
2.0		
2.5		

Borehole: **BH2**

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557052
Depth (m):	1.20	**Northing:**	6812727
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

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Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
		CLAY LOAM, Very dark greyish brown (10yr3/2), common medium pebbles, weak to moderate polyhedral (5-10mm) structure, earthy fabric, weak consistence, few very fine to fine roots, moist;
.5		CLAY LOAM, Dark greyish brown (10yr4/2), common medium pebbles, weak polyhedral (5-10mm) structure, earthy fabric, weak consistence, very few very fine to fine roots, moist;
		CLAY LOAM, Dark brown (7.5yr3/4), watertable at 0.85m, moderate polyhedral (5-10mm) structure, rough ped fabric, weak consistence, moist;
1.0		LIGHT CLAY, Dark red (2.5yr3/6), few small pebbles, weak to moderate subangular blocky (5-10mm) structure, rough ped fabric, weak consistence, moist, borehole terminated at 1.20m.
1.5		
2.0		
2.5		

Borehole: **BH3**

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557052
Depth (m):	2.00	**Northing:**	6812770
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Dark greyish brown (10yr4/2), few small to medium pebbles, weak subangular blocky (2-5mm) structure, earthy fabric, weak consistence, many fine to medium roots, moist, gradual change to;
.5		LIGHT CLAY, Brown (10yr4/3), watertable at 0.56m, few small pebbles, weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence, few very fine roots, moist;
1.0		LIGHT CLAY, Dark greyish brown (2.5y4/2), few to common small to medium pebbles, weak subangular blocky (5-10mm) structure, rough ped fabric, weak to firm consistence, few fine roots, moist;
1.5		MEDIUM HEAVY CLAY, Light olive brown (2.5y5/6), common medium pebbles, massive, rough ped fabric, weak consistence, moist, borehole terminated at 2.00m.
2.0		
2.5		

Borehole: BH4

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557189
Depth (m):	1.50	**Northing:**	6812664
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
0.0–0.2		LOAM, Brown (10yr4/3), few small pebbles, weak polyhedral (2-5mm) structure, earthy fabric, firm consistence, common fine roots, moist;
0.2–0.6 (.5)		CLAY LOAM, Dark greyish brown (2.5y4/2), massive, rough ped fabric, weak consistence, few fine roots, moist;
0.6–1.2 (1.0)		LIGHT MEDIUM CLAY, Red (2.5yr5/8), weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence, moist;
1.2–1.5 (1.5)		LIGHT CLAY, Red (10r4/8), weak polyhedral (2-5mm) structure, rough ped fabric, weak consistence, moist, borehole terminated at 1.50m.
2.0		
2.5		

Borehole:	**BH5**		
Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557134
Depth (m):	2.00	**Northing:**	6813254
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

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Depth NSL(m)	Graphic log	**Drilling** Comments
0.0–0.3		CLAY LOAM, Brown (7.5yr4/4), massive, earthy fabric, weak consistence, common very fine to fine roots, moist;
0.3–2.0 (.5, 1.0, 1.5, 2.0)		LIGHT CLAY, Strong brown (7.5yr5/8), weak polyhedral (2-5mm) structure, rough ped fabric, weak consistence, moist, borehole terminated at 2.00.
2.5		

Borehole: **BH6**

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557113
Depth (m):	2.50	**Northing:**	6813165
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
0.0–0.2		LOAM, Dark yellowish brown (10yr3/4), massive, earthy fabric, very weak consistence, very fine to fine roots, moist;
0.2–0.8 (.5)		CLAY LOAM, Dark yellowish brown (10yr3/6), weak subangular blocky (2-5mm) structure, rough ped fabric, very weak consistence, moist.
0.8–1.2 (1.0)		SILTY LIGHT CLAY, Yellowish brown (10yr5/6), weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence, moist;
1.2–2.5 (1.5, 2.0, 2.5)		SILTY LIGHT CLAY, Red (2.5yr5/8), weak polyhedral (2-5mm) structure, rough ped fabric, weak consistence, moist, borehole terminated at 2.50m.

Borehole: BH7

Project:	10734	**Drill Method:**	Solid Flight Auger
Client:	Lend Lease	**Easting:**	557085
Depth (m):	2.50	**Northing:**	6813030
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	07.12.11		

Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
0.0–0.2		CLAY LOAM, Dark brown (10yr3/3), trace of coarse sand (KS), massive, earthy fabric, weak consistence, few fine and medium roots, moist;
0.2–1.0 (.5)		CLAY LOAM, Dark yellowish brown (10yr4/4), watertable at 0.90m, few small pebbles, massive, rough ped fabric, weak consistence, moist;
1.0–1.3		CLAY LOAM, Dark olive grey (5y3/2), common small pebbles, weak subangular blocky (5-10mm) structure, rough ped fabric, weak consistence, moist;
1.3–1.6 (1.5)		HEAVY CLAY, Dark bluish grey (10B4/1), massive, smooth ped fabric, firm consistence, moist;
1.6–2.0		SILTY MEDIUM CLAY, Dark bluish grey (10B4/1), common small pebbles, weak subangular blocky (5-10mm) structure, rough ped fabric, weak to firm consistence, moist;
2.0–2.5		SILTY LIGHT CLAY, Greenish grey (5BG5/1), common small to medium pebbles, weak subangular blocky (5-10mm) structure, rough ped fabric, weak to firm consistence, moist, borehole terminated at 2.50m.

Borehole: Obs2

Project:	10734
Client:	Lend Lease
Depth (m):	1.50
Logged by:	DJY
Drilled by:	G&S
Drill date:	07.12.11
Drill Method:	Solid Flight Auger
Easting:	557047
Northing:	6812621

Drilling

Depth NSL(m)	Comments
	LOAM, Dark brown (7.5yr3/4), few small pebbles, massive, earthy fabric, weak consistence, many fine to medium roots, moist, sample taken from an open cut;
	CLAY LOAM, Strong brown (7.5yr5/8), very few small to large pebbles, massive, rough ped fabric, weak consistence, moist;
.5	CLAY LOAM, Dark brown (7.5yr3/3), very few cobbles to large pebbles, weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence, moist, sample taken from an open cut;
1.0	CLAY LOAM, Red (2.5yr5/8), very few medium pebbles, weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence,moist, sample taken from an open cut, observation terminated at 1.50m.
1.5	
2.0	
2.5	

Borehole: **BH8**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557093
Depth (m):	0.60	**Northing:**	6813019
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Olive grey (5y4/2), very few small pebbles, moderate sunangular blocky (2-5mm) structure, earthy fabric, weak consistence, common very fine and fine roots, moist;
		CLAY LOAM, Dark grey (10yr4/1), watertable at 0.22m, moderate subangular blocky (2-5mm) structure, earthy fabric, weak consistence, moist;
.5		LIGHT CLAY, Dark grey (5y4/1), strong subangular blocky (5-10mm) structure, rough ped fabric, very weak consistence, moist, borehole terminated at 0.50m.
1.0		
1.5		
2.0		
2.5		

Borehole: BH9

Project:	10734	**Drill Method:**	Hand Auger (Ḋ8cm)
Client:	Lend Lease	**Easting:**	557153
Depth (m):	1.00	**Northing:**	6812971
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
0.0–0.25		LIGHT CLAY, Black (5y2.5/1), massive, earthy fabric, weak consistence, many fine to medium roots, moist;
.5		MEDIUM HEAVY CLAY, Bluish grey (5PB5/1), watertable at 0.58m, massive, earthy fabric, weak consistence;
		HEAVY CLAY, Bluish grey (5PB5/1), massive, weak consistence;
1.0		HEAVY CLAY, Dark bluish grey (5PB4/1), massive, weak consistence, borehole terminated at 1.00m.
1.5		
2.0		
2.5		

Borehole: **BH10**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557109
Depth (m):	1.00	**Northing:**	6812983
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
0.0–0.2		LIGHT MEDIUM CLAY, Black (10yr2/1), strong subangular blocky (2-5mm) structure, earthy fabric, firm consistence, common fine to medium roots, moist;
0.2–0.5		MEDIUM HEAVY CLAY, Dark bluish grey (10B4/1), watertable at 0.33m, massive, firm consistence, few fine roots, moist;
.5–1.0		MEDIUM CLAY, Bluish grey (5PB5/1), massive, firm consistence, borehole terminated at 1.00m.
1.5		
2.0		
2.5		

Borehole: **BH11**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557045
Depth (m):	1.00	**Northing:**	6812965
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
		LIGHT CLAY, Dark grey (10yr4/1), very weak subangular blocky (2-5mm) structure, rough ped fabric, weak consistence, few fine roots, moist;
.5		MEDIUM CLAY, Bluish grey (5PB6/1), watertable at 0.32m, weak polyhedral (5-10mm) structure, rough ped fabric, weak consistence, very few fine roots, moist;
		MEDIUM HEAVY CLAY, Very dark bluish grey (5PB3/1), massive, weak consistence, moist;
1.0		MEDIUM HEAVY CLAY, Bluish black (5PB2.5/1), massive, firm consistence, moist, borehole terminated at 1.00m.
1.5		
2.0		
2.5		

Borehole: **BH12**

Project:	10734	**Drill Method:**	Hand Auger (D8cm)
Client:	Lend Lease	**Easting:**	556993
Depth (m):	1.00	**Northing:**	6812914
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Dark grey (10yr4/1), massive, earthy fabric, weak consistence, many fine to medium roots, moist;
		MEDIUM HEAVY CLAY, Dark greyish brown (10yr4/2), watertable at 0.18m, moderate subangular blocky (10-20mm) structure, rough ped fabric, firm consistence, very few fine roots, moist;
.5		LIGHT CLAY, Dark bluish grey (5PB4/1), massive, earthy fabric, weak consistence, moist;
		LIGHT CLAY, Bluish grey (5PB6/1), massive, firm consistence, moist, borehole terminated at 1.00m.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH13**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557028
Depth (m):	0.80	**Northing:**	6813065
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
		CLAY LOAM, Strong brown (7.5yr5/8), massive, earthy fabric, very weak consistence, many fine to medium roots, moist;
.5		CLAY LOAM, Reddish yellow (7.5yr6/8), moderate angular blocky (5-10mm) structure, rough ped fabric, weak consistence, very few fine roots, moist, borehole terminated at 0.80m.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH14**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ8cm)
Client:	Lend Lease	**Easting:**	557033
Depth (m):	1.00	**Northing:**	6812832
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

GILBERT SUTHERLAND

Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Dark grey (2.5y4/1), few large pebbles and small cobbles, moderate subangular blocky (2-5mm) structure, earthy fabric, weak consistence, common fine to medium roots, moist;
.5		HEAVY CLAY, Black (5y2.5/2), watertable at 0.35m, too disturbed to establish ped structure, weak consistence, moist;
		MEDIUM HEAVY CLAY, Dark bluish grey (5PB4/1), massive, weak consistence, moist;
		MEDIUM HEAVY CLAY, Dark bluish grey (5PB4/1), massive, weak consistence, moist, borehole terminated at 1.00m.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH15**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557254
Depth (m):	0.70	**Northing:**	6812979
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
		LIGHT CLAY, Dark yellowish brown (10yr4/4), moderate subangular blocky (2-5mm) structure, earthy fabric, weak consistence, many fine to few medium roots, moist;
.5		HEAVY CLAY, Yellowish brown (10yr5/4), watertable at 0.4m, few small pebbles, moderate polyhedral (2-5mm) structure, earthy fabric, weak consistence, saturated, borehole terminated at 0.70m.
1.0		
1.5		
2.0		
2.5		

Borehole: BH16

Project:	10734	**Drill Method:**	Hand Auger (Ḋ8cm)
Client:	Lend Lease	**Easting:**	557080
Depth (m):	1.00	**Northing:**	6812896
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Depth NSL(m)	Graphic log	Drilling — Comments
		LIGHT CLAY, Very dark greyish brown (2.5y3/2), weak polyhedral (5-10mm) structure, earthy fabric, weak consistence, common fine roots, moist;
.5		MEDIUM CLAY, Very dark bluish grey (5PB3/1), watertable at 0.2m, massive, firm consistence, few fine roots, moist;
1.0		HEAVY CLAY, Bluish grey (10B6/1), massive, weak consistence, moist, borehole terminated at 1.00m.
1.5		
2.0		
2.5		

Borehole: **BH17**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	556965
Depth (m):	1.00	**Northing:**	6812841
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Depth NSL(m)	Graphic log	Drilling: Comments
		HEAVY CLAY, Black (5y2.5/1), too disturbed to establish ped structure, earthy fabric, firm consistence, few fine to medium roots, moist;
		HEAVY CLAY, Bluish grey (10B5/1), massive, firm consistence, moist;
.5		HEAVY CLAY, Dark bluish grey (5PB4/1), massive, firm consistence, moist;
		HEAVY CLAY, Bluish grey (10B5/1), massive, firm consistence, moist;
		HEAVY CLAY, Bluish grey (10B6/1), massive, firm consistence, moist, borehole terminated at 1.00m.
1.0		
1.5		
2.0		
2.5		

Borehole: BH18

Project:	10734	**Drill Method:**	Hand Auger (Ḋ8cm)
Client:	Lend Lease	**Easting:**	557179
Depth (m):	1.00	**Northing:**	6812888
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
0.0–0.25		CLAY LOAM, Grey (10yr5/1), strong polyhedral (2-5mm) structure, earthy fabric, weak consistence, common fine roots, moist;
0.25–1.0		LIGHT CLAY, Dark bluish grey (10B4/1), watertable at 0.25m, moderate subangular blocky (2-5mm) structure, earthy fabric, firm consistence, very few fine roots, moist, borehole terminated at 1.00m.

Depth scale: .5, 1.0, 1.5, 2.0, 2.5

Borehole: BH19

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557288
Depth (m):	0.60	**Northing:**	6812946
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
		CLAY LOAM, Dark grey (5y4/1), very few small pebbles, moderate subangular blocky (2-5mm) structure, earthy fabric, weak consistence, common fine roots, moist;
.5		CLAY LOAM, Olive (5y4/4), watertable at 0.4m, many small pebbles to small cobbles, massive, weak consistence, few fine roots, saturated, borehole terminated at 0.60m due to collapse.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH20**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557346
Depth (m):	0.80	**Northing:**	6812800
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

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Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
0.0–0.35		CLAY LOAM, Yellowish brown (10yr5/4), few small pebbles, moderate subangular blocky (2-5mm) structure, earthy fabric, weak consistence, common fine roots, moist;
.5 (0.35–0.80)		SILTY CLAY LOAM, Yellowish brown (10yr5/6), very few small pebbles, weak polyhedral (5-10mm) structure, earthy fabric, weak consistence, moist, borehole terminated at 0.80m.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH21**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557359
Depth (m):	0.60	**Northing:**	6813123
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Drilling

Depth NSL(m)	Graphic log	Comments
0.0–0.2		LIGHT CLAY, Yellowish brown (10yr5/4), moderate polyhedral (2-5mm) structure, earthy fabric, weak consistence, common fine roots, moist;
0.2–0.6 (.5)		LIGHT MEDIUM CLAY, Yellowish brown (10yr5/6), few charcoal fragments and grey to white rounded (5-25mm) concretions increasing with depth, moderate subangular blocky (2-5mm) structure, earthy fabric, firm consistence, very few fine roots, moist, borehole terminated at 0.60m.
1.0		
1.5		
2.0		
2.5		

Borehole: **BH22**

Project:	10734	**Drill Method:**	Hand Auger (Ḋ10cm)
Client:	Lend Lease	**Easting:**	557304
Depth (m):	0.30	**Northing:**	6812811
Logged by:	DJY		
Drilled by:	G&S		
Drill date:	13.12.11		

Depth NSL(m)	Drilling: Graphic log	Drilling: Comments
		SILTY CLAY LOAM, Black (5y2.5/1), very few small pebbles, weak to moderate subangular blocky (5-10mm) structure, rough ped fabric, weak consistence, few fine roots, moist;
		MEDIUM CLAY, Olive (5y4/3), few small to medium pebbles, moderate subangular blocky (2-5mm) structure, rough ped fabric, firm consistence, few fine roots, moist, borehole terminated at 0.30m.
.5		
1.0		
1.5		
2.0		
2.5		

7 Appendix 2 – Permeability test results

Permeability Results

Constant head permeameter

Project 10734 **Location** BH5 (WP72)

Site description Stormwater Advice, Lennox Head, NSW

Tested by DJY **Date** 30-Nov-11

Test hole geometry

	Test 1	Test 2
Hole depth (m)	2	
Depth (m) of water in hole	1.7	
Hole diameter (mm)	90	
Depth (m) to imperm. layer		

	Test 1	Test 2
Source of test water	tap	
Est. salinity (mg/L) of test water		
Est. SAR of test water		

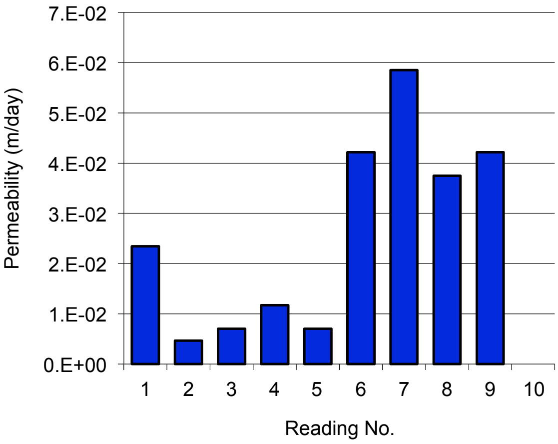
TEST 1

Depth interval (m) tested 0.3 to 2

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.10	2.00	5.0E-02	2.3E-02
2	0.02	2.00	1.0E-02	4.7E-03
3	0.03	2.00	1.5E-02	7.0E-03
4	0.05	2.00	2.5E-02	1.2E-02
5	0.03	2.00	1.5E-02	7.0E-03
6	0.18	2.00	9.0E-02	4.2E-02
7	0.25	2.00	1.3E-01	5.9E-02
8	0.16	2.00	8.0E-02	3.7E-02
9	0.18	2.00	9.0E-02	4.2E-02
			Average:	2.6E-02



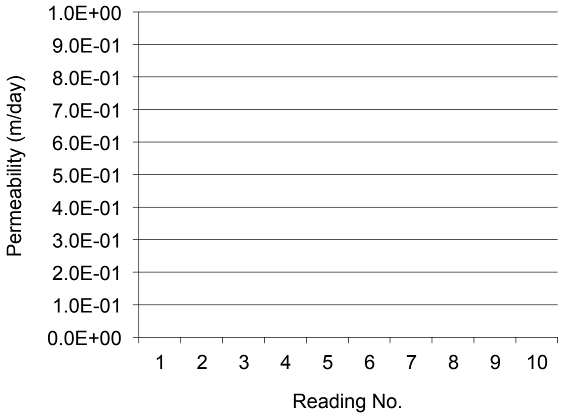
TEST 2

Depth interval (m) tested to

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
			Average:	



Note: Permeability $K = 4.4Q\{\sinh^{-1}(H/2r)-[(r/H)^2+0.25]^{0.5}+(r/H)\}/2piH^2$ where Q = infiltration rate, H = depth of water in test hole, r = hole radius and pi = 3.1416. H should be in the range 5r to 10r. See Australian/New Zealand Standard 1547: 2000 *On-site domestic-wastewater management.* Appendix 4.1F.

If an impermeable layer is at depth S no more than 2H below the base of the test hole, use K = 3Qln[H/r]/piH(2H+3S).

See Talsma, T. and Hallam, P. (1980): Hydraulic Conductivity Measurement of Forest Catchments. *Australian Journal of Soil Research* 30, pp 139-148.

Permeability Results

Constant head permeameter

Project 10734 **Location** BH7 (WP74)

Site description Stormwater Advice, Lennox Head, NSW

Tested by DJY **Date** 30-Nov-11

Test hole geometry

	Test 1	Test 2
Hole depth (m)	1.05	
Depth (m) of water in hole	1	
Hole diameter (mm)	100	
Depth (m) to imperm. layer		

	Test 1	Test 2
Source of test water	tap	
Est. salinity (mg/L) of test water		
Est. SAR of test water		

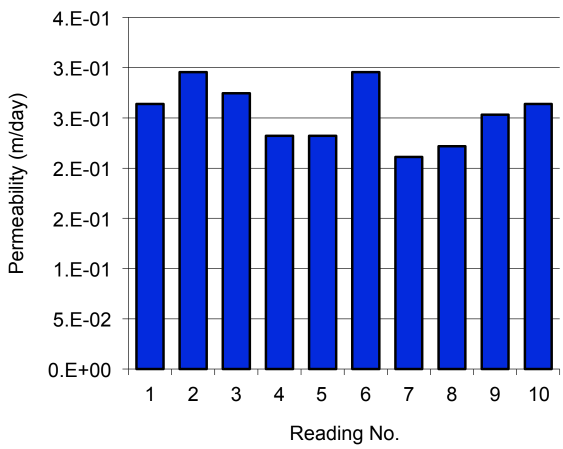
TEST 1

Depth interval (m) tested 0.05 to 1.05

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.25	1.00	2.5E-01	2.6E-01
2	0.28	1.00	2.8E-01	3.0E-01
3	0.26	1.00	2.6E-01	2.7E-01
4	0.22	1.00	2.2E-01	2.3E-01
5	0.22	1.00	2.2E-01	2.3E-01
6	0.28	1.00	2.8E-01	3.0E-01
7	0.20	1.00	2.0E-01	2.1E-01
8	0.21	1.00	2.1E-01	2.2E-01
9	0.24	1.00	2.4E-01	2.5E-01
10	0.25	1.00	2.5E-01	2.6E-01
			Average:	2.5E-01



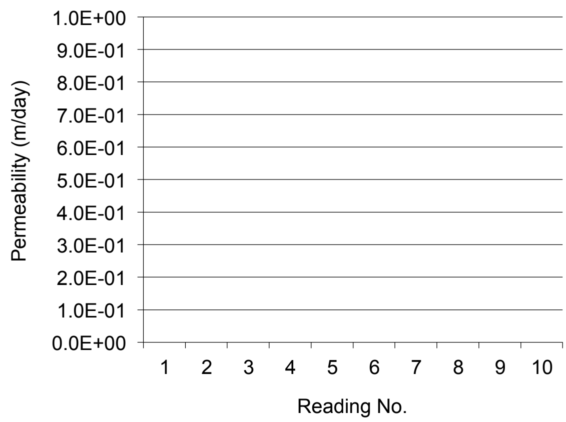
TEST 2

Depth interval (m) tested to

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
			Average:	



Note: Permeability $K = 4.4Q\{\sinh^{-1}(H/2r)-[(r/H)^2+0.25]^{0.5}+(r/H)\}/2piH^2$ where Q = infiltration rate, H = depth of water in test hole, r = hole radius and pi = 3.1416. H should be in the range 5r to 10r. See Australian/New Zealand Standard 1547: 2000 *On-site domestic-wastewater management.* Appendix 4.1F.

If an impermeable layer is at depth S no more than 2H below the base of the test hole, use K = 3Qln[H/r]/piH(2H+3S).

See Talsma, T. and Hallam, P. (1980): Hydraulic Conductivity Measurement of Forest Catchments. *Australian Journal of Soil Research* 30, pp 139-148.

Permeability Results

Constant head permeameter

Project 10734 **Location** BH13

Site description Stormwater Advice, Lennox Head, NSW

Tested by DJY **Date** 14-Dec-11

Test hole geometry

	Test 1	Test 2
Hole depth (m)	0.8	0.8
Depth (m) of water in hole	0.72	0.72
Hole diameter (mm)	115	115
Depth (m) to imperm. layer		

	Test 1	Test 2
Source of test water	tap	tap
Est. salinity (mg/L) of test water		
Est. SAR of test water		

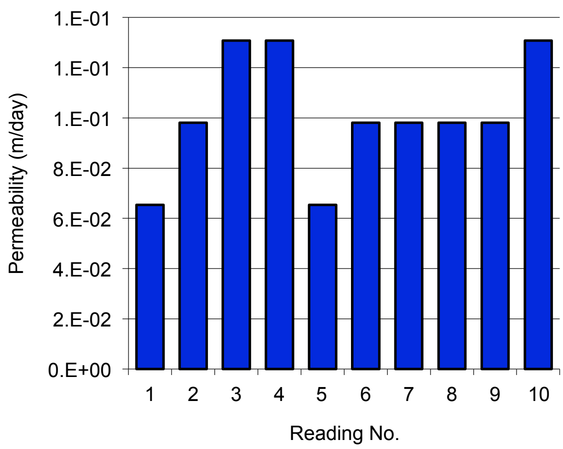
TEST 1

Depth interval (m) tested 0.08 to 0.8

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.02	0.50	4.0E-02	6.5E-02
2	0.03	0.50	6.0E-02	9.8E-02
3	0.04	0.50	8.0E-02	1.3E-01
4	0.04	0.50	8.0E-02	1.3E-01
5	0.02	0.50	4.0E-02	6.5E-02
6	0.03	0.50	6.0E-02	9.8E-02
7	0.03	0.50	6.0E-02	9.8E-02
8	0.03	0.50	6.0E-02	9.8E-02
9	0.03	0.50	6.0E-02	9.8E-02
10	0.04	0.50	8.0E-02	1.3E-01
			Average:	1.0E-01



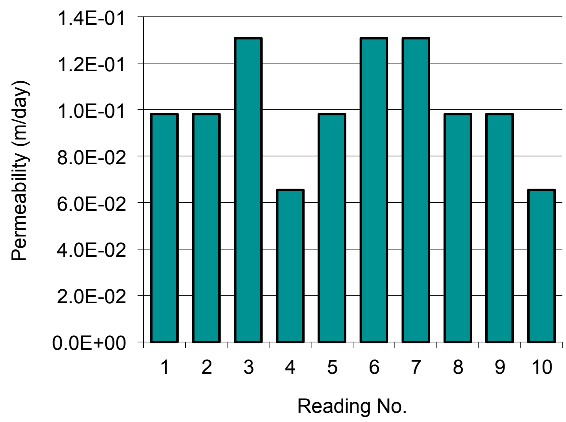
TEST 2

Depth interval (m) tested 0.08 to 0.8

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.03	0.50	6.0E-02	9.8E-02
2	0.03	0.50	6.0E-02	9.8E-02
3	0.04	0.50	8.0E-02	1.3E-01
4	0.02	0.50	4.0E-02	6.5E-02
5	0.03	0.50	6.0E-02	9.8E-02
6	0.04	0.50	8.0E-02	1.3E-01
7	0.04	0.50	8.0E-02	1.3E-01
8	0.03	0.50	6.0E-02	9.8E-02
9	0.03	0.50	6.0E-02	9.8E-02
10	0.02	0.50	4.0E-02	6.5E-02
			Average:	1.0E-01



Note: Permeability $K = 4.4Q\{\sinh^{-1}(H/2r)-[(r/H)^2+0.25]^{0.5}+(r/H)\}/2piH^2$ where Q = infiltration rate, H = depth of water in test hole, r = hole radius and pi = 3.1416. H should be in the range 5r to 10r. See Australian/New Zealand Standard 1547: 2000 *On-site domestic-wastewater management.* Appendix 4.1F.

If an impermeable layer is at depth S no more than 2H below the base of the test hole, use K = 3Qln[H/r]/piH(2H+3S).

See Talsma, T. and Hallam, P. (1980): Hydraulic Conductivity Measurement of Forest Catchments. *Australian Journal of Soil Research* 30, pp 139-148.

Permeability Results

Constant head permeameter

Project 10734 **Location** BH20

Site description Stormwater Advice, Lennox Head, NSW

Tested by DJY **Date** 14-Dec-11

Test hole geometry

	Test 1	Test 2
Hole depth (m)	0.8	0.8
Depth (m) of water in hole	0.72	0.72
Hole diameter (mm)	115	115
Depth (m) to imperm. layer		

	Test 1	Test 2
Source of test water	tap	tap
Est. salinity (mg/L) of test water		
Est. SAR of test water		

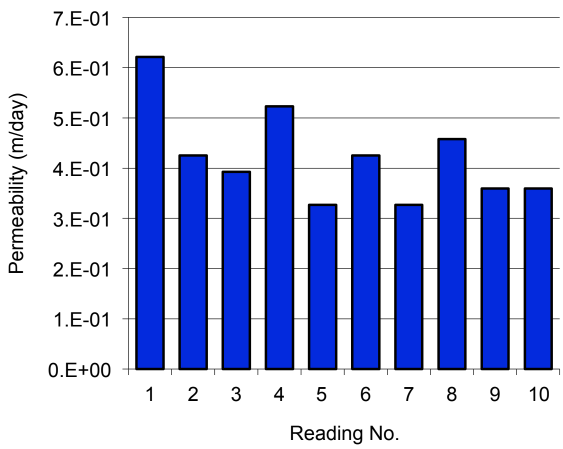
TEST 1

Depth interval (m) tested 0.08 to 0.8

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.19	0.50	3.8E-01	6.2E-01
2	0.13	0.50	2.6E-01	4.3E-01
3	0.12	0.50	2.4E-01	3.9E-01
4	0.16	0.50	3.2E-01	5.2E-01
5	0.10	0.50	2.0E-01	3.3E-01
6	0.13	0.50	2.6E-01	4.3E-01
7	0.10	0.50	2.0E-01	3.3E-01
8	0.14	0.50	2.8E-01	4.6E-01
9	0.11	0.50	2.2E-01	3.6E-01
10	0.11	0.50	2.2E-01	3.6E-01
			Average:	4.2E-01



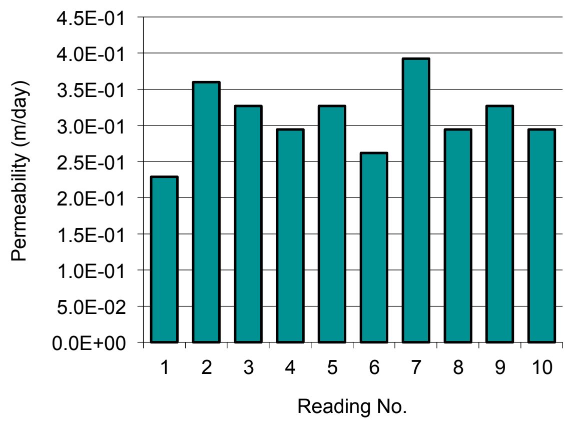
TEST 2

Depth interval (m) tested 0.08 to 0.8

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.07	0.50	1.4E-01	2.3E-01
2	0.11	0.50	2.2E-01	3.6E-01
3	0.10	0.50	2.0E-01	3.3E-01
4	0.09	0.50	1.8E-01	2.9E-01
5	0.10	0.50	2.0E-01	3.3E-01
6	0.08	0.50	1.6E-01	2.6E-01
7	0.12	0.50	2.4E-01	3.9E-01
8	0.09	0.50	1.8E-01	2.9E-01
9	0.10	0.50	2.0E-01	3.3E-01
10	0.09	0.50	1.8E-01	2.9E-01
			Average:	3.1E-01



Note: Permeability $K = 4.4Q\{\sinh^{-1}(H/2r)-[(r/H)^2+0.25]^{0.5}+(r/H)\}/2piH^2$ where Q = infiltration rate, H = depth of water in test hole, r = hole radius and pi = 3.1416. H should be in the range 5r to 10r. See Australian/New Zealand Standard 1547: 2000 *On-site domestic-wastewater management.* Appendix 4.1F.

If an impermeable layer is at depth S no more than 2H below the base of the test hole, use K = 3Qln[H/r]/piH(2H+3S).

See Talsma, T. and Hallam, P. (1980): Hydraulic Conductivity Measurement of Forest Catchments. *Australian Journal of Soil Research* 30, pp 139-148.

Permeability Results

Constant head permeameter

Project 10734 **Location** BH21

Site description Stormwater Advice, Lennox Head, NSW

Tested by DJY **Date** 14-Dec-11

Test hole geometry

	Test 1	Test 2
Hole depth (m)	0.6	0.6
Depth (m) of water in hole	0.52	0.52
Hole diameter (mm)	115	115
Depth (m) to imperm. layer		

	Test 1	Test 2
Source of test water	tap	tap
Est. salinity (mg/L) of test water		
Est. SAR of test water		

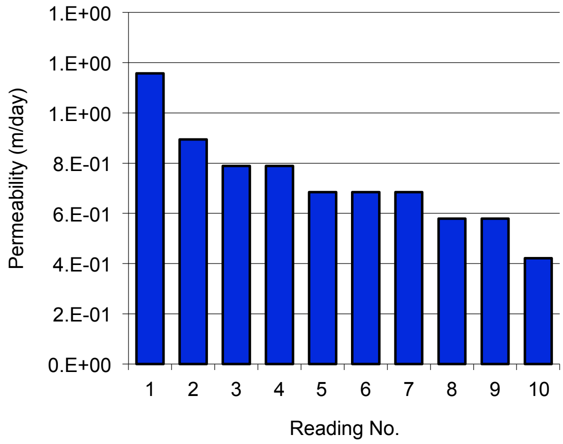
TEST 1

Depth interval (m) tested 0.08 to 0.6

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.22	0.50	4.4E-01	1.2E+00
2	0.17	0.50	3.4E-01	8.9E-01
3	0.15	0.50	3.0E-01	7.9E-01
4	0.15	0.50	3.0E-01	7.9E-01
5	0.13	0.50	2.6E-01	6.8E-01
6	0.13	0.50	2.6E-01	6.8E-01
7	0.13	0.50	2.6E-01	6.8E-01
8	0.11	0.50	2.2E-01	5.8E-01
9	0.11	0.50	2.2E-01	5.8E-01
10	0.08	0.50	1.6E-01	4.2E-01
			Average:	7.3E-01



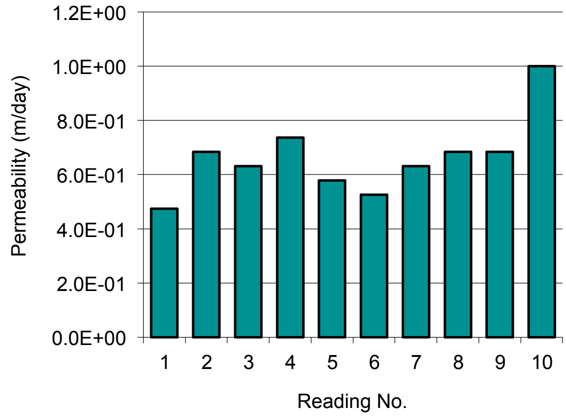
TEST 2

Depth interval (m) tested 0.08 to 0.6

Test duration (mins)

Soil type tested

Reading No.	Water infiltrated (L)	Time to infiltrate (min)	Infiltrat. rate (L/min)	Perme-ability (m/day)
1	0.09	0.50	1.8E-01	4.7E-01
2	0.13	0.50	2.6E-01	6.8E-01
3	0.12	0.50	2.4E-01	6.3E-01
4	0.14	0.50	2.8E-01	7.4E-01
5	0.11	0.50	2.2E-01	5.8E-01
6	0.10	0.50	2.0E-01	5.3E-01
7	0.12	0.50	2.4E-01	6.3E-01
8	0.13	0.50	2.6E-01	6.8E-01
9	0.13	0.50	2.6E-01	6.8E-01
10	0.19	0.50	3.8E-01	1.0E+00
			Average:	6.6E-01



Note: Permeability $K = 4.4Q\{\sinh^{-1}(H/2r)-[(r/H)^2+0.25]^{0.5}+(r/H)\}/2piH^2$ where Q = infiltration rate, H = depth of water in test hole, r = hole radius and pi = 3.1416. H should be in the range 5r to 10r. See Australian/New Zealand Standard 1547: 2000 *On-site domestic-wastewater management.* Appendix 4.1F.

If an impermeable layer is at depth S no more than 2H below the base of the test hole, use $K = 3Q\ln[H/r]/piH(2H+3S)$.

See Talsma, T. and Hallam, P. (1980): Hydraulic Conductivity Measurement of Forest Catchments. *Australian Journal of Soil Research* 30, pp 139-148.

8 Appendix 3 – MEDLI modelling results

****
SUMMARY OUTPUT
MEDLI Version 1.30

Data Set: 10734_Lennox zero irrigation
Run Date: 06/03/12 Time:14:08:27.47
****

GENERAL INFORMATION
****
Title: Pacific Pines, Lennox Head
Subject: Water balance assessment
Client: Lendlease
User: Nick Gifford
Time: Tue Mar 06 14:05:11 2012
Comments: [no entry]

RUN PERIOD
****

Starting Date 1/ 1/1893
Ending Date 31/12/1995
Run Length 103 years 0 days

CLIMATE INFORMATION
****

Enterprise site: Lennox Head -28.8 deg S 153.6 deg E
Weather station: Ballina

ANNUAL TOTALS	10 Percentile	50 percentile	90 Percentile
Rainfall mm/year	1228.	1704.	2433.
Pan Evap mm/year	1540.	1603.	1688.

MONTHLY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	181	200	215	181	197	165	134	100	72	92	103	142	1782
Pan Evap (mm)	186	146	139	115	84	75	88	112	139	163	170	194	1610
Ave Max Temp DegC	27	28	26	24	22	20	19	20	22	23	25	26	23
Ave Min Temp DegC	21	21	20	17	15	13	12	12	14	16	18	20	16
Rad (MJ/m2/day)	24	20	17	13	11	10	11	15	19	21	23	24	17

MONTHLY IRRIGATION
****

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Irrigation (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0

SOIL PROPERTIES
****

Soil type: Grey Clay

SOIL WATER PROPERTIES

		Layer 1	Layer 2	Layer 3	Layer 4
Bulk Density	(g/cm3)	1.4	1.4	1.4	1.4
Porosity	(mm/layer)	47.5	245.3	287.5	146.0
Saturated Water Content	(mm/layer)	47.0	243.0	284.4	144.6
Drained Upper Limit	(mm/layer)	42.0	218.0	254.4	128.1
Lower Storage Limit	(mm/layer)	26.7	137.5	184.2	98.4
Air Dry Moisture Content	(mm/layer)	4.2			
Layer Thickness	(mm)	100.0	500.0	600.0	300.0

		Profile	Max Rootzone
Total Saturated Water Content	(mm)	719.0	290.0
Total Drained Upper Limit	(mm)	642.5	260.0
Total Lower Storage Limit	(mm)	446.8	164.2
Total Air Dry Moisture Content	(mm)	5.6	4.7
Total Depth	(mm)	1500.0	600.0

Maximum Plant Available Water Capacity		95.8
Saturated Hydraulic Conductivity		
At Surface	(mm/hr)	10.0
Limiting	(mm/hr)	0.1

RUNOFF

Runoff curve No II 75.0

SOIL EVAPORATION

CONA	(mm/day^0.5)	3.5
URITCH	(mm)	6.0

AVERAGE WASTE STREAM
****

Other waste stream
(All values relate to influent after any screening and recycling, if applicable).

Inflow Volume	(ML/year)	36.52
Nitrogen	(tonne/year)	0.00
Phosphorus	(tonne/year)	0.00
Salinity	(tonne/year)	0.00

Nitrogen Concentration	(mg/L)	0.00
Phosphorus Concentration	(mg/L)	0.00
Salinity	(mg/L)	0.00
Salinity	(dS/m)	0.00

WASTE STREAM DETAILS (for last inflow event):

Nitrogen Concentration	(mg/L)	0.00

Phosphorus Concentration	(mg/L)	0.00
TDS Concentration	(mg/L)	0.00
Salinity	(dS/m)	0.00

IRRIGATION WATER
****

Irrigation triggered every 1 days
Irrigating 0 % of amount to reach upper storage limit

AREA

Total Irrigation Area	(ha)	1.00

VOLUMES

Total Irrigation	(ML/year)	0.00
Minimum Volume Irrigated by Pump	(ML/ha/day)	0.00
Maximum Volume Irrigated by Pump	(ML/ha/day)	0.00
Maximum Vol. Available For Shandying	(ML/yr)	0.00

IRRIGATION CONCENTRATIONS

Average salinity of Irrigation	(dS/m)	0.00
Average salinity of Irrigation	(mg/L)	0.00
Average Nitrogen Conc of Irrigation		
Before ammonia loss	(mg/L)	0.00
After ammonia loss	(mg/L)	0.00
Average Phosphorus Conc of Irrigation	(mg/L)	0.00

FRESH WATER USAGE
****

Irrigation (shandying) water	(ML/yr)	0.00
Avg volume of fresh water used	(ML/yr)	0.00
Annual allocation	(ML/yr)	N/A

POND INFORMATION
****

POND GEOMETRY

		Pond 1
Final pond volume	(ML)	1.00
Final liquid volume	(ML)	1.00
Final sludge volume	(ML)	0.00
Average pond volume	(ML)	1.00
Average active volume	(ML)	1.00
Maximum pond volume	(ML)	1.00
Minimum allowable pond volume	(ML)	0.06
Average pond depth	(m)	4.00
Pond depth at outlet	(m)	4.00
Maximum water surface area	(m2 x1000)	0.39
Pond catchment area	(m2 x1000)	0.47

Pond footprint length	(m)	21.64
Pond footprint width	(m)	21.64

POND WATER BALANCE

Inflow of Effluent to pond system	(ML/yr)	36.52
Recycle Volume from pond system	(ML/yr)	0.00
Rain water added to pond system	(ML/yr)	0.83
Evaporation loss from pond system	(ML/yr)	0.43
Seepage loss from pond system	(ML/yr)	0.01
Irrigation from last pond	(ML/yr)	0.00
Volume of overtopping	(ML/yr)	36.90
Sludge accumulated	(ML/yr)	0.00
Sludge accumulated	(t DM/yr)	0.00
Sludge removed	(ML/yr)	0.00
No of desludging events every 10 years		0.00
Increase in pond water volume	(ML/yr)	0.01

OVERTOPPING EVENTS

Volume of overtopping	(ML/yr)	36.90
No. of days pond overtops per 10 years		3651.53
Average Length of overtopping events	(days)	37609.00
% Reuse		0.00

No. of overtopping events every 10 years

> 0.000 ML	0.10
> 0.000 ML*	0.00
> 1.000 ML	0.00
> 2.000 ML	0.00
> 5.000 ML	0.00
> 10.000 ML	0.00
> 20.000 ML	0.00
> 50.000 ML	0.00

* Volume equivalent to 1 mm depth of water

No. periods/year without irrigable effluent		0.00
Average Length of such periods	(days)	0.00

POND NITROGEN BALANCE

Nitrogen Added by Effluent	(tonne/yr)	0.00	Irrig. from pond (ML/yr) 0.0
Nitrogen removed by Irrigation	(tonne/yr)	0.00	
Nitrogen removed by Volatilisation	(tonne/yr)	0.00	
Nitrogen removed by Seepage	(tonne/yr)	0.00	
Nitrogen accumulated in Sludge	(tonne/yr)	0.00	
Nitrogen lost by Overtopping	(tonne/yr)	0.00	
Nitrogen involved in Recycling	(tonne/yr)	0.00	
Increase in pond Nitrogen	(tonne/yr)	0.00	

POND PHOSPHORUS BALANCE

Phosphorus Added by Effluent	(tonne/yr)	0.00	Irrig. from pond (ML/yr) 0.0
Phosphorus removed by Irrigation	(tonne/yr)	0.00	
Phosphorus removed by Seepage	(tonne/yr)	0.00	
Phosphorus accumulated in Sludge	(tonne/yr)	0.00	
Phosphorus lost by Overtopping	(tonne/yr)	0.00	
Phosphorus involved in Recycling	(tonne/yr)	0.00	
Increase in pond Phosphorus	(tonne/yr)	0.00	

POND SALINITY BALANCE

Salinity Added by Effluent	(tonne/yr)	0.00

```
Salinity removed by Irrigation    (tonne/yr)    0.00
Salinity removed by Seepage       (tonne/yr)    0.00
Salinity lost by Overtopping      (tonne/yr)    0.00
Salinity involved in Recycling    (tonne/yr)    0.00
Increase in pond Salinity         (tonne/yr)    0.00
```

POND CONCENTRATIONS

```
                                              Pond 1

Average Nitrogen Conc of Pond Liquid  (mg/L)    0.0
Average Phosphorus Conc of Pond Liquid(mg/L)    0.0
Average TDS Conc of Pond Liquid       (mg/L)    0.0
Average Salinity of Pond Liquid       (dS/m)    0.0
Average Potassium Conc of Pond Liquid (mg/L)    0.0

(On final day of simulation)
Nitrogen Conc of Pond Liquid          (mg/L)    0.0
Phosphorus Conc of Pond Liquid        (mg/L)    0.0
TDS Conc of Pond Liquid               (mg/L)    0.0
EC of Pond Liquid                     (dS/m)    0.0
Potassium Conc of Pond Liquid         (mg/L)    0.0
```

REMOVED SLUDGE - NUTRIENT & SALT CONCENTRATIONS

```
Nitrogen in removed Sludge (db)   (kg/tonne)    0.00
Phosphorus in removed Sludge (db) (kg/tonne)    0.00
Salt in removed Sludge (db)       (kg/tonne)    0.00
Potassium in removed Sludge (db)  (kg/tonne)    0.00
```

REMOVED SLUDGE - NUTRIENT & SALT MASSES

```
Nitrogen in removed Sludge        (tonne/yr)    0.00
Phosphorus in removed Sludge      (tonne/yr)    0.00
Salt in removed Sludge (mass bal.)(tonne/yr)    0.00
Salt in removed Sludge            (tonne/yr)    0.00
Potm. in removed Sludge (mass bal.)(tonne/yr    0.00
Potassium in removed Sludge       (tonne/yr)    0.00
```

LAND DISPOSAL AREA
****

WATER BALANCE

```
(Initial soil water assumed to be at field capacity)
(Irrigated up to    0.00% of field capacity)
Rainfall                         (mm/year)   1782.2   Irrigation Area     (ha)
1.0
Irrigation                       (mm/year)      0.0
Soil Evaporation                 (mm/year)    363.9
Transpiration                    (mm/year)    581.9
Runoff                           (mm/year)    571.1
Drainage                         (mm/year)    265.2
Change in soil moisture          (mm/year)      0.1
```

ANNUAL TOTALS

Year	Rain (mm)	Irrig (mm)	Sevap (mm)	Trans (mm)	Runoff (mm)	Drain (mm)	Change (mm)
1893	2657.0	0.0	211.4	779.0	1330.2	367.0	-30.6

1894	2191.0	0.0	46.2	787.4	834.8	420.1	102.5
1895	1555.0	0.0	45.1	739.5	584.0	251.7	-65.3
1896	1668.0	0.0	48.3	824.3	427.1	356.6	11.6
1897	1849.0	0.0	49.6	775.0	650.9	319.4	54.1
1898	2035.0	0.0	82.0	701.5	982.6	389.0	-120.1
1899	2499.0	0.0	180.8	744.3	1138.4	341.2	94.3
1900	1348.0	0.0	124.7	654.1	491.0	210.2	-132.1
1901	1560.0	0.0	283.3	504.4	511.3	279.2	-18.2
1902	1189.0	0.0	192.8	591.9	194.7	200.3	9.2
1903	1360.0	0.0	330.7	490.0	236.3	219.7	83.3
1904	1301.0	0.0	99.6	652.0	447.7	192.6	-90.9
1905	1108.0	0.0	395.5	271.4	277.6	120.1	43.4
1906	1432.0	0.0	210.2	716.2	191.4	207.7	106.4
1907	1938.0	0.0	52.7	752.2	856.6	291.8	-15.3
1908	1541.0	0.0	149.1	651.3	528.1	309.3	-96.8
1909	1391.0	0.0	219.9	717.9	156.1	259.7	37.5
1910	1610.0	0.0	47.8	801.0	508.7	262.7	-10.2
1911	1032.0	0.0	46.8	714.5	85.9	245.5	-60.8
1912	1472.0	0.0	237.4	550.2	488.4	195.0	1.0
1913	1771.0	0.0	285.7	634.3	648.0	201.7	1.3
1914	1861.0	0.0	363.1	621.2	530.9	288.3	57.5
1915	714.0	0.0	275.4	425.4	31.3	57.0	-75.0
1916	1702.0	0.0	258.5	674.6	308.4	331.2	129.3
1917	1598.0	0.0	50.6	826.2	487.9	285.3	-52.0
1918	1280.0	0.0	77.5	696.8	246.1	318.2	-58.6
1919	1549.0	0.0	451.9	432.2	466.2	183.0	15.7
1920	1691.0	0.0	253.6	760.2	295.6	359.1	22.4
1921	2296.0	0.0	47.2	716.3	1068.4	349.3	114.8
1922	1472.0	0.0	101.9	687.6	520.1	294.9	-132.5
1923	1196.0	0.0	410.1	356.4	283.5	144.1	1.9
1924	1706.0	0.0	300.1	729.3	524.0	159.0	-6.4
1925	2477.0	0.0	52.3	862.9	1051.4	381.7	128.7
1926	1300.0	0.0	111.5	640.1	336.1	267.4	-55.0
1927	2267.0	0.0	306.7	689.7	885.2	311.1	74.3
1928	1556.0	0.0	82.9	724.8	515.5	329.5	-96.8
1929	2269.0	0.0	405.2	616.3	1025.3	256.8	-34.4
1930	2344.0	0.0	450.5	485.4	1163.8	277.2	-32.8
1931	2025.0	0.0	543.6	460.1	649.7	294.9	76.6
1932	1155.0	0.0	433.1	480.7	128.0	199.2	-86.0
1933	2331.0	0.0	439.2	675.4	722.9	328.4	165.0
1934	2301.0	0.0	45.3	765.1	1131.3	377.3	-18.1
1935	1976.0	0.0	48.0	755.6	923.8	384.6	-136.0
1936	1622.0	0.0	96.4	628.6	524.1	227.7	145.1
1937	2666.0	0.0	487.0	726.2	1113.2	406.2	-66.6
1938	2109.0	0.0	81.1	736.0	1029.6	344.2	-81.9
1939	1787.0	0.0	479.8	481.1	564.5	271.1	-9.5
1940	1579.0	0.0	502.4	603.8	235.2	227.1	10.4
1941	1294.0	0.0	148.6	557.9	324.6	259.0	3.9
1942	1473.0	0.0	460.1	547.3	173.8	207.5	84.3
1943	2011.0	0.0	120.5	788.4	756.4	265.9	79.8
1944	1836.0	0.0	366.3	570.3	803.6	253.0	-157.1
1945	2053.0	0.0	490.9	478.8	832.9	209.2	41.2
1946	1241.0	0.0	435.5	446.5	249.1	126.5	-16.7
1947	1798.0	0.0	498.8	557.5	498.3	215.1	28.2
1948	1990.0	0.0	482.4	553.0	792.8	213.0	-51.2
1949	1739.0	0.0	501.1	595.9	439.9	228.4	-26.3
1950	2768.0	0.0	578.1	531.5	1224.7	373.1	60.6
1951	1215.0	0.0	338.2	501.8	230.8	197.7	-53.6
1952	1682.0	0.0	482.4	450.1	496.4	265.8	-12.7
1953	1937.0	0.0	459.5	418.8	859.1	158.7	40.9
1954	2315.0	0.0	542.1	576.3	886.6	343.9	-33.9
1955	2026.0	0.0	586.9	384.8	639.5	260.9	153.9
1956	1718.0	0.0	532.2	428.0	568.1	258.6	-68.8

1957	1250.0	0.0	454.6	500.0	177.8	186.9	-69.3
1958	2302.0	0.0	515.8	534.2	984.2	252.4	15.4
1959	2848.0	0.0	575.6	705.2	1063.1	423.9	80.2
1960	1201.0	0.0	402.1	598.1	91.0	179.7	-69.9
1961	1979.0	0.0	549.4	672.8	400.0	344.3	12.6
1962	2650.0	0.0	402.9	572.2	1242.2	317.7	115.1
1963	2569.0	0.0	545.9	613.8	1175.9	312.9	-79.6
1964	1694.0	0.0	475.9	546.8	429.0	244.9	-2.6
1965	1587.0	0.0	496.6	468.1	364.0	209.2	49.1
1966	1377.0	0.0	467.8	524.3	324.4	183.1	-122.6
1967	2138.0	0.0	417.1	718.5	691.7	298.7	12.0
1968	1119.0	0.0	316.6	607.9	85.6	106.1	2.8
1969	1640.0	0.0	552.4	509.6	259.8	277.7	40.5
1970	1661.0	0.0	576.4	529.2	276.5	169.2	109.7
1971	1280.0	0.0	502.1	447.7	209.9	287.5	-167.2
1972	2627.0	0.0	561.8	495.7	1208.1	318.1	43.3
1973	1678.0	0.0	468.6	566.2	301.9	325.3	15.9
1974	2389.0	0.0	553.2	402.6	1230.7	227.8	-25.3
1975	2331.0	0.0	568.6	486.0	813.9	365.0	97.5
1976	2054.0	0.0	491.0	552.2	797.6	305.6	-92.4
1977	1418.0	0.0	521.7	394.0	319.3	222.7	-39.7
1978	1729.0	0.0	577.0	449.8	365.4	218.8	118.0
1979	1567.0	0.0	524.3	410.9	461.3	286.9	-116.5
1980	1503.0	0.0	541.8	394.6	321.9	163.7	81.0
1981	1554.0	0.0	519.7	562.8	326.0	209.9	-64.4
1982	2015.0	0.0	483.7	595.6	606.3	331.6	-2.3
1983	2322.0	0.0	577.9	538.4	745.2	308.7	151.8
1984	2016.0	0.0	490.0	624.3	614.2	350.2	-62.7
1985	1831.0	0.0	473.9	658.9	545.8	238.7	-86.3
1986	1086.0	0.0	515.1	335.8	64.6	147.1	23.5
1987	2006.0	0.0	552.1	549.3	601.4	263.3	40.0
1988	2568.0	0.0	529.0	528.3	1122.3	345.7	42.7
1989	1677.0	0.0	619.5	426.5	395.7	300.0	-64.7
1990	1861.0	0.0	516.8	491.4	670.3	247.0	-64.4
1991	1650.0	0.0	500.3	414.6	416.0	204.2	114.8
1992	1128.0	0.0	552.3	435.2	34.1	211.1	-104.7
1993	1397.0	0.0	541.2	412.1	174.1	241.3	28.3
1994	1946.0	0.0	489.4	465.7	615.7	317.7	57.5
1995	1491.0	0.0	541.6	501.4	192.2	240.9	14.8

NUTRIENT BALANCE

NITROGEN

Total N irrigated from ponds	(kg/ha/year)	0.0	% of Total as ammonium	80.0
Nitrogn lost by ammonia volat.	(kg/ha/year)	0.0	Deep Drainage (mm/year)	265.2
Nitrogen added in irrigation	(kg/ha/year)	0.0		
Nitrogen added in seed	(kg/ha/year)	1.1		
Nitrogen removed by crop	(kg/ha/year)	32.9		
Denitrification	(kg/ha/year)	0.3		
Leached NO3-N	(kg/ha/year)	0.0		
Change in soil organic-N	(kg/ha/year)	-31.7		
Change in soil solution NH4-N	(kg/ha/year)	0.0		
Change in soil solution NO3-N	(kg/ha/year)	-0.5		
Change in adsorbed NH4-N	(kg/ha/year)	0.0		
Initial soil organic-N	(kg/ha)	3272.0		
Final soil organic-N	(kg/ha)	8.6		
Initial soil inorganic-N	(kg/ha)	51.3		

Final soil inorganic-N (kg/ha) 0.0
Average N03-N conc in the root zone (mg/L) 0.0
Average N03-N conc below root zone (mg/L) 0.0
Average N03-N conc of deep drainage (mg/L) 0.0

PHOSPHORUS

Phosphorus added in irrigatn (kg/ha/year) 0.0 % of Total as phosphate 100.0
Phosphorus added in seed (kg/ha/year) 0.1
Phosphorus removed by crop (kg/ha/year) 0.1
Leached PO4-P (kg/ha/year) 0.0
Change in dissolved PO4-P (kg/ha/year) 0.0
Change in adsorbed PO4-P (kg/ha/year) 0.0
Average P04-P conc in the root zone (mg/L) 0.0
Average P04-P conc below root zone (mg/L) 0.0

SOIL P STORAGE LIFE

Year	YearNo.	Tot P stored kg/ha	P leached in year kg/ha
1893	1	248.2	0.0
1894	2	248.2	0.0
1895	3	248.1	0.0
1896	4	248.8	0.0
1897	5	248.1	0.0
1898	6	248.0	0.0
1899	7	248.0	0.0
1900	8	247.9	0.0
1901	9	247.9	0.0
1902	10	247.9	0.0
1903	11	247.8	0.0
1904	12	248.5	0.0
1905	13	247.8	0.0
1906	14	247.8	0.0
1907	15	247.7	0.0
1908	16	248.4	0.0
1909	17	247.7	0.0
1910	18	247.6	0.0
1911	19	247.6	0.0
1912	20	248.2	0.0
1913	21	247.5	0.0
1914	22	247.5	0.0
1915	23	247.5	0.0
1916	24	248.1	0.0
1917	25	247.4	0.0
1918	26	247.4	0.0
1919	27	247.3	0.0
1920	28	248.0	0.0
1921	29	247.2	0.0
1922	30	247.2	0.0
1923	31	247.2	0.0
1924	32	247.8	0.0
1925	33	247.1	0.0
1926	34	247.1	0.0
1927	35	247.1	0.0
1928	36	247.7	0.0
1929	37	247.0	0.0
1930	38	247.0	0.0
1931	39	246.9	0.0
1932	40	247.6	0.0
1933	41	246.9	0.0

1934	42	246.8	0.0
1935	43	246.8	0.0
1936	44	247.5	0.0
1937	45	246.7	0.0
1938	46	246.7	0.0
1939	47	246.7	0.0
1940	48	247.3	0.0
1941	49	246.6	0.0
1942	50	246.6	0.0
1943	51	246.6	0.0
1944	52	247.2	0.0
1945	53	246.5	0.0
1946	54	246.5	0.0
1947	55	246.5	0.0
1948	56	247.2	0.0
1949	57	246.5	0.0
1950	58	246.4	0.0
1951	59	246.4	0.0
1952	60	247.0	0.0
1953	61	246.4	0.0
1954	62	246.3	0.0
1955	63	246.3	0.0
1956	64	246.9	0.0
1957	65	246.2	0.0
1958	66	246.2	0.0
1959	67	246.2	0.0
1960	68	246.8	0.0
1961	69	246.1	0.0
1962	70	246.1	0.0
1963	71	246.1	0.0
1964	72	246.7	0.0
1965	73	246.0	0.0
1966	74	246.0	0.0
1967	75	246.0	0.0
1968	76	246.6	0.0
1969	77	245.9	0.0
1970	78	245.9	0.0
1971	79	245.9	0.0
1972	80	246.5	0.0
1973	81	245.8	0.0
1974	82	245.8	0.0
1975	83	245.8	0.0
1976	84	246.4	0.0
1977	85	245.7	0.0
1978	86	245.7	0.0
1979	87	245.7	0.0
1980	88	246.3	0.0
1981	89	245.6	0.0
1982	90	245.6	0.0
1983	91	245.6	0.0
1984	92	246.2	0.0
1985	93	245.5	0.0
1986	94	245.5	0.0
1987	95	245.5	0.0
1988	96	246.1	0.0
1989	97	245.4	0.0
1990	98	245.4	0.0
1991	99	245.4	0.0
1992	100	246.0	0.0
1993	101	245.3	0.0
1994	102	245.3	0.0
1995	103	245.3	0.0

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PLANT

Plant species: Temperate pasture

PLANT WATER USE

Irrigation	(mm/year)	0.	Totl Irrigation Area(ha)	1.0
Pan coefficient	(%)	1.0		
Maximum crop coefficient	(%)	0.8		
Average Plant Cover	(%)	55.		
Average Plant Total Cover	(%)	67.		
Average Plant Rootdepth	(mm)	418.		
Average Plant Available Water Capacity	(mm)	96.		
Average Plant Available Water	(mm)	69.		
Yield produced per unit transp.	(kg/ha/mm)	6.		

PLANT NUTRIENT UPTAKE

Dry Matter Yield (Shoots)	(kg/ha/yr)	3731.		
Net nitrogen removed by plant	(kg/ha/yr)	32.	Shoot Concn (%DM)	0.85
Net phosphorus removed by plant	(kg/ha/yr)	0.	Shoot Concn (%DM)	0.00

AVERAGE MONTHLY GROWTH STRESS (0=no stress, 1=full stress)

Month	Yield kg/ha	Nitr	Temp	Water Defic	Water Logging
1	373.	0.6	0.4	0.2	0.0
2	327.	0.7	0.4	0.1	0.1
3	364.	0.8	0.3	0.1	0.1
4	281.	0.8	0.2	0.1	0.1
5	231.	0.8	0.1	0.1	0.1
6	219.	0.8	0.0	0.0	0.1
7	251.	0.8	0.0	0.1	0.1
8	309.	0.8	0.0	0.1	0.0
9	364.	0.8	0.1	0.2	0.0
10	345.	0.8	0.1	0.3	0.0
11	329.	0.7	0.2	0.3	0.0
12	338.	0.6	0.3	0.3	0.0

>>> NO-PLANT EVENTS <<<

%Days due to water stress	4.7
%Days due to nitrogen stress	0.0
No. of forced harvests per year	0.8
No. of normal harvests per year	0.6

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SALINITY

Salt tolerance - plant species: tolerant

Average EC of Irrigation Water (dS/m) 0.0 Irrigation (mm/year) 0.0
Average EC of Rainwater (dS/m x10) 0.3 Rainfall (mm/year) 1782.2

>>>No salinity calculations<<<
No. of years chosen for running averages 10

GROUNDWATER
****

Average Groundwater Recharge (m3/day) 7.3
Average Nitrate-N Conc of Recharge (mg/L) 0.0

Thickness of the Aquifer (m) 10.0
Distance (m) from Irrigation Area to where
Nitrate-N Conc in Groundwater is Calculated 1000.0

Concentration of NITRATE-N in Groundwater (mg/L)

	Year	Depth Below Water Table Surface 0.0 m	5.0 m	9.0 m
	1897	0.0	0.0	0.0
	1902	0.0	0.0	0.0
	1907	0.0	0.0	0.0
	1912	0.0	0.0	0.0
	1917	0.0	0.0	0.0
	1922	0.0	0.0	0.0
	1927	0.0	0.0	0.0
	1932	0.0	0.0	0.0
	1937	0.0	0.0	0.0
	1942	0.0	0.0	0.0
	1947	0.0	0.0	0.0
	1952	0.0	0.0	0.0
	1957	0.0	0.0	0.0
	1962	0.0	0.0	0.0
	1967	0.0	0.0	0.0
	1972	0.0	0.0	0.0
	1977	0.0	0.0	0.0
	1982	0.0	0.0	0.0
	1987	0.0	0.0	0.0
	1992	0.0	0.0	0.0
Last	1995	0.0	0.0	0.0

ACKNOWLEDGMENTS
****
This run brought to you courtesy of:

MEDLIEXE.EXE : 1300468 bytes Fri Mar 12 10:26:56 1999

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OTHER INDUSTRY INPUT PARAMETERS - DATA SUMMARY

Nature of Industry: other

>>> Dryland run! <<<   1 file(s) copied

UNCONDITIONAL FINISH

****
SUMMARY OUTPUT
MEDLI Version 1.30

Data Set: 10734
Run Date: 07/02/12 Time:11:26:31.92
****

GENERAL INFORMATION
****
Title: Pacific Pines, Lennox Head
Subject: Water balance assessment
Client: Lendlease
User: Nick Gifford
Time: Tue Feb 07 10:59:02 2012
Comments: [no entry]

RUN PERIOD
****

Starting Date 1/ 1/1893
Ending Date 31/12/1995
Run Length 103 years 0 days

CLIMATE INFORMATION
****

Enterprise site: Lennox Head -28.8 deg S 153.6 deg E
Weather station: Ballina

ANNUAL TOTALS	10 Percentile	50 percentile	90 Percentile
Rainfall mm/year	1228.	1704.	2433.
Pan Evap mm/year	1540.	1603.	1688.

MONTHLY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	181	200	215	181	197	165	134	100	72	92	103	142	1782
Pan Evap (mm)	186	146	139	115	84	75	88	112	139	163	170	194	1610
Ave Max Temp DegC	27	28	26	24	22	20	19	20	22	23	25	26	23
Ave Min Temp DegC	21	21	20	17	15	13	12	12	14	16	18	20	16
Rad (MJ/m2/day)	24	20	17	13	11	10	11	15	19	21	23	24	17

MONTHLY IRRIGATION
****

Irrigation (mm)	54	34	28	26	16	16	24	35	49	58	56	62	458

SOIL PROPERTIES
****

Soil type: Grey Clay

SOIL WATER PROPERTIES

		Layer 1	Layer 2	Layer 3	Layer 4
Bulk Density	(g/cm3)	1.4	1.4	1.4	1.4
Porosity	(mm/layer)	47.5	245.3	287.5	146.0
Saturated Water Content	(mm/layer)	47.0	243.0	284.4	144.6
Drained Upper Limit	(mm/layer)	42.0	218.0	254.4	128.1
Lower Storage Limit	(mm/layer)	26.7	137.5	184.2	98.4
Air Dry Moisture Content	(mm/layer)	4.2			
Layer Thickness	(mm)	100.0	500.0	600.0	300.0

		Profile	Max Rootzone
Total Saturated Water Content	(mm)	719.0	290.0
Total Drained Upper Limit	(mm)	642.5	260.0
Total Lower Storage Limit	(mm)	446.8	164.2
Total Air Dry Moisture Content	(mm)	5.6	4.7

Total Depth	(mm)	1500.0	600.0

Maximum Plant Available Water Capacity		95.8
Saturated Hydraulic Conductivity		
At Surface	(mm/hr)	10.0
Limiting	(mm/hr)	0.1

RUNOFF

Runoff curve No II	75.0

SOIL EVAPORATION

CONA	(mm/day^0.5)	3.5
URITCH	(mm)	6.0

AVERAGE WASTE STREAM
****

Other waste stream
(All values relate to influent after any screening and recycling, if applicable).

Inflow Volume	(ML/year)	36.52
Nitrogen	(tonne/year)	0.00
Phosphorus	(tonne/year)	0.00
Salinity	(tonne/year)	0.00

Nitrogen Concentration	(mg/L)	0.00
Phosphorus Concentration	(mg/L)	0.00
Salinity	(mg/L)	0.00
Salinity	(dS/m)	0.00

WASTE STREAM DETAILS (for last inflow event):

Nitrogen Concentration	(mg/L)	0.00
Phosphorus Concentration	(mg/L)	0.00
TDS Concentration	(mg/L)	0.00
Salinity	(dS/m)	0.00

IRRIGATION WATER
****

Irrigation triggered every 1 days
Irrigating 100 % of amount to reach upper storage limit

AREA

Total Irrigation Area	(ha)	1.00

VOLUMES

Total Irrigation	(ML/year)	4.58
Minimum Volume Irrigated by Pump	(ML/ha/day)	0.00
Maximum Volume Irrigated by Pump	(ML/ha/day)	8.00
Maximum Vol. Available For Shandying	(ML/yr)	0.00

IRRIGATION CONCENTRATIONS

Average salinity of Irrigation	(dS/m)	0.00
Average salinity of Irrigation	(mg/L)	0.00
Average Nitrogen Conc of Irrigation		
Before ammonia loss	(mg/L)	0.00
After ammonia loss	(mg/L)	0.00
Average Phosphorus Conc of Irrigation	(mg/L)	0.00

FRESH WATER USAGE

****

Irrigation (shandying) water	(ML/yr)	0.00
Avg volume of fresh water used	(ML/yr)	0.00
Annual allocation	(ML/yr)	N/A

POND INFORMATION
****

POND GEOMETRY

		Pond 1
Final pond volume	(ML)	0.98
Final liquid volume	(ML)	0.98
Final sludge volume	(ML)	0.00
Average pond volume	(ML)	0.99
Average active volume	(ML)	0.99
Maximum pond volume	(ML)	1.00
Minimum allowable pond volume	(ML)	0.06
Average pond depth	(m)	4.00
Pond depth at outlet	(m)	4.00
Maximum water surface area	(m2 x1000)	0.39
Pond catchment area	(m2 x1000)	0.47
Pond footprint length	(m)	21.64
Pond footprint width	(m)	21.64

POND WATER BALANCE

Inflow of Effluent to pond system	(ML/yr)	36.52
Recycle Volume from pond system	(ML/yr)	0.00
Rain water added to pond system	(ML/yr)	0.83
Evaporation loss from pond system	(ML/yr)	0.43
Seepage loss from pond system	(ML/yr)	0.01
Irrigation from last pond	(ML/yr)	4.58
Volume of overtopping	(ML/yr)	32.32
Sludge accumulated	(ML/yr)	0.00
Sludge accumulated	(t DM/yr)	0.00
Sludge removed	(ML/yr)	0.00
No of desludging events every 10 years		0.00
Increase in pond water volume	(ML/yr)	0.01

OVERTOPPING EVENTS

Volume of overtopping	(ML/yr)	32.32
No. of days pond overtops per 10 years		3651.14
Average Length of overtopping events	(days)	37605.00
% Reuse		12.41

No. of overtopping events every 10 years

> 0.000 ML	0.10
> 0.000 ML*	0.00
> 1.000 ML	0.00
> 2.000 ML	0.00
> 5.000 ML	0.00
> 10.000 ML	0.00
> 20.000 ML	0.00
> 50.000 ML	0.00

* Volume equivalent to 1 mm depth of water

No. periods/year without irrigable effluent		0.00
Average Length of such periods	(days)	0.00

POND NITROGEN BALANCE

Nitrogen Added by Effluent	(tonne/yr)	0.00	Irrig. from pond (ML/yr)	4.6
Nitrogen removed by Irrigation	(tonne/yr)	0.00		
Nitrogen removed by Volatilisation	(tonne/yr)	0.00		
Nitrogen removed by Seepage	(tonne/yr)	0.00		
Nitrogen accumulated in Sludge	(tonne/yr)	0.00		
Nitrogen lost by Overtopping	(tonne/yr)	0.00		

Nitrogen involved in Recycling	(tonne/yr)	0.00			
Increase in pond Nitrogen	(tonne/yr)	0.00			

POND PHOSPHORUS BALANCE

Phosphorus Added by Effluent	(tonne/yr)	0.00	Irrig. from pond	(ML/yr)	4.6
Phosphorus removed by Irrigation	(tonne/yr)	0.00			
Phosphorus removed by Seepage	(tonne/yr)	0.00			
Phosphorus accumulated in Sludge	(tonne/yr)	0.00			
Phosphorus lost by Overtopping	(tonne/yr)	0.00			
Phosphorus involved in Recycling	(tonne/yr)	0.00			
Increase in pond Phosphorus	(tonne/yr)	0.00			

POND SALINITY BALANCE

Salinity Added by Effluent	(tonne/yr)	0.00
Salinity removed by Irrigation	(tonne/yr)	0.00
Salinity removed by Seepage	(tonne/yr)	0.00
Salinity lost by Overtopping	(tonne/yr)	0.00
Salinity involved in Recycling	(tonne/yr)	0.00
Increase in pond Salinity	(tonne/yr)	0.00

POND CONCENTRATIONS

		Pond 1
Average Nitrogen Conc of Pond Liquid	(mg/L)	0.0
Average Phosphorus Conc of Pond Liquid	(mg/L)	0.0
Average TDS Conc of Pond Liquid	(mg/L)	0.0
Average Salinity of Pond Liquid	(dS/m)	0.0
Average Potassium Conc of Pond Liquid	(mg/L)	0.0

(On final day of simulation)

Nitrogen Conc of Pond Liquid	(mg/L)	0.0
Phosphorus Conc of Pond Liquid	(mg/L)	0.0
TDS Conc of Pond Liquid	(mg/L)	0.0
EC of Pond Liquid	(dS/m)	0.0
Potassium Conc of Pond Liquid	(mg/L)	0.0

REMOVED SLUDGE - NUTRIENT & SALT CONCENTRATIONS

Nitrogen in removed Sludge (db)	(kg/tonne)	0.00
Phosphorus in removed Sludge (db)	(kg/tonne)	0.00
Salt in removed Sludge (db)	(kg/tonne)	0.00
Potassium in removed Sludge (db)	(kg/tonne)	0.00

REMOVED SLUDGE - NUTRIENT & SALT MASSES

Nitrogen in removed Sludge	(tonne/yr)	0.00
Phosphorus in removed Sludge	(tonne/yr)	0.00
Salt in removed Sludge (mass bal.)	(tonne/yr)	0.00
Salt in removed Sludge	(tonne/yr)	0.00
Potm. in removed Sludge (mass bal.)	(tonne/yr	0.00
Potassium in removed Sludge	(tonne/yr)	0.00

LAND DISPOSAL AREA
****

WATER BALANCE

(Initial soil water assumed to be at field capacity)
(Irrigated up to 100.00% of field capacity)

Rainfall	(mm/year)	1782.2	Irrigation Area	(ha)	1.0
Irrigation	(mm/year)	458.0			
Soil Evaporation	(mm/year)	50.2			
Transpiration	(mm/year)	838.9			
Runoff	(mm/year)	931.9			
Drainage	(mm/year)	418.7			
Change in soil moisture	(mm/year)	0.5			

ANNUAL TOTALS

Year	Rain (mm)	Irrig (mm)	Sevap (mm)	Trans (mm)	Runoff (mm)	Drain (mm)	Change (mm)
1893	2657.0	464.8	245.7	793.0	1627.2	424.2	31.6
1894	2191.0	288.7	46.2	783.6	1167.2	437.8	44.9
1895	1555.0	404.6	45.1	776.0	708.6	437.1	-7.2
1896	1668.0	388.6	48.3	820.9	755.5	439.2	-7.4
1897	1849.0	477.5	49.6	871.8	958.8	431.6	14.6
1898	2035.0	431.4	48.1	833.5	1195.6	414.6	-25.3
1899	2499.0	394.1	48.1	810.4	1575.9	438.0	20.7
1900	1348.0	591.5	49.6	863.2	636.2	415.6	-25.2
1901	1560.0	621.5	51.6	891.7	872.8	416.9	-51.5
1902	1189.0	538.1	47.5	820.3	428.7	420.9	9.7
1903	1360.0	446.1	47.4	811.7	524.0	379.2	43.8
1904	1301.0	529.8	48.1	838.9	560.0	418.2	-34.4
1905	1108.0	548.6	46.1	787.7	449.0	347.6	26.2
1906	1432.0	468.3	50.6	860.0	523.0	430.8	35.9
1907	1938.0	493.2	52.7	903.1	1107.0	377.4	-8.9
1908	1541.0	501.2	49.7	857.6	740.6	417.2	-23.0
1909	1391.0	461.9	48.1	833.4	517.0	438.0	16.4
1910	1610.0	439.1	47.8	839.1	749.3	436.3	-23.4
1911	1032.0	521.0	47.3	819.2	281.2	437.9	-32.6
1912	1472.0	632.7	50.8	882.7	781.0	385.8	4.3
1913	1771.0	524.5	46.9	851.9	973.8	423.8	-0.9
1914	1861.0	429.7	50.6	830.0	955.1	417.8	37.1
1915	714.0	694.1	52.2	904.7	133.6	363.1	-45.6
1916	1702.0	366.3	47.2	828.6	717.9	422.0	52.6
1917	1598.0	464.3	50.6	836.6	757.3	436.3	-18.6
1918	1280.0	568.1	50.3	928.4	490.9	410.9	-32.5
1919	1549.0	538.6	51.0	832.9	781.6	397.1	24.9
1920	1691.0	450.7	50.5	908.9	746.4	438.6	-2.8
1921	2296.0	423.8	47.2	806.9	1390.6	422.0	53.0
1922	1472.0	495.6	50.6	842.3	699.8	417.2	-42.3
1923	1196.0	580.1	47.2	831.3	505.7	390.3	1.6
1924	1706.0	549.4	50.5	920.6	870.3	436.6	-22.6
1925	2477.0	449.1	52.3	844.4	1541.8	428.4	59.2
1926	1300.0	538.7	49.8	835.7	570.6	378.5	4.1
1927	2267.0	397.6	47.2	808.9	1395.4	420.1	-7.1
1928	1556.0	416.9	48.4	843.6	677.1	408.4	-4.6
1929	2269.0	435.7	48.1	832.1	1408.0	438.0	-21.5
1930	2344.0	403.5	47.4	816.3	1492.6	412.0	-20.8
1931	2025.0	420.2	47.2	809.9	1156.2	416.6	15.3
1932	1155.0	453.1	45.8	791.7	378.4	399.7	-7.6
1933	2331.0	348.2	45.6	819.9	1329.3	438.0	46.4
1934	2301.0	334.9	45.3	787.8	1377.4	438.0	-12.6
1935	1976.0	404.8	48.0	799.7	1132.9	438.0	-37.7
1936	1622.0	437.3	46.9	794.8	744.7	428.5	44.4
1937	2666.0	351.7	50.2	877.5	1676.4	438.0	-24.3
1938	2109.0	483.8	51.5	904.2	1236.6	438.0	-37.5
1939	1787.0	491.9	47.0	873.6	938.8	420.6	-1.2
1940	1579.0	418.3	50.4	800.6	691.7	436.0	18.5
1941	1294.0	444.6	46.7	811.8	525.9	374.3	-20.1
1942	1473.0	489.6	46.9	864.7	572.0	408.4	70.4
1943	2011.0	404.2	47.9	801.7	1143.5	426.4	-4.4
1944	1836.0	525.7	50.2	849.7	1068.1	416.9	-23.2
1945	2053.0	554.5	49.3	934.7	1183.5	438.0	2.1
1946	1241.0	522.7	50.0	785.8	588.9	355.3	-16.3
1947	1798.0	376.4	45.4	821.0	875.3	413.5	19.2
1948	1990.0	441.2	47.5	805.1	1174.9	427.6	-24.0
1949	1739.0	382.2	46.6	828.3	823.4	438.0	-15.0
1950	2768.0	316.2	46.9	804.9	1775.9	432.8	23.7
1951	1215.0	481.8	48.6	840.3	497.7	340.2	-30.0
1952	1682.0	465.4	47.9	802.2	896.9	408.5	-8.1
1953	1937.0	599.5	49.0	896.6	1137.7	407.7	45.5
1954	2315.0	328.4	47.7	754.4	1439.2	438.0	-35.9
1955	2026.0	493.9	46.4	931.8	1078.2	410.8	52.8
1956	1718.0	383.4	47.7	691.1	946.4	424.5	-8.3
1957	1250.0	632.9	49.2	953.5	495.7	418.0	-33.4
1958	2302.0	397.9	49.4	794.0	1380.0	438.0	38.5

1959	2848.0	327.4	50.5	853.7	1836.4	438.0	-3.2
1960	1201.0	608.2	49.7	1010.7	382.5	389.9	-23.6
1961	1979.0	240.0	48.2	671.5	1054.0	438.0	7.3
1962	2650.0	417.1	44.5	786.7	1791.1	411.4	33.4
1963	2569.0	432.0	47.7	973.1	1547.6	438.0	-5.5
1964	1694.0	325.3	47.2	652.1	904.7	416.4	-1.1
1965	1587.0	486.0	48.6	838.4	787.8	411.1	-12.9
1966	1377.0	621.8	47.0	983.7	561.8	428.0	-21.7
1967	2138.0	336.9	48.0	702.1	1279.0	433.5	12.3
1968	1119.0	518.1	49.9	792.4	404.6	410.4	-20.3
1969	1640.0	480.5	48.4	926.0	688.5	433.4	24.1
1970	1661.0	545.2	49.0	1016.9	716.0	399.7	24.6
1971	1280.0	282.1	44.8	603.0	562.5	417.5	-65.8
1972	2627.0	327.0	46.1	736.0	1735.8	417.2	18.9
1973	1678.0	407.3	44.3	822.0	750.2	438.0	30.8
1974	2389.0	585.0	46.9	1007.0	1504.0	434.2	-18.2
1975	2331.0	342.6	46.5	712.4	1462.7	435.5	16.5
1976	2054.0	347.1	49.2	718.9	1200.5	427.8	4.8
1977	1418.0	514.5	50.9	857.9	673.6	413.5	-63.4
1978	1729.0	496.5	48.9	933.0	753.5	410.4	79.7
1979	1567.0	654.1	49.3	1054.6	776.2	409.9	-68.9
1980	1503.0	508.8	51.1	879.6	604.8	418.8	57.5
1981	1554.0	352.0	49.2	668.2	752.2	438.0	-1.7
1982	2015.0	376.6	49.9	762.4	1191.1	426.3	-38.2
1983	2322.0	339.7	48.3	819.4	1309.0	438.0	47.0
1984	2016.0	453.7	47.7	887.1	1098.8	437.0	-0.8
1985	1831.0	490.2	48.5	987.8	882.9	437.6	-35.6
1986	1086.0	726.3	49.9	1107.0	283.9	385.1	-13.5
1987	2006.0	385.3	48.3	762.9	1087.8	438.0	54.3
1988	2568.0	274.2	47.5	636.6	1738.9	425.1	-5.9
1989	1677.0	296.2	48.3	706.7	831.1	416.8	-29.7
1990	1861.0	390.0	46.8	740.3	1041.0	436.8	-14.0
1991	1650.0	494.4	47.9	818.4	826.7	401.8	49.6
1992	1128.0	440.7	47.4	869.5	319.4	387.9	-55.5
1993	1397.0	507.7	46.9	917.9	507.3	422.8	9.7
1994	1946.0	509.7	45.3	937.7	1044.1	423.9	4.7
1995	1491.0	584.6	46.7	1023.1	563.6	426.5	15.7

NUTRIENT BALANCE

NITROGEN

Total N irrigated from ponds	(kg/ha/year)	0.0	% of Total as ammonium	80.0
Nitrogn lost by ammonia volat.	(kg/ha/year)	0.0	Deep Drainage (mm/year)	418.7
Nitrogen added in irrigation	(kg/ha/year)	0.0		
Nitrogen added in seed	(kg/ha/year)	0.0		
Nitrogen removed by crop	(kg/ha/year)	31.9		
Denitrification	(kg/ha/year)	0.3		
Leached NO3-N	(kg/ha/year)	0.0		
Change in soil organic-N	(kg/ha/year)	-31.7		
Change in soil solution NH4-N	(kg/ha/year)	0.0		
Change in soil solution NO3-N	(kg/ha/year)	-0.5		
Change in adsorbed NH4-N	(kg/ha/year)	0.0		
Initial soil organic-N	(kg/ha)	3272.0		
Final soil organic-N	(kg/ha)	6.9		
Initial soil inorganic-N	(kg/ha)	51.3		
Final soil inorganic-N	(kg/ha)	0.0		
Average N03-N conc in the root zone	(mg/L)	0.0		
Average N03-N conc below root zone	(mg/L)	0.0		
Average N03-N conc of deep drainage	(mg/L)	0.0		

PHOSPHORUS

Phosphorus added in irrigatn	(kg/ha/year)	0.0	% of Total as phosphate	100.0
Phosphorus added in seed	(kg/ha/year)	0.0		
Phosphorus removed by crop	(kg/ha/year)	0.0		
Leached PO4-P	(kg/ha/year)	0.0		
Change in dissolved PO4-P	(kg/ha/year)	0.0		

Change in adsorbed PO4-P (kg/ha/year) 0.0
Average P04-P conc in the root zone (mg/L) 0.0
Average P04-P conc below root zone (mg/L) 0.0

SOIL P STORAGE LIFE

Year	YearNo.	Tot P stored kg/ha	P leached in year kg/ha
1893	1	248.2	0.0
1894	2	248.2	0.0
1895	3	248.1	0.0
1896	4	248.8	0.0
1897	5	248.0	0.0
1898	6	248.0	0.0
1899	7	247.9	0.0
1900	8	247.9	0.0
1901	9	247.8	0.0
1902	10	247.7	0.0
1903	11	247.7	0.0
1904	12	248.3	0.0
1905	13	247.6	0.0
1906	14	247.5	0.0
1907	15	247.5	0.0
1908	16	248.1	0.0
1909	17	247.4	0.0
1910	18	247.3	0.0
1911	19	247.3	0.0
1912	20	247.9	0.0
1913	21	247.2	0.0
1914	22	247.1	0.0
1915	23	247.1	0.0
1916	24	247.7	0.0
1917	25	247.0	0.0
1918	26	246.9	0.0
1919	27	246.9	0.0
1920	28	247.5	0.0
1921	29	246.8	0.0
1922	30	246.7	0.0
1923	31	246.7	0.0
1924	32	247.3	0.0
1925	33	246.6	0.0
1926	34	246.5	0.0
1927	35	246.5	0.0
1928	36	247.1	0.0
1929	37	246.4	0.0
1930	38	246.4	0.0
1931	39	246.3	0.0
1932	40	247.0	0.0
1933	41	246.3	0.0
1934	42	246.2	0.0
1935	43	246.2	0.0
1936	44	246.8	0.0
1937	45	246.1	0.0
1938	46	246.0	0.0
1939	47	246.0	0.0
1940	48	246.6	0.0
1941	49	245.9	0.0
1942	50	245.9	0.0
1943	51	245.8	0.0
1944	52	246.5	0.0
1945	53	245.8	0.0
1946	54	245.7	0.0
1947	55	245.7	0.0
1948	56	246.3	0.0
1949	57	245.6	0.0
1950	58	245.5	0.0
1951	59	245.5	0.0
1952	60	246.1	0.0
1953	61	245.4	0.0
1954	62	245.4	0.0

1955	63	245.3	0.0
1956	64	246.0	0.0
1957	65	245.3	0.0
1958	66	245.2	0.0
1959	67	245.2	0.0
1960	68	245.8	0.0
1961	69	245.1	0.0
1962	70	245.1	0.0
1963	71	245.0	0.0
1964	72	245.6	0.0
1965	73	244.9	0.0
1966	74	244.9	0.0
1967	75	244.8	0.0
1968	76	245.5	0.0
1969	77	244.8	0.0
1970	78	244.7	0.0
1971	79	244.7	0.0
1972	80	245.3	0.0
1973	81	244.6	0.0
1974	82	244.6	0.0
1975	83	244.5	0.0
1976	84	245.1	0.0
1977	85	244.4	0.0
1978	86	244.4	0.0
1979	87	244.3	0.0
1980	88	245.0	0.0
1981	89	244.3	0.0
1982	90	244.2	0.0
1983	91	244.2	0.0
1984	92	244.8	0.0
1985	93	244.1	0.0
1986	94	244.1	0.0
1987	95	244.0	0.0
1988	96	244.6	0.0
1989	97	243.9	0.0
1990	98	243.9	0.0
1991	99	243.8	0.0
1992	100	244.5	0.0
1993	101	243.8	0.0
1994	102	243.7	0.0
1995	103	243.7	0.0

PLANT

Plant species: Temperate pasture

PLANT WATER USE

Irrigation	(mm/year)	458.	Totl Irrigation Area(ha)	1.0
Pan coefficient	(%)	1.0		
Maximum crop coefficient	(%)	0.8		
Average Plant Cover	(%)	65.		
Average Plant Total Cover	(%)	97.		
Average Plant Rootdepth	(mm)	599.		
Average Plant Available Water Capacity	(mm)	96.		
Average Plant Available Water	(mm)	106.		
Yield produced per unit transp.	(kg/ha/mm)	4.		

PLANT NUTRIENT UPTAKE

Dry Matter Yield (Shoots)	(kg/ha/yr)	3655.			
Net nitrogen removed by plant	(kg/ha/yr)	32.	Shoot Concn	(%DM)	0.87
Net phosphorus removed by plant	(kg/ha/yr)	0.	Shoot Concn	(%DM)	0.00

AVERAGE MONTHLY GROWTH STRESS (0=no stress, 1=full stress)

Month	Yield kg/ha	Nitr	Temp	Water Defic	Water Logging
1	394.	0.8	0.4	0.0	0.1
2	306.	0.8	0.4	0.0	0.2
3	304.	0.8	0.3	0.0	0.2
4	246.	0.8	0.2	0.0	0.2
5	194.	0.8	0.1	0.0	0.3
6	194.	0.8	0.0	0.0	0.2
7	228.	0.8	0.0	0.0	0.2
8	288.	0.8	0.0	0.0	0.1
9	355.	0.8	0.1	0.0	0.0
10	382.	0.8	0.1	0.0	0.0
11	366.	0.9	0.2	0.0	0.1
12	398.	0.9	0.3	0.0	0.1

No. of normal harvests per year 0.9

SALINITY

Salt tolerance - plant species: tolerant

Average EC of Irrigation Water	(dS/m)	0.0	Irrigation	(mm/year)	458.0
Average EC of Rainwater	(dS/m x10)	0.3	Rainfall	(mm/year)	1782.2
Average EC of Infiltrated water	(dS/m)	0.0			
Av. water-upt-weightd rootzone EC	(dS/m s.e.)	0.0			
EC soil soln (FC) at base of rootzone	(dS/m)	0.1	Deep Drainage	(mm/year)	418.7
Reduction in Crop yield due to Salinity	(%)	0.0			
Percentage of yrs that crop yld falls below 90% of potential because of soil salinity		0.0			

Period	ECrootzone sat ext (dS/m)	ECbase in situ (dS/m)	Rel Yield (%)
1893 - 1902	0.02	0.06	100.
1894 - 1903	0.02	0.06	100.
1895 - 1904	0.02	0.06	100.
1896 - 1905	0.02	0.06	100.
1897 - 1906	0.02	0.06	100.
1898 - 1907	0.02	0.06	100.
1899 - 1908	0.02	0.06	100.
1900 - 1909	0.02	0.06	100.
1901 - 1910	0.02	0.06	100.
1902 - 1911	0.02	0.06	100.
1903 - 1912	0.02	0.06	100.
1904 - 1913	0.02	0.06	100.
1905 - 1914	0.02	0.06	100.
1906 - 1915	0.02	0.06	100.
1907 - 1916	0.02	0.06	100.
1908 - 1917	0.02	0.06	100.
1909 - 1918	0.02	0.06	100.
1910 - 1919	0.02	0.06	100.
1911 - 1920	0.02	0.06	100.
1912 - 1921	0.02	0.06	100.
1913 - 1922	0.02	0.06	100.
1914 - 1923	0.02	0.06	100.
1915 - 1924	0.02	0.06	100.
1916 - 1925	0.02	0.06	100.
1917 - 1926	0.02	0.06	100.
1918 - 1927	0.02	0.06	100.
1919 - 1928	0.02	0.06	100.
1920 - 1929	0.02	0.06	100.
1921 - 1930	0.02	0.06	100.
1922 - 1931	0.02	0.06	100.
1923 - 1932	0.02	0.06	100.
1924 - 1933	0.02	0.06	100.
1925 - 1934	0.02	0.06	100.
1926 - 1935	0.02	0.06	100.

1927 - 1936	0.02	0.06	100.
1928 - 1937	0.02	0.06	100.
1929 - 1938	0.02	0.06	100.
1930 - 1939	0.02	0.06	100.
1931 - 1940	0.02	0.06	100.
1932 - 1941	0.02	0.06	100.
1933 - 1942	0.02	0.06	100.
1934 - 1943	0.02	0.06	100.
1935 - 1944	0.02	0.06	100.
1936 - 1945	0.02	0.06	100.
1937 - 1946	0.02	0.06	100.
1938 - 1947	0.02	0.06	100.
1939 - 1948	0.02	0.06	100.
1940 - 1949	0.02	0.06	100.
1941 - 1950	0.02	0.06	100.
1942 - 1951	0.02	0.06	100.
1943 - 1952	0.02	0.06	100.
1944 - 1953	0.02	0.06	100.
1945 - 1954	0.02	0.06	100.
1946 - 1955	0.02	0.06	100.
1947 - 1956	0.02	0.06	100.
1948 - 1957	0.02	0.06	100.
1949 - 1958	0.02	0.06	100.
1950 - 1959	0.02	0.06	100.
1951 - 1960	0.02	0.06	100.
1952 - 1961	0.02	0.06	100.
1953 - 1962	0.02	0.06	100.
1954 - 1963	0.02	0.06	100.
1955 - 1964	0.02	0.06	100.
1956 - 1965	0.02	0.06	100.
1957 - 1966	0.02	0.06	100.
1958 - 1967	0.02	0.06	100.
1959 - 1968	0.02	0.06	100.
1960 - 1969	0.02	0.06	100.
1961 - 1970	0.02	0.06	100.
1962 - 1971	0.02	0.06	100.
1963 - 1972	0.02	0.06	100.
1964 - 1973	0.02	0.06	100.
1965 - 1974	0.02	0.06	100.
1966 - 1975	0.02	0.06	100.
1967 - 1976	0.02	0.06	100.
1968 - 1977	0.02	0.06	100.
1969 - 1978	0.02	0.06	100.
1970 - 1979	0.02	0.06	100.
1971 - 1980	0.02	0.06	100.
1972 - 1981	0.02	0.06	100.
1973 - 1982	0.02	0.06	100.
1974 - 1983	0.02	0.06	100.
1975 - 1984	0.02	0.06	100.
1976 - 1985	0.02	0.06	100.
1977 - 1986	0.02	0.06	100.
1978 - 1987	0.02	0.06	100.
1979 - 1988	0.02	0.06	100.
1980 - 1989	0.02	0.06	100.
1981 - 1990	0.02	0.06	100.
1982 - 1991	0.02	0.06	100.
1983 - 1992	0.02	0.06	100.
1984 - 1993	0.02	0.06	100.
1985 - 1994	0.02	0.06	100.
1986 - 1995	0.02	0.06	100.

GROUNDWATER
****

Average Groundwater Recharge	(m3/day)	11.5
Average Nitrate-N Conc of Recharge	(mg/L)	0.0
Thickness of the Aquifer	(m)	10.0
Distance (m) from Irrigation Area to where Nitrate-N Conc in Groundwater is Calculated		1000.0

Concentration of NITRATE-N in Groundwater (mg/L)

	Year	Depth Below Water Table Surface 0.0 m	5.0 m	9.0 m
	1897	0.0	0.0	0.0
	1902	0.0	0.0	0.0
	1907	0.0	0.0	0.0
	1912	0.0	0.0	0.0
	1917	0.0	0.0	0.0
	1922	0.0	0.0	0.0
	1927	0.0	0.0	0.0
	1932	0.0	0.0	0.0
	1937	0.0	0.0	0.0
	1942	0.0	0.0	0.0
	1947	0.0	0.0	0.0
	1952	0.0	0.0	0.0
	1957	0.0	0.0	0.0
	1962	0.0	0.0	0.0
	1967	0.0	0.0	0.0
	1972	0.0	0.0	0.0
	1977	0.0	0.0	0.0
	1982	0.0	0.0	0.0
	1987	0.0	0.0	0.0
	1992	0.0	0.0	0.0
Last	1995	0.0	0.0	0.0

ACKNOWLEDGMENTS
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UNCONDITIONAL FINISH

9 Appendix 4 – Freshwater wetland EEC analyses

9.1 Bioretention details

The bioretention basins would be designed generally in accordance with QUDM and the Healthy Waterways Technical Design Guidelines. It is envisaged that the basins would be used to manage water quality alone and would generally be dry. However during (and for a short period after) wet weather, the basin may contain water to a depth of up to 300mm.

Where possible, a high flow bypass for flows in excess of $Q_{3months}$ would be installed. Otherwise, a combination of weir and pipe outlets would be provided.

The filter surface should be level while the floor of the basin should have a minimum grade of 0.5% towards a low point that would be additionally drained by a system of subsurface perforated drains at 1.5m maximum spacings. The subsurface drainage pipes are to be 100mm diameter class 400 perforated corrugated PVC pipe Type 1 with 6 rows of perforations 1.25mm wide by 7.4mm long. A non-perforated riser with a sealed removable screw cap is to be provided at the end of each perforated pipe for maintenance flushing.

Filter media

The bioretention filter's upper layer provides the majority of the pollutant removal function and is intended to support healthy vegetation growth to enhance the treatment process. It is to consist of at least 400mm depth of sandy loam with a nominal particle size of 0.45 to 0.50mm and a saturated hydraulic conductivity of 145 to 220 mm/hour. The organic content (measured in accordance with AS 1289.4.1.1-1997) should be 5% to 10%. The filter media must meet the requirements of FAWB 2009.[8]

Sieve size	%passing
3.4mm	100%
2.0mm	97 – 100%
1.0mm	89 – 92%
0.25mm	30 – 50%
0.15mm	10 – 30%
0.05mm	0 – 3%

Transition layer

The transition layer underlies the filter medium and is intended to prevent the filter medium flowing into the drainage layer and the pipe drains. This layer is be 150mm thick and is to consist of coarse sand having a particle size distribution as shown below.

Sieve size	%passing
1.4mm	100%
1.0mm	80%
0.7mm	44%
0.5mm	8.4%

[8] Facility for Advancing Water Biofiltration, 2009, *Guidelines for Soil Filter Media in Bioretention Systems* (v3.01) June 2009.

The lowest layer in the system is to consist of 150mm depth of granular backfill (2mm to 5mm gravel) bedding medium surrounding the perforated pipes. It provides for the free flow of filtered water to the pipe drainage system.

Details of the bioretention basin are presented within the SMEC civil drawings (Appendix 5). The basin characteristics are detailed in Table 4.2.1.

Table 4.2.1 Bioretention basin details

Basin No.	3	4
Inlet Properties		
Low Flow Bypass (m^3/s)	0.0	0.0
High Flow Bypass (m^3/s)	100	100
Storage Properties		
Extended Detention Depth (m)	0.3	0.3
Surface Area (m^2)	270	90
Seepage loss (mm/hr)	0.0	0.0
Infiltration Properties		
Filter area (m^2)	200	90
Filter depth (m)	0.6	0.6
Filter particle effective diameter (mm)	0.45	0.45
Saturated hydraulic conductivity (mm/hr)	180	180
Outlet properties		
Overflow weir width (m)	5.0	5.0

It is intended that the bioretention basin would be landscaped and planted out as a ‘rain garden’, rather than simply topsoiled and turfed. Species used would be selected from the list of approved species included in Appendix A of the Healthy Waterways Technical Design Guidelines. Details of the plant species selection, size and spacing would be provided by the landscape architects in a landscape plan to be submitted as part of an application for approval to operational works (landscaping).

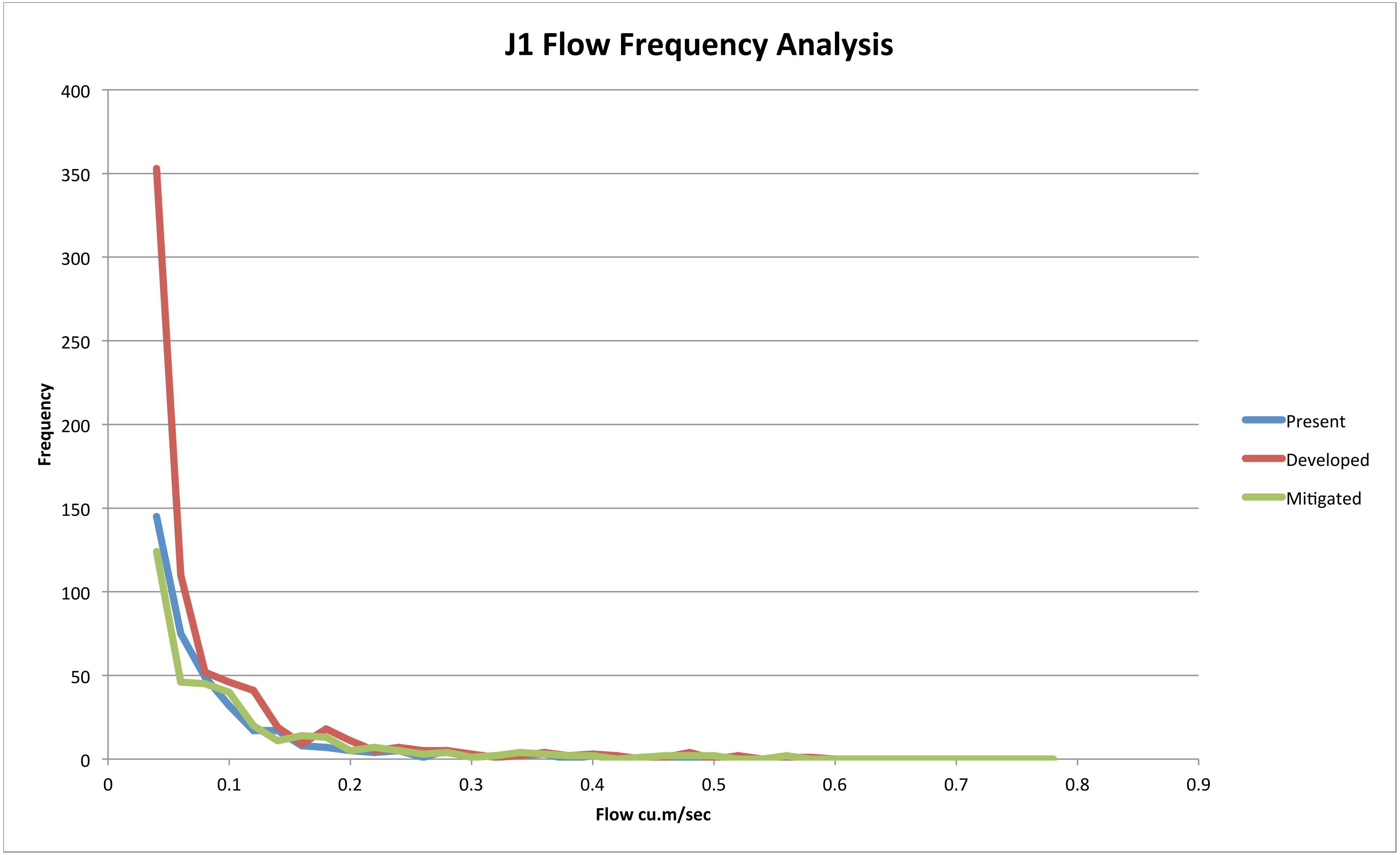
9.2 Average daily flows

Job No	10734
Client	Lend Lease
Project	Pacific Pines NSW
Date	21/09/2012

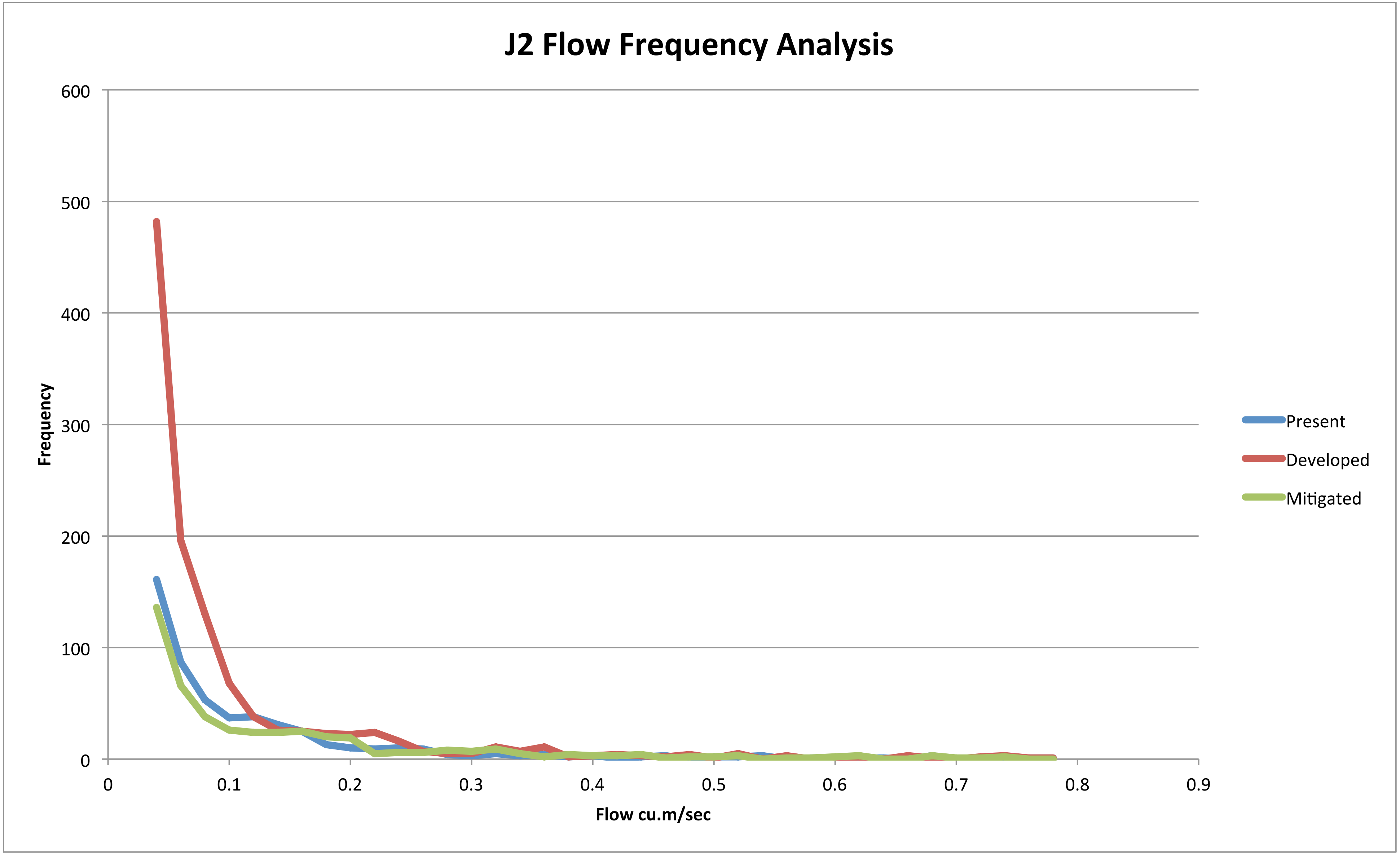
	J1	J2	J3
Base Case			
	Outflow cu.m/sec	Outflow cu.m/sec	Outflow cu.m/sec
10%ile	0.00000	0.00000	0.00000
Median	0.00017	0.00032	0.00045
StdDev	0.02309	0.04428	0.05908
Mean	0.00529	0.01008	0.01393
90%ile	0.00623	0.01166	0.01756
Developed Case			
10%ile	0.00000	0.00000	0.00000
Median	0.00048	0.00081	0.00101
StdDev	0.03434	0.06509	0.08395
Mean	0.00983	0.01842	0.02370
90%ile	0.02057	0.03809	0.04892
Change from Base Case			
10%ile	0	0	0
Median	175.9	148.6	121.6
StdDev	48.7	47.0	42.1
Mean	85.8	82.7	70.2
90%ile	230.1	226.8	178.6
Mitigated Case			
10%ile	0.00000	0.00000	0.00000
Median	0.00000	0.00000	0.00000
StdDev	0.03101	0.00000	0.00027
Mean	0.00551	0.05824	0.07665
90%ile	0.00186	0.01026	0.01589
Change from Base Case			
10%ile	0	0	0
Median	-100.0	-100.0	-100.0
StdDev	34.3	-100.0	-99.5
Mean	4.0	477.6	450.4
90%ile	-70.2	-11.9	-9.5

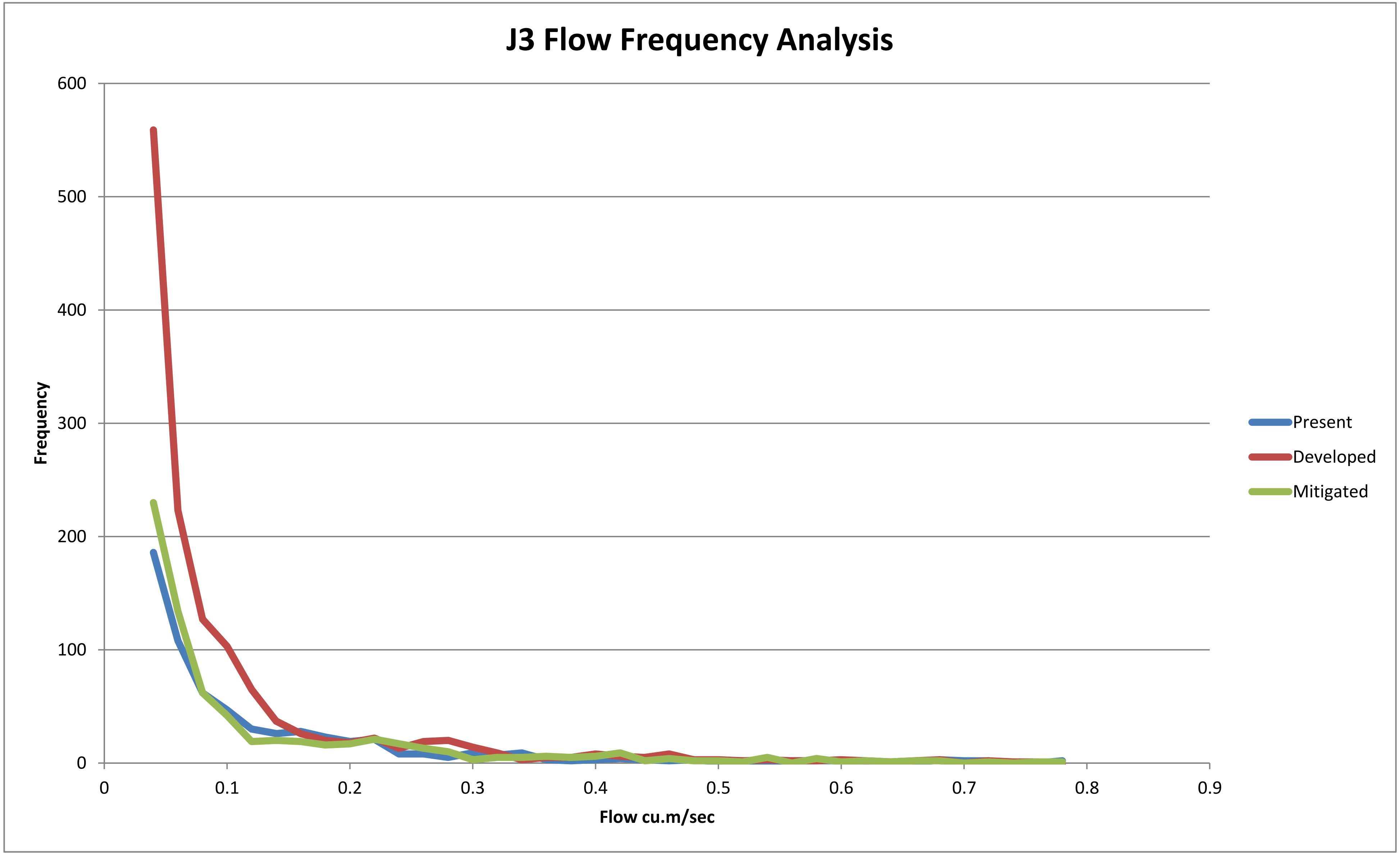
J1 Flow frequency analysis				J2 Flow frequency analysis				J3 Flow frequency analysis			
Flow cu.m/sec	Bas_Count	Dev_Count	Mit_Count	Flow cu.m/sec	Bas_Count	Dev_Count	Mit_Count	Flow cu.m/sec	Bas_Count	Dev_Count	Mit_Count
0	1726	1663	4568	0	1682	1622	4490	0	1441	1442	1307
0.02	4810	4546	1988	0.02	4705	4148	1955	0.02	4832	4107	4899
0.04	145	353	124	0.04	161	482	136	0.04	186	559	230
0.06	75	110	46	0.06	87	196	66	0.06	108	223	134
0.08	49	52	45	0.08	53	130	38	0.08	62	127	62
0.1	32	46	40	0.1	37	68	26	0.1	47	103	42
0.12	17	41	20	0.12	38	38	24	0.12	30	65	19
0.14	17	19	11	0.14	31	26	24	0.14	26	37	20
0.16	8	9	14	0.16	25	25	25	0.16	28	26	19
0.18	7	18	13	0.18	13	23	20	0.18	23	20	16
0.2	5	11	5	0.2	10	22	19	0.2	19	18	17
0.22	4	5	7	0.22	9	24	5	0.22	21	22	21
0.24	5	7	5	0.24	10	16	6	0.24	8	13	17
0.26	1	5	3	0.26	9	7	6	0.26	8	19	13
0.28	5	5	4	0.28	4	5	8	0.28	5	20	10
0.3	1	3	1	0.3	3	5	7	0.3	9	14	3
0.32	2	1	2	0.32	5	11	9	0.32	7	9	5
0.34	2	2	4	0.34	3	7	5	0.34	9	3	5
0.36	3	4	3	0.36	4	11	2	0.36	3	5	6
0.38	0	2	2	0.38	2	2	4	0.38	2	5	5
0.4	2	3	2	0.4	3	3	3	0.4	3	8	6
0.42	0	2	0	0.42	1	4	3	0.42	4	6	9
0.44	0	0	1	0.44	2	3	4	0.44	3	5	2
0.46	0	1	2	0.46	3	2	1	0.46	2	8	4
0.48	0	4	2	0.48	0	4	2	0.48	3	3	2
0.5	0	0	2	0.5	2	1	2	0.5	1	3	2
0.52	0	2	0	0.52	2	5	3	0.52	2	2	1
0.54	0	0	0	0.54	3	0	0	0.54	1	3	5
0.56	0	1	2	0.56	0	3	1	0.56	2	2	0
0.58	0	1	0	0.58	1	0	1	0.58	2	2	4
0.6	0	0	0	0.6	1	1	2	0.6	2	3	1
0.62	0	0	0	0.62	1	2	3	0.62	1	2	2
0.64	0	0	0	0.64	1	0	0	0.64	0	1	1
0.66	0	0	0	0.66	0	3	0	0.66	0	2	2
0.68	0	0	0	0.68	3	1	3	0.68	3	3	2
0.7	0	0	0	0.7	0	0	1	0.7	2	0	0
0.72	0	0	0	0.72	0	2	1	0.72	2	2	1
0.74	0	0	0	0.74	0	3	2	0.74	0	1	0
0.76	0	0	0	0.76	1	1	0	0.76	0	1	1
0.78	0	0	0	0.78	1	1	0	0.78	2	0	1

9.3 Freshwater wetland flow frequency graphs



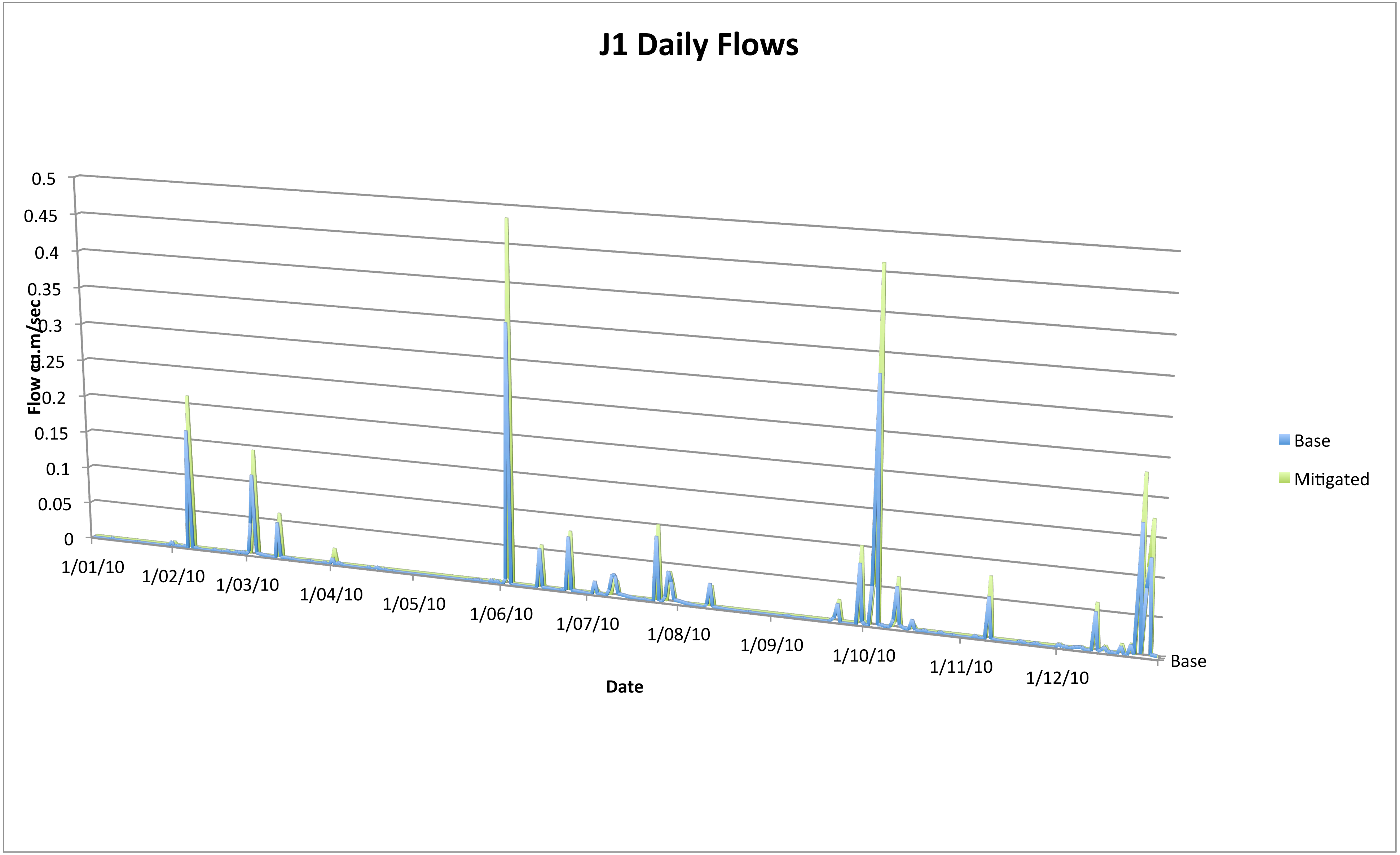
J1 Flow Frequency Analysis
Frequency
400
350
300
250
200
150
100
50
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Flow cu.m/sec
Present
Developed
Mitigated

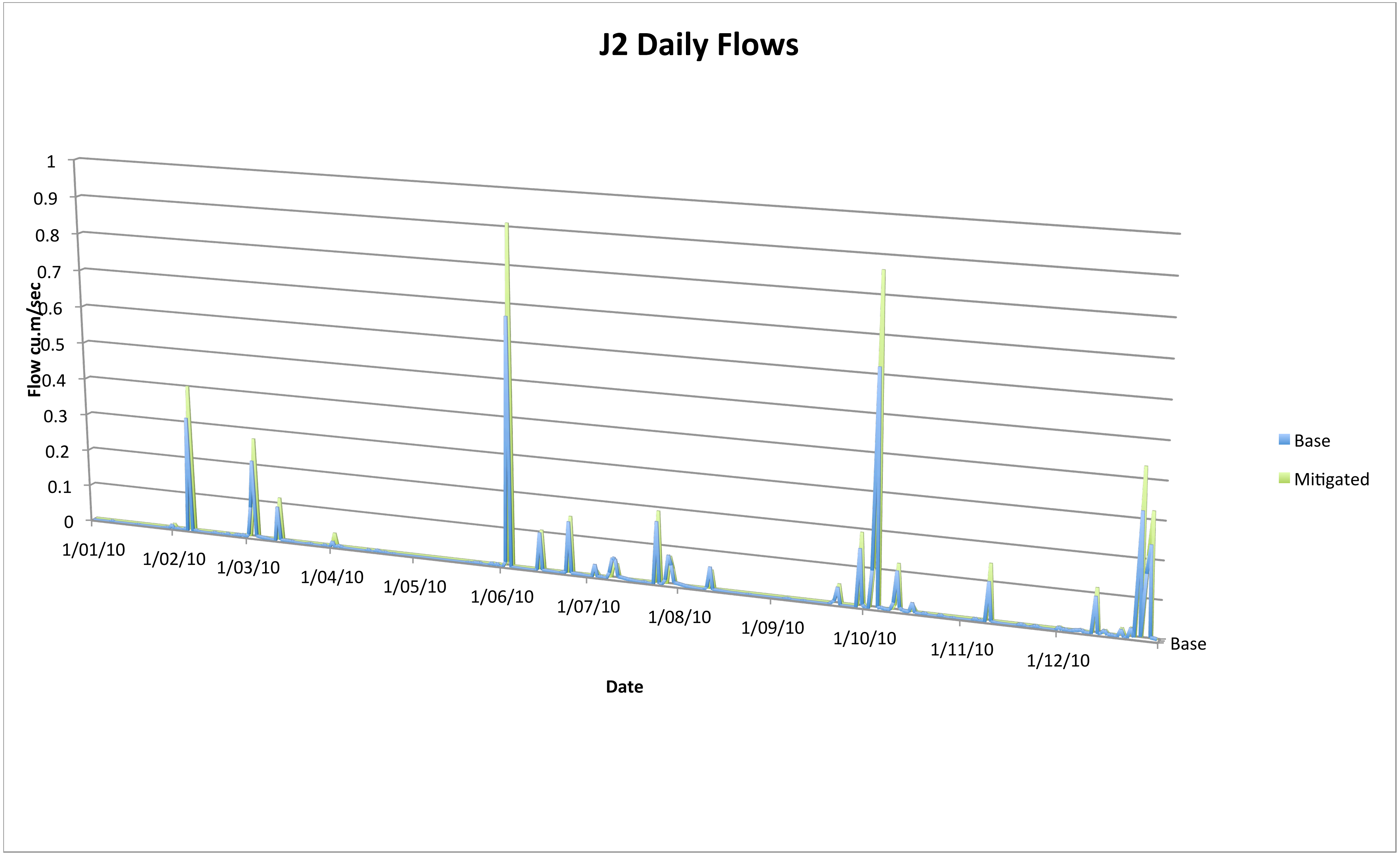

J2 Flow Frequency Analysis
Frequency
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Flow cu.m/sec
Present
Developed
Mitigated

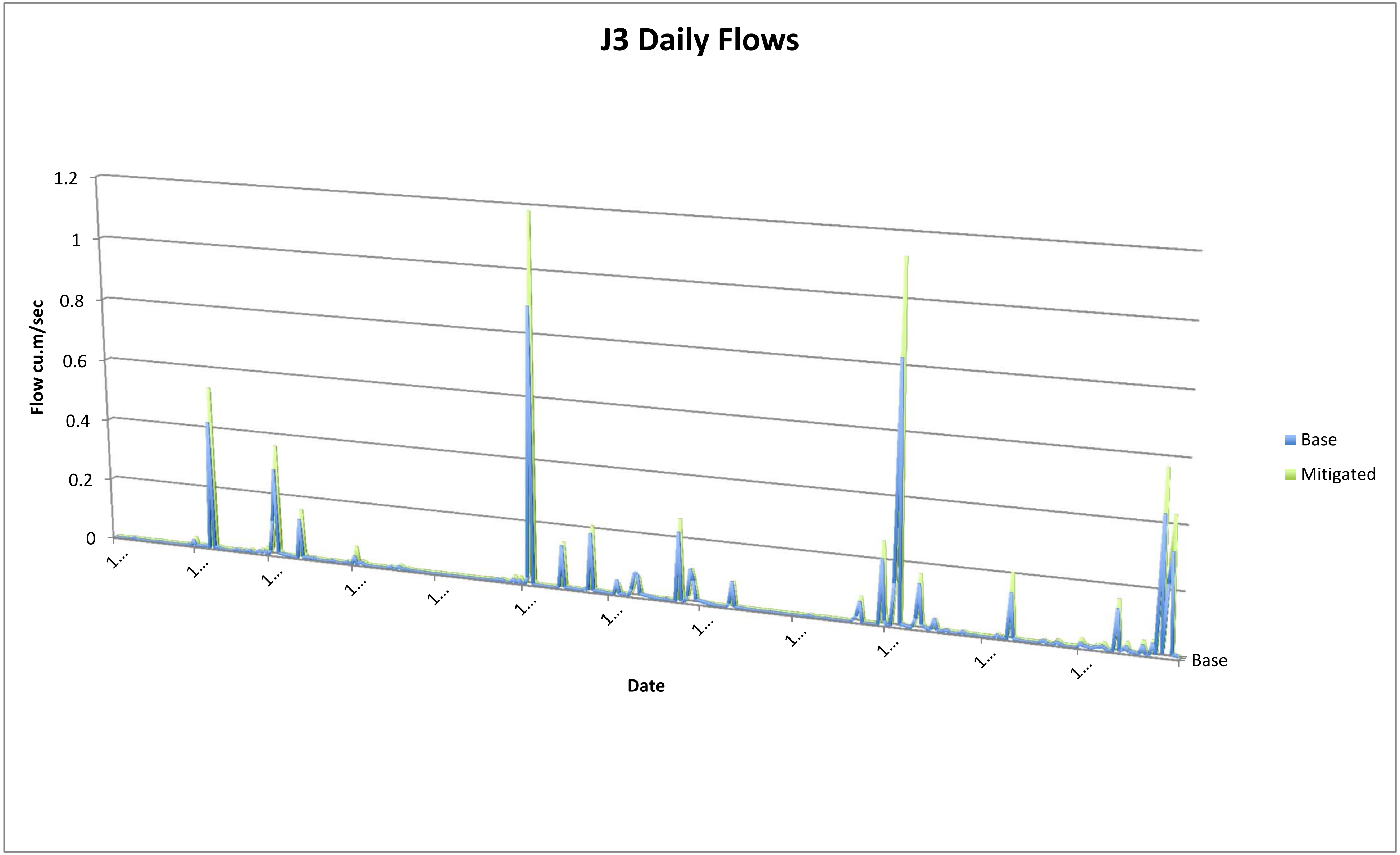


J3 Flow Frequency Analysis
600
500
400
300
200
100
0
Frequency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Flow cu.m/sec
Present
Developed
Mitigated

9.4 Freshwater wetland EEC daily flows

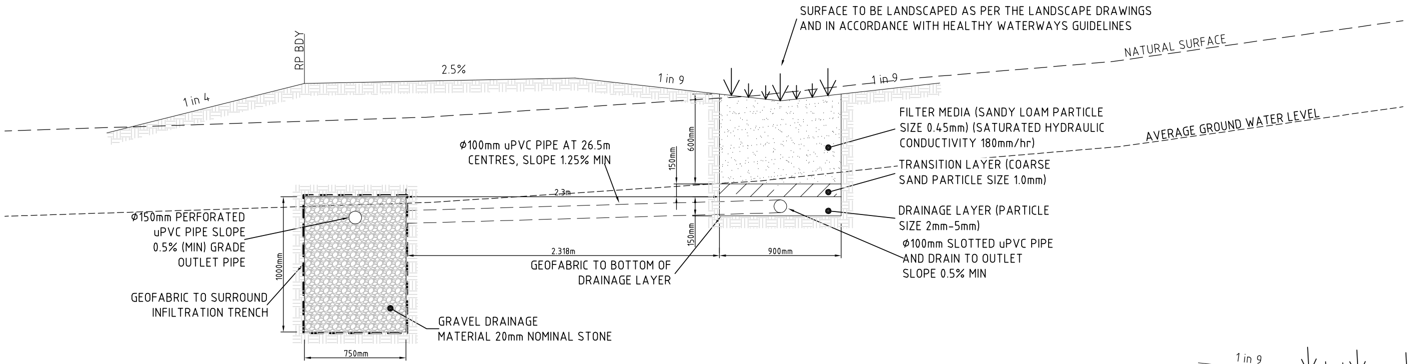

J1 Daily Flows
Flow cu.m/sec
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/01/10
1/02/10
1/03/10
1/04/10
1/05/10
1/06/10
1/07/10
1/08/10
1/09/10
1/10/10
1/11/10
1/12/10
Date
Base
Base
Mitigated


J2 Daily Flows
Flow cu.m/sec
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/01/10
1/02/10
1/03/10
1/04/10
1/05/10
1/06/10
1/07/10
1/08/10
1/09/10
1/10/10
1/11/10
1/12/10
Date
Base
Base
Mitigated

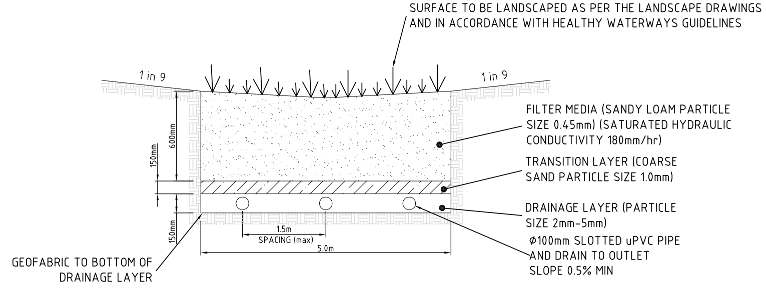


J3 Daily Flows
Flow cu.m/sec
1.2
1
0.8
0.6
0.4
0.2
0
Date
Base
Mitigated

10 Appendix 5 – Reference drawings by SMEC civil engineering

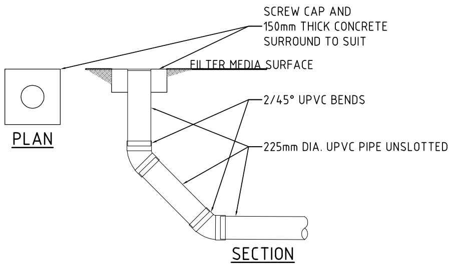


TYPICAL DETAIL A
BIO-RETENTION SWALE AND INFILTRATION TRENCH
NTS

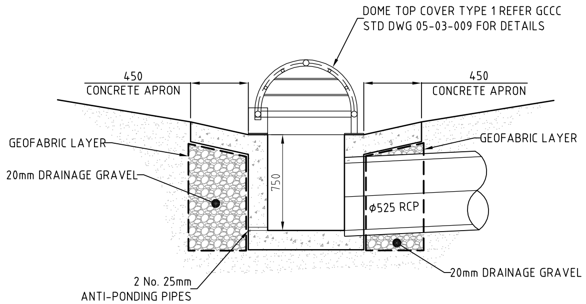


TYPICAL DETAIL B
BIO-RETENTION SWALE
NTS

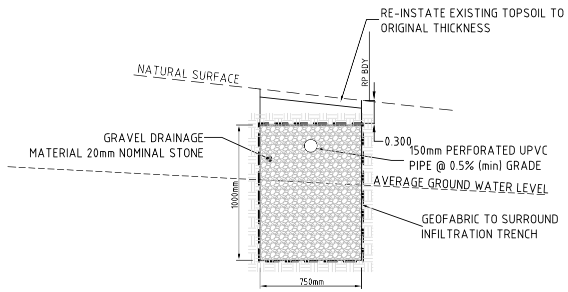
NOTE
1. THE BIO-RETENTION FILTER MEDIA IS NOT TO BE INSTALLED UNTIL ALL OTHER WORKS ON THE SUBDIVISION IS COMPLETED. REFER TO GILBERT AND SUTHERLAND APPROVED STORMWATER MANAGEMENT REPORT FOR FURTHER DETAILS.
2. THE BIO-RETENTION AREA IS TO BE COVERED IN GEOTEXTILE FABRIC, 2.5mm COURSE SAND AND TURFED DURING THE ON MAINTENANCE PERIOD.



INSPECTION OPENING (ISO) DETAILS - END OF LINE
SCALE 1:25



TYPICAL DETAIL D
SLOTTED 900x600 SURCHARGE PIT
1:20



TYPICAL DETAIL C
INFILTRATION TRENCH
NTS

REVISION		DATE	DES/DFT	APP'D
E	Details Amended	25.09.12	SH/JF	
D	Response to IR	15.08.12	SA/JF	
C	Response to IR	07.08.12	SH/JF	
B	Response to IR	25.07.12	SH/DS	
A	Issued For Approval	18.01.12	SH/JF	

Lend Lease

Principal
Lend Lease
235 Varsity Parade
Varsity Lakes QLD 4227

Project Leader S.Sandford
Designed S.Hartley
Drawn J.Flynn
Checked
Authorised
Date October 2011

Scale @ A1
0 0.2 0.4 0.8
Scale 1:20

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PACIFIC PINES ESTATE
Stage 1A
Ballina Shire Council
Stormwater
Stormwater Infiltration Trench and Bio-Retention Swale
Drawing No. 3310069E-01A-67 **Rev E**
Dev. App. No.
Sheet No. 1 of 1

Subject to Approval
Not to be used for construction