RESPONSE TO SUBMISSIONS

RURAL SUBDIVISION
LOTS 1000, 2240, 2275 AND 3045
PRESTON BEACH ROAD, LAKE CLIFTON
PUBLIC ENVIRONMENTAL REVIEW
EPA Assessment No. 1440

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Prepared for:

Cape Bouvard Investments

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STATEMENT OF LIMITATIONS

Scope of Services

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

Reliance on Data

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

Environmental Conclusions

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

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

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

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

Other Limitations

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

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

1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

The Proponent, Cape Bouvard Investments (CBI) has prepared a Public Environmental Review which details the potential environmental impact of the proposal to subdivide Lots 1000, 2240, 2275, 2675, and 3045 Preston Beach Road (herein referred to as the Site) in Clifton along the western side of Lake Clifton into 24 rural lots.

The proposal required formal assessment by the Environmental Protection Authority (EPA) and the Commonwealth Department of Environment, Water, Heritage, and the Arts (DEWHA). In August 2004 , it was determined that a bilateral assessment was applicable to the project under the terms of the Agreement by the Commonwealth of Australia and Western Australia under Section 45 of the EPBC Act Relating to Environmental Impact Assessment and the level of assessment was set at Public Environmental Review (PER) with an eight week comment period.

The PER was prepared and advertised for public comment from 11 January 2010 to 8 March 2010. A total of 16 submissions were received including comment from individuals, community groups, local authorities and state government agencies (including various branches of the Department of Environment and Conservation (DEC)) responded to the PER with a number of queries.

The purpose of this document is to respond to public and government submissions on the PER (ENV, 2009). The queries raised in this document relate directly to a compilation of the questions raised by the public and the government agencies. As a result, each query has been grouped into a sub-section relating to its topic and responded to directly.

1.2 DESIGN STATUS OF THE PROPOSAL

As a result of the submissions received through the public consultation period the CBI has changed and updated the nature of the proposal.

In lieu of developing a consolidated local planning policy for the proposal CBI proposed to undertake a survey-strata subdivision of the site. A survey-strata would effectively result in the creation of one lot comprising 24 strata titles. The single lot would be private property with access to the subdivision via a private road controlled such that it would not be open to the general public.

In undertaking a survey-strata subdivision conditions of subdivision can be applied to address relevant planning, environmental and fire management controls. In addition, communal infrastructure items and relevant management matters can be identified within strata by-laws with responsibility for regulation and enforcement undertaken by a strata management company (or Body Corporate).

Implementation of further environmental management plans can be undertaken and implemented by the Body Corporate. Additionally, by-laws can be used to stipulate the responsibilities of the Strata Company with regards to a range of environmental matters which can be regulated by the Body Corporate. These can include:

- Identifying responsibilities of landowners towards the protection of Declared Rare Flora.
- The fencing of conservation areas to ensure their protection.
- The provision of buffers to wetland areas.
- Identifying responsibilities of landowners including no additional clearing.
- The provision of ongoing water monitoring.

Reference should be made to Appendix A which provides letters from local authorities and the project planning consultant that demonstrate acceptance of the above described approach.

2 NATURE OF THE SUBDIVISION DESIGN

2.1 QUERY 1: KEY CHARACTERISTICS TABLES

"The Key Characteristics Table should provide total footprint sizes for all subdivision elements, i.e. roads, driveways, building envelopes, fire protection zones around building envelopes, fencing, driveways and firebreaks. A separate table should indicate the amount of clearing required for all sub-division elements making reference to the critical asset, vegetation type or community and the condition of the community that is to be cleared. Details of the calculations, i.e. widths of roads, location of turnarounds etc., should also be provided for clarity. "

Subdivision of the 975.2 ha landholding to create 24 survey strata lots ranging in size from 19.5 ha to 181 ha. Locations of building envelopes have been visited in the field to ensure that no conservation significant vegetation will be cleared.

A Draft Fire Management Plan has been prepared for the Proposal by Fireplan WA and is provided in Appendix B to this report. The fire management strategy has been developed following consultation with the City of Mandurah, Shire of Waroona, and the Fire and Emergency Services Authority (FESA). The use of strategic firebreaks which divide the subdivision into cell areas is envisaged to reduce the amount of clearing required for effective fire management. Existing firebreaks and cleared tracks are being utilised to minimise clearing and fragmentation of vegetation throughout the site. Overhead powerlines will source power to the proposed subdivision via roads and firebreaks. The width and vertical clearance required for firebreaks is considered adequate for the provision of overhead powerlines.

A fire bunker or bush fire bunker are purpose built structures for private use, that are intended to provide temporary shelter for people from a bushfire during the passage of the fire front. These structures may be above or below ground, but are separate from a house, and should be distinguished from a cellar under a house or a safe room within a house (Victorian Bushfires Royal Commission, 2009).

The key characteristics of the subdivision are articulated in Table 1 below and shown spatially as Figure 1.

Table 1: Key Characteristics

Characteristic	Total Cleared Area(ha)	Area Currently Cleared(ha)	Clearing as a Result of the Proposal (ha)
Building Envelopes	103.0	12.6	90.4
Fire Bunker Area	4.2	0.1	4.1
Roads (20m wide)	15.3	3.3	12.0

Characteristic	Total Cleared Area(ha)	Area Currently Cleared(ha)	Clearing as a Result of the Proposal (ha)
Strategic Firebreaks (6m wide)	9.8	5.4	4.4
Firebreaks (4m)	5.3	3.5	1.8
Driveways (6m)	2.2	0.4	1.8
Total Clearing	**139.8**	**25.3**	114.5

Each building envelope provides for 20 m building area, 30 m building protection zone and a 70 m fire protection zone. It should also be noted that the total area of clearing amounts to 114.5 ha which is approximately 11.7% of the sites 975.2 ha.

Table 2: Area of Vegetation Units Being Cleared

Veg Unit/Clearing Type	200m Building Envelope	200m Fire bunker	20m firebreak	4m wide firebreak	6m driveway	6m wide firebreak	Grand Total(ha)
cleared	9.81	0.01	2.67	1.10	0.32	2.73	**16.63**
not surveyed				0.80	0.00	0.00	**0.80**
rehab	0.57			0.01	0.00	0.21	**0.79**
unit 1				0.05	0.00		**0.05**
unit 11				0.04	0.00		**0.04**
unit 12	0.91		0.92	0.05	0.00	0.43	**2.31**
unit 13	0.56			0.22	0.00	0.05	**0.83**
unit 15					0.00	0.03	**0.03**
unit 17	7.68		1.07	0.48	0.02	0.24	**9.48**
unit 18	0.54		0.17	0.04	0.00	0.17	**0.93**
unit 2	6.07		4.27	0.23	0.49	0.27	**11.32**
unit 20	1.68				0.00	0.00	**1.68**
unit 22			0.35		0.00	0.08	**0.44**
unit 24				1.20	0.00		**0.20**
unit 25			0.21		0.00	0.05	**0.27**
unit 26			0.21		0.00		**0.21**
unit 27			0.00		0.00		**0.00**
unit 28	2.46		0.91		0.04	0.35	**3.76**

Veg Unit/Clearing Type	200m Building Envelope	200m Fire bunker	20m firebreak	4m wide firebreak	6m driveway	6m wide firebreak	Grand Total(ha)
unit 29	0.16		0.16		0.00		**0.31**
unit 3	0.07		0.08	0.00	0.00	0.00	**0.15**
unit 30			0.00		0.00	0.03	**0.03**
unit 31	1.14				0.03	0.06	**1.24**
unit 32	0.39				0.00	0.09	**0.48**
unit 33	16.12			0.15	0.19	0.61	**17.08**
unit 34	0.08			0.07	0.00	0.08	**0.23**
unit 35					0.05	0.02	**0.07**
unit 36	0.33				0.00	0.01	**0.33**
unit 37					0.00	0.07	**0.07**
unit 38			0.07		0.00	0.06	**0.13**
unit 39	0.01		0.24	0.08	0.00		**0.33**
unit 4	2.14		0.18	0.02	0.00		**2.34**
unit 40	0.55				0.05	0.08	**0.68**
unit 41			0.00		0.00		**0.00**
unit 43				0.16	0.00		**0.16**
unit 47	0.19				0.00		**0.19**
unit 49	0.71	0.06			0.00	0.00	**0.78**
unit 5	1.27		0.17	0.02	0.00	0.19	**1.65**
unit 50	1.61	0.04	0.01		0.00	0.49	**2.16**
unit 51	5.25				0.09	0.13	**5.47**
unit 52	3.86				0.37		**4.23**
unit 53	9.01		0.30		0.05	1.40	**10.76**
unit 54	15.88			0.05	0.24	1.45	**17.62**
unit 56				0.06	0.00		**0.06**
unit 57				0.11	0.00		**0.11**
unit 59				0.02	0.00		**0.02**
unit 6	4.48		0.15	0.12	0.03	0.00	**4.78**

Veg Unit/Clearing Type	200m Building Envelope	200m Fire bunker	20m firebreak	4m wide firebreak	6m driveway	6m wide firebreak	Grand Total(ha)
unit 60	8.55	1.12	2.07		0.05	0.26	**12.05**
unit 61					0.00	0.04	**0.04**
unit 62			0.33		0.00	0.05	**0.38**
unit 64	0.24		0.14		0.12		**0.50**
unit 65				0.04	0.00		**0.04**
unit 66			0.15		0.00		**0.15**
unit 67	0.11				0.00	0.00	**0.11**
unit 68	0.46	2.96	0.43		0.02	0.08	**3.95**
unit 7	0.08			0.17	0.00		**0.25**
unit 8				0.01	0.00		**0.01**
unit 9			0.04		0.00		**0.04**
water				0.02	0.00		**0.02**
Grand Total	**102.98**	**4.19**	**15.31**	**5.32**	**2.16**	**9.81**	**139.76**

1. See Figure 2 for Vegetation Unit Descriptions

Table 3: Total Area of Each Vegetation Condition Being Cleared

	Completely Degraded	Degraded	Excellent	Good	Very Good	Very Good - Excellent	Total
200m Building Envelope	12.56	5.41	0.00	38.35	4.04	42.63	**103.0**
200m Firebunker	0.10	0.00	0.00	3.70	0.00	0.39	**4.2**
20m Firebreak	3.33	2.55	1.23	6.69	1.51	0.00	**15.3**
4m wide firebreaks (existing)	3.76	0.33	0.23	0.67	0.26	0.04	**5.3**
6m driveways	0.37	0.44	0.00	0.45	0.01	0.92	**2.2**
6m wide firebreaks	5.42	0.30	0.06	2.09	0.07	1.88	**9.8**
Total	**25.54**	**9.02**	**1.52**	**51.96**	**5.89**	**45.86**	**139.8**

Bush Forever Condition Scales (Government of WA, 2000)

1. See Figure 3 for Vegetation Condition.

Table 4 summarises the potential impacts of the proposal on species of national significance under the EPBC Act. With respect to the Priority 4 listed plant *Stylidium maritimum*, recorded specimens of the plant occur within the fire setback Hazard Separation Zone, clearing in this area will not require the removal of ground cover plants, only control of significant biomass such as trees and shrubs.

Table 4: Summary of EPBC Act Issues

EPBC Act Issue	Description	Cleared Area (ha)
White-tailed Black Cockatoo Habitat	Vegetation containing suitable foraging habitat or roosting habitat.	Forging Only: 7.6 Nesting Only: 12.8 Both: 0.2
Graceful Sun-Moth	Coastal vegetation area containing *Lomandra* sp.	54.7
Chuditch	No actual habitat for the Chuditch within the site. Cleared area refers to potential habitat only.	19.6
Western ringtail possum	No actual habitat for the Western ringtail possum within the site. Cleared area refers to potential habitat only. Vegetation unit characterised by *Agonis flexuosa.*	16.3
Wetland	Defined as mapped wetlands from the Department of Environment and Conservation Wetland Mapping Dataset.	No clearing
Threatened ecological communities (TEC)	TEC 26a *Melaleuca huegelii – Melaleuca acerosa* shrublands on limestone ridges	No clearing
	TEC 18 Shrublands on	No clearing

EPBC Act Issue	Description	Cleared Area (ha)
	calcareous silts	
Declared Rare Flora	*Eucalyptus argutifolia*	No clearing

2.2 QUERY 2: LOT SIZES

"Are the lot sizes proposed within the subdivision consistent with the gazetted City of Mandurah Town Planning Scheme and the Shire of Waroona's Local Planning Strategy?"

The lot sizes are proposed to maintain a 40 ha average lot size in order to optimise environmental outcomes. Whilst the requirement of the relevant Town Planning Scheme (TPS) stipulate a 40 ha minimum gross lot size, the average 40 ha lot size is consistent with the Western Australian Planning Commission's performance based outcome, particularly on the basis that the proposal achieves a positive environmental outcome by larger conservation friendly lots. The Department of Planning has provided feedback in their response to the PER to this effect.

2.3 QUERY 3: LAND USE WITHIN LOTS

"What are acceptable land uses within lots? How will permitted uses be regulated and by which agency?"

The intent of the proposal is to maintain a conservation focus to rural development. Landowners will be limited to clearing 2500m^2 for building envelopes and are bound by the allowable uses within a rural lot as stipulated by the City of Mandurah and Shire of Waroona TPSs. In addition, the following land uses will be prohibited:

1. Clearing beyond the building envelope;
2. Agriculture;
3. Stock grazing;
4. Hobby farms;
5. Market Gardening and
6. Future Subdivision.

Restrictions on land uses will be regulated through annotated in the bylaws of the Strata Company and distributed to the future residents. The ongoing uses will be regulated by the appointed Body Corporate with recourse to the State Administrative

Tribunal. The Body Corporate will set up a legal arrangement which binds the owners to the obligations under the conditions of the environmental and planning approvals.

2.4 QUERY 4: REZONING

"Under the Development Policy 3.4: Subdivision of Rural Land the proponent should consider rezoning the lots to conservation."

The use of the site is consistent with its current zoning and there is no requirement for an amendment to the current zone.

2.5 QUERY 5: COASTAL SETBACK

"Further detail regarding assumptions used in the PER to define the coastal setback is required."

The coastal foreshore setback has been developed consistent with *Statement of Planning Policy No. 2.6: State Coastal Planning* (WAPC, 2003) (herein referred to as SPP 2.6). Setback calculations are described in Schedule 1 of SPP 2.6 for a variety of coastal types and provide guidance for appropriate setback distances from the coast where numerical modelling is not undertaken.

For the purpose of the PER a conservative shoreline scenario has been adopted and no numerical modelling has been undertaken for the Proposal. The setback is based on the calculation of three factors:

1. **(S1) Distance for Absorbing Acute Erosion -** The setback has adopted the default value of 40m for a typical exposed sandy shore and in the absence of modelling.

2. **(S2) Distance to Allow for Historic Trend (Chronic Erosion or Accretion) -** The shoreline is a mix between accretion and erosion in the *Coastal and Lakeland Planning Strategy* (WAPC, 1999). Additionally, *The Yalgorup Coastal Report* undertaken by Damara WA Pty Ltd (2009) indicated that the shoreline adjacent to the proposal area is dominantly stable and/or accreting. The minimum historical trend has been applied in this instance as the value for S2 as 20m

3. **(S3) Distance to Allow for Sea Level Change-** The value for S3 has been assumed as the default value of 38 m consistent with sandy shores.

Adding the above parameters (S1, S2 and S3) provides a horizontal setback datum of 98m.

Additionally, the EPA has advised that the Western Australian Planning Commission (WAPC) have recently revised State Planning Policy 2.6 Coastal Planning Policy and have increased the minimum setback from 98m as described above to 150m. Increasing the setback distance from 98m to 150m presents no risk to proposed building envelopes. As

stated in the policy the physical process setback is intended to reduce risk to physical structures and homes, therefore it is unlikely that the small sections of firebreak within the physical setback area will be impacted by coastal processes. Access to lots will not be influenced.

2.6 QUERY 6: FENCING

"Will internal and boundary fencing limit movement of fauna between lots and the segmented portions of Yalgorup National Park?"

There will be no internal boundary fencing between lots in the Proposal. Management of the future subdivision through a Body Corporate will ensure that no internal fencing is established by future residents.

Currently, standard post and rail boundary fencing is established around the perimeter of the Proposal area and this fencing will be maintained. The limited amount of fencing does not currently pose a limitation to fauna movement in the area. Additionally, fencing will be established on the perimeter of wetland buffer areas to prevent movement of people into wetland areas.

2.7 QUERY 7: BUILDING ENVELOPES

"How will the location and extent of building envelopes be determined, monitored and approved?"

The location of building envelopes has been provided as part of this response to submissions. Building envelopes have been located outside of environmentally sensitive areas including Threatened Ecological Communities (TECs), wetlands, wetland buffers, and the groundwater protection area as shown on Figure 1.

Building envelopes will be annotated on the survey Strata plan and described by geographic coordinates (eastings and northings). Local council will have the authority to approve dwellings within these building envelopes.

2.8 QUERY 8: YALGORUP NATIONAL PARK SETBACKS

"Does the setback distance from Yalgorup National Park provide adequate protection against pedestrian access, trail bikes, weeds, fire and domestic animals?"

Currently, Yalgorup National Park is open to pedestrian access, trail bikes, weeds, fire and domestic animals and the proponent reports that in the recent past visitors have accessed the site regularly. There will be no additional pedestrian or access trails cleared as part of the Proposal. The introduction of residents into the area should reduce the amount of trail bike riders as the area will be passively surveyed for trespassers by owners, which is not the case currently.

The potential for transference of weeds is not considered to be a significant issue. An Environmental Management Plan will be prepared for subdivision which will outline a weed management programme that will be implemented by the Body Corporate. This plan will also focus on preventing weeds present in the adjacent national park from being spread onto the property.

Fire will be managed in accordance with the Fire Management Plan which has been updated to reflect the changes to the Proposal and is provided as Appendix B to this document.

No domesticated animals such as cattle, horses, and goats will be permitted within the Proposal Area. This will be articulated within the bylaws of the Strata Company with the Body Corporate regulating residents.

3 PHYSICAL IMPACTS TO YALGORUP LAKE SYSTEM

3.1 QUERY 1: IMPACT TO THROMBOLITES

"Thrombolites should be documented as being listed as 'critically endangered' under the Environment Protection and Conservation Biodiversity Act 1999. It is also unclear how the proposed development may potentially impact the thrombolite community. For example what are the potential impacts of the predicted nutrient levels and changed water balance on the community?"

Thrombolites are listed as a critically endangered threatened ecological community (TEC) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Potential sources of impact to the thrombolites include changes to the hydrological regime including water quality and quantity. The thrombolites are located on the opposite shore of Lake Clifton from the Project Area; therefore, no physical impacts are anticipated as a result of the Proposal.

Changes to the hydrological regime have been modelled using a predictive numerical model. The model simulated both changes to the water balance and water quality which are a result of the Proposal. Results of the model have indicated that minimal change in the stormwater or groundwater flow regime over the short or long term. Additionally, the model has indicated that the addition of nutrients in the system is minimal and is well within the natural fluctuation of nutrient values within the Lake Clifton.

3.2 QUERY 2: WETLAND VALUES

"Further documentation regarding the wetland values including state, national and international recognition, attributes and functions should be provided."

The Peel-Yalgorup Lake System which includes Lake Clifton and Boundary Lake is recognised internationally under the Ramsar Convention due to the wetland system being internationally important for migratory birds.

Lake Clifton is of unique importance as it is one of two locations in south-west Australia where the internationally important benthic microbial community of living thrombolites occur in hypersaline water (Peel-Harvey Catchment Council, 2007). As mentioned in Section 3.1, the thrombolites of Lake Clifton are listed as 'critically endangered' under the EPBC Act.

Wetland values associated with the Yalgorup Lakes System adjacent to the site can be categorised as uniqueness, naturalness, habitat attributes, and scientific attributes.

The Yalgorup Lake System is also recognised as nationally important under the:

- Directory of Important Wetlands in Australia; and
- Register of National Estate (Australian Heritage Database, Department of Environment, Water, Heritage and Arts Registered, 1978)

At a State Level, Lake Clifton, Boundary Lake, Unnamed Lake and Lake Pollard are recognised as Environmental Protection Policy (EPP) Lakes and have a management category classification of conservation category according to the Geomorphic Wetlands of the Swan Coastal Plain (Hill et al, 1996).

The predominant attributes of the lakes are defined by their hydrology and by the fact that their invert is below sea level. The lakes are very shallow, generally less than 2 m deep, with surface heights varying below sea level. The lakes receive virtually no surface water runoff and are maintained by direct rainfall and groundwater inflow. Lake Clifton is a groundwater sink which means the sole source of inflow is via groundwater and has no outflow other than evaporation. The lakes are underlain by hypersaline groundwater which, because it is denser than sea water, allows the lake levels to periodically fall below sea level (WAPC, 1999). The attributes of the Lakes within and adjacent to the project area have been studied extensively for the purpose of both the PER and this document. An hydrological model has been compiled and run to estimate any potential impacts as a result of the proposal.

Lake Clifton supports the largest known examples of living non-marine microbialites in the Southern Hemisphere, and is one of only two sites known where microbialites occur in water less salty than sea water. The thrombolites at Lake Clifton are actively growing and rely on the inflow of fresh groundwater rich in calcium and bicarbonate. This water source maintains lake levels that in turn prevents desiccation of the thrombolites, and keeps salinity in the system hyposaline (1–10 ppt) throughout the year. Unlike other cyanobacterial communities (such as phytoplankton) the thrombolites do not require significant nutrient inputs (Hale, J. and Butcher, R., 2007).

As summarised by Hale and Butcher (2007), the Yalgorup lakes are important habitat for a number of waterbird species and are considered a summer sanctuary for waterfowl (CALM, 1995). Lake Clifton and Lake Preston, in particular, supported large numbers of waterbirds in the period up to Ramsar listing. The cumulative number of species recorded for the Yalgorup lakes during 1976-2007 is 73 and represents records spanning three decades. This includes 24 species listed under the international migratory bird agreements JAMBA and CAMBA as well as an additional 15 Australian migratory species protected under the EPBC Act. There are two species for which the Lakes represent the only observations within the Ramsar site. These are the Bridled Tern and Pacific Gull, both of which are principally marine species. In addition, the Little Stint and Pacific Golden Plover, which are regularly recorded at the Yalgorup Lakes, have only been rarely seen at other locations within the Ramsar site.

3.3 QUERY 3: HYDROLOGICAL REGIME OF WETLANDS

"Further information should be provided in how changes to the hydrological regime will specifically impact the wetlands. For example, it should address the predicted changes to the hydrological regime, including quantity, quality and seasonality; and how these changes are going to affect the wetland processes and vegetation communities that are associated with the wetland system. That is, provide a clear understanding of the link between the groundwater studies, pressure from the development and the wetland system. Consequential impacts to fauna should also be addressed, such as for roosting or nesting birds. This should be provided in context of identifying impacts and proposing suitable management responses. Any changes to Ecological Character resulting from the proposal should also be identified, as identified in Hale and Butcher (2007)."

Hale and Butcher (2007) describe the primary determinants of ecological character as abiotic components and habitat which contribute to the health of biological components, key species and communities.

The primary abiotic components consist of water quality (salinity and nutrients) and hydrology (groundwater). Changes to hydrological regime have been estimated through the construction and calibration of a numerical hydrological model specifically designed to assess the potential impacts of the Proposal. The model was calibrated and run with the results of a comprehensive field monitoring programme. Further detail regarding the technical aspects of the model is provided in Section 4. Changes to water quality as a result of the Proposal are summarised as follows:

- No addition of any salt load.
- Total Phosphorus generated by the addition of ATUs is small and likely to be adsorbed by soils.
- Total Nitrogen concentrations are anticipated to increase 6% or from 0.01-0.001mg/L in comparison to the existing concentrations that are between 0.2 mg/L and 8.6 mg/L.
- No change to water levels in Lake Clifton or to its groundwater catchment.

Hale and Butcher (2007) describe habitat components as open water, mudflats, samphire, aquatic plants, paperbark, and sedges. Based on the limited changes to hydrology as discussed above there is no anticipated change to open water levels and extents of mudflats therefore not influencing the habitat for birds either roosting or inhabiting Lake Clifton. Additionally, any samphire and sedge populations are unlikely to be affected by changes in water quality. As noted in Hale and Butcher (2007) Lake Clifton has a small paperbark fringe (less than 20 m) which is supported by the Flora and Vegetation survey across the site. All paperbark vegetation is within the setback distance from Lake Clifton.

Based on the above analysis of the primary determinants it is unlikely that the overall ecological character of Lake Clifton will be influenced by the Proposal.

3.4 QUERY 4: WETLAND BUFFERING

"The proposed buffering for the wetlands requires further justification to ensure the ongoing protection of their functions and values. It is noted that clearing within the buffers is proposed, such as for fire management. The potential impacts and overall effectiveness of the buffers if this should occur should also be discussed and quantified."

A development exclusion zone of 300 m from the high water mark of Lake Clifton has been implemented consistent with the City of Mandurah Town Planning Scheme. This exceeds the requirements of EPA Guidance Statement 28 and the Coastal and Lakelands Planning Strategy, which sought a 150 m development setback from the high water mark of the Lake Clifton and development exclusion from the Vasse soils, including a 20 m buffer from the soils. The proposed 300 m buffer, which has been calculated from the visible edge of landward ephemeral vegetation, exceeds the development exclusion requirements for the Vasse soils. Additionally, this setback exceeds the recommendations in the peer reviewed paper by Davies and Lane (1996)

Fragmentation of the area surrounding Boundary Lake, Unnamed Lake and Lake Clifton has been minimised by reducing the number of adjacent lots. Boundary Lake, Unnamed Lake, their 50m buffers and a large extent of the 300m buffer of Lake Clifton are contained within a single lot reducing human impact and habitat fragmentation. Physical impacts to Boundary Lake and Unnamed Lake are limited to the potential impacts of a single landowner. The 50m buffer areas between Boundary Lake and Unnamed Lake are connected providing a continuous ecological linkage between the two areas.

Additionally, all wetland dependent vegetation is contained within the setback area.

All firebreaks adjacent to wetlands are shown in Figure 1. Currently, there are a number of existing firebreaks within the wetland buffer areas, in particular to Boundary Lake to the north (Figure 1). These firebreaks will be maintained post development to minimise excessive clearing and increase fragmentation throughout the site. No additional clearing will be undertaken to build fences as they will be located on the boundary of a firebreak. Fences will protect all wetlands from access. **No additional clearing in wetland buffers is proposed.**

3.5 QUERY 5: ALLOWABLE LANDUSE WITHIN WETLAND BUFFER

"Allowable land uses within the wetland buffer should be clearly stated including whether wetland buffers will be fenced and how human access and threatening processes will be controlled."

Within the wetland buffer all remnant vegetation will be retained. The recommended setback distances are considered sufficient for the prevention of weed infestation (Western Australian Planning Commission, 2005). No clearing will be permitted for buildings and structures. The following actions will not be permitted within the wetland buffer; importation of fill, application of fertilisers or chemicals, stormwater drainage, groundwater abstraction, surface water abstraction, no liquid or solid waste disposal, and no excavation.

The perimeter of wetland buffers is proposed to be fenced using fauna friendly fences to limit access to the wetland areas. By fencing the wetland buffer wetland access will be limited to pedestrians, and recreational vehicles.

3.6 QUERY 6: OWNERSHIP OF WETLAND BUFFERS

"Wetlands and their buffer areas should be considered to be ceded to the Crown or through other protective or conservation measures."

In a rural subdivision there is no requirement for land to be ceded to the Crown and thus wetland buffers will not be ceded. It is considered that they are adequately protected by the wetland buffer and its associated controls and implementation mechanisms.

4 ROBUSTNESS OF HYDROLOGICAL MODELLING

4.1 QUERY 1: HYDROLOGICAL MODELLING

"Model has not been properly verified and includes a 20% predictive error, indicating a low level of accuracy in describing wetland hydrology."

The issue of calibration of the model has been the subject of further work and this work is reported in Appendix C. Calibration of a model compares model predictions and measured data over a selected period, to allow the adjustment of aquifer parameters to minimise error. However, complete elimination of model error is not possible. The residual error between measured and predicted heads or concentration is indicative of deficiencies either in the calibration process or the conceptual model. The deficiencies in the calibration process typically relate to inappropriate calibration bores, errors in data, and numerical limitations inherent in the model implementation. Deficiencies in the conceptual model typically manifest themselves as systematic errors over large areas, localised areas of high error, and errors that are intractable or insensitive to parameter variations.

The evaluation of calibration error provides a basis on which to modify the conceptual hydrogeological model, improve data fidelity and optimise available resources to efficiently minimise model error. The verification of a numerical model is difficult and suffers from the same limitations as demonstrating that a groundwater model is a unique. Verification of a model is best described as assessing whether the model has any predictive capability, by testing it against data that is independent from the calibration data. The Lake Clifton model was verified using data from November 2008 to April 2010.

A review of the verification simulation shows that the error in this model is similar to the error in the calibration model, suggesting that the calibrated model has some predictive capability. Given that the verification period presents an entirely different hydrological regime than the calibration period, the results of the verification further support the conclusion that the model has some predictive capability. The average absolute error is a measure of the fit of the model, and is 4.0% for the verification flow model. This percentage error is consistent with the accepted modelling guidelines which generally recommend a percentage error less than 5.0%.

"All components of the water mass balance are not captured within the hydrological concept model e.g. water flow and interaction between the lakes are not captured. Evidence presented within the PER indicates the hydrological linkages between the lakes but it was not accounted for in the conceptual or numerical modelling."

It is considered that all significant components of the water mass balance are captured within the hydrological concept model in relation to predicting potential impacts from

the Proposal to the lakes. The Proposal is not considered to have any potential to impact on the hydrological linkages between the lakes.

"Preferential flowpaths through the karst system have been ignored, which given the 20% error should be readdressed."

The 20% references in the question are addressed in 4.1. The hydraulic characteristics of the Tamala Limestone at the location have been incorporated into the groundwater model.

"Local groundwater recharge via subsurface flow of rainfall recharge directly to the lake, therefore bypassing recharge of the deeper groundwater, has not been considered. If nutrients within the surface water flows are significant enough to be considered in the nutrient budgets then so is the quality and quality of the flows".

The nutrients within the surface water flows were considered in the nutrient budgets as these theoretically have the potential to be impacted upon by the Proposal and the public would wish to have this issue considered. Modelling however has shown this not to be the case. In contrast flows from the surface of the lake, as a consequence of rainfall, to the aquifer do not have the potential to be impacted upon by the Proposal and thus were not considered.

"The PER is inconsistent in dealing with leakage to the Leederville Formation for water and solutes."

While this may be the case it is considered that this is of no consequence to the findings of the modelling.

"Scenarios investigated are not informative. Scenario modeling should include investigating potential impacts to the lake under the influences of climate change as well as various scenarios relating to development including increased abstraction, increased discharge via stormwater and effluent systems. "

Climate change scenarios have been provided in Scenarios 3 and 4 of Appendix C. Abstraction scenarios are provided in Scenarios 7 and 8 of Appendix C.

4.2 QUERY 2: WATER BALANCE

"Information regarding the pre-development water balance is not considered to be adequate. It is vitally important to establish whether or not the lake water balance is currently in flux (ie whether all the components, ie inflows and outflows, to the lake are changing as well as whether the lake is moving towards a new and different steady state hydroperiod) and to understand what impacts this alone may have on the lake. Additionally it is necessary to understand what further potential impacts climate change may compound, before even beginning to look at the impacts to the system due to the proposed development."

It is considered that the scenarios described in the above comment are academic. The changes that are speculated upon as possibly occurring would occur independently of the Proposal, whether the Proposal proceeds or not. The modeling performed has shown that;

- No addition of any salt load.
- Total Phosphorus generated by the addition of ATUs is small and likely to be adsorbed by soils.
- Total Nitrogen concentrations are anticipated to increase 6% or from 0.01-0.001mg/L in comparison to the existing concentrations that are between 0.2 mg/L and 8.6 mg/L.
- No change to water levels in Lake Clifton or to its groundwater catchment.

4.3 QUERY 3: GROUNDWATER ABSTRACTION

"How will groundwater abstraction by future residents influence the salinity levels in the groundwater and the Yalgorup Lakes?"

Figure 25 (Appendix C) shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 26 (Appendix C) shows the groundwater level impact due to increased abstraction after 100 years of simulation. The only notable feature is the cone of depression associated with the 4500 kL/annum abstraction from each lot. The drawdown due to this abstraction is a maximum of 0.03 m.

4.4 QUERY 4: MODELLING SCENARIOS

"The PER states the land is currently not being grazed. Therefore the hydrological modelling did not compare the proposal to the current land use rather it compared it to a future potential use. Please comment on the appropriateness of this comparative evaluation."

The Proposal is to change the zoning of the land which currently allows grazing. Indeed grazing is performed on an adjacent property with the same zoning and the subject property has been put to this use throughout most of its recent history. Accordingly it was considered appropriate to compare the proposed land use to grazing.

4.5 QUERY 5: IMPACTS TO THE YALGORUP LAKE SYSTEM

"What is the nature of the impacts from pollutant and nutrient discharge from the proposed subdivision to the Yalgorup Lake System, including to Lake Pollard? Who will

be responsible for monitoring and managing the discharges and the installation of best practice Alternative Treatment Units?"

Changes to hydrological regime have been estimated through the construction and calibration of a numerical hydrological model specifically designed to assess the potential impacts of the Proposal. The model was calibrated and run with the results of a comprehensive field monitoring programme. Further detail regarding the technical aspects of the model is provided in Section 4. Changes to water quality as a result of the Proposal are summarised as follows:

- No addition of any salt load.
- Total Phosphorus generated by the addition of ATUs is small and likely to be adsorbed by soils.
- Total Nitrogen concentrations are anticipated to increase 6% or from 0.01-0.001mg/L in comparison to the existing concentrations that are between 0.2 mg/L and 8.6 mg/L.
- No change to water levels in Lake Clifton or to its groundwater catchment.

Implementation of environmental management will be undertaken and implemented by the Body Corporate. Additionally, by-laws can be used to stipulate the responsibilities of the Strata Company with regards to a range of environmental matters which can be regulated by the Body Corporate. This can include monitoring and managing the discharges and the installation of best practice Alternative Treatment Units.

4.6 QUERY 6: GROUNDWATER MODEL CALIBRATION

"Is the calibration of the groundwater model to a single year adequate? How was the rainfall pattern experienced during the survey year modified to account for inter-annual variability? The role or relevance the studies from 1984 is unclear, particularly in regards to calibration given the shift towards a drier climate since that period."

The issue of calibration of the model has been the subject of further work and this work is reported in Appendix C. Calibration of a model compares model predictions and measured data over a selected period, to allow the adjustment of aquifer parameters to minimise error. However, complete elimination of model error is not possible. The residual error between measured and predicted heads or concentration is indicative of deficiencies either in the calibration process or the conceptual model. The deficiencies in the calibration process typically relate to inappropriate calibration bores, errors in data, and numerical limitations inherent in the model implementation. Deficiencies in the conceptual model typically manifest themselves as systematic errors over large areas, localised areas of high error, and errors that are intractable or insensitive to parameter variations.

The evaluation of calibration error provides a basis on which to modify the conceptual hydrogeological model, improve data fidelity and optimise available resources to efficiently minimise model error. The verification of a numerical model is difficult and suffers from the same limitations as demonstrating that a groundwater model is a unique. Verification of a model is best described as assessing whether the model has any predictive capability, by testing it against data that is independent from the calibration data. The Lake Clifton model was verified using data from November 2008 to April 2010.

A review of the verification simulation shows that the error in this model is similar to the error in the calibration model, suggesting that the calibrated model has some predictive capability. Given that the verification period presents an entirely different hydrological regime than the calibration period, the results of the verification further support the conclusion that the model has some predictive capability. The average absolute error is a measure of the fit of the model, and is 4.0% for the verification flow model. This percentage error is consistent with the accepted modelling guidelines which generally recommend a percentage error less than 5.0%.

4.7 QUERY 7: MODEL CLIMATE PATTERNS

"What sort of climate patterns has the hydrological modelling considered? "

The climate change data used in the model is from CSIRO. The model chosen runs '**C Mid'**, which has a 7% decrease in average rainfall, but results in a 40% increase in runoff when run in the SW. This is the most commonly used scenario by DoW.

The model considers rainfall patterns.

Scenario 1 – Dry Rainfall: is the base case simulation, modified by using the average rainfall sequence from SILO, scaled to 925, to reflect a dry sequence as defined by CSIRO from their climate change analysis, CSIRO, 2010. The parameters used in Scenario 1 simulation are shown in Table 4 of Appendix C.

Scenario 2 – Above Average Rainfall: is the base case simulation, modified by using the wet rainfall sequence as defined by the CSIRO climate analysis. The parameters used in the Scenario 2 simulation are shown in Table 5 of Appendix C.

4.8 QUERY 8: CLIMATE CHANGE SCENARIOS

"How does the model account for climate change? What scenarios have been considered?"

The model accounts for climate change using the sea level rise scenario. Sea level rise is a central element in projecting climate change. It is predicted that sea level could rise by 1.2m by 2110. A recent study of the risks of natural hazards to the Perth region

identified that the stretch of coast between Bunbury and Mandurah as the most vulnerable to coastal erosion due to sea level rise. Sea level will rise during the 21st century as a result of greenhouse gas emissions warming the earth. (CSIRO & ACECRC, 2010).

Scenario 3 – Higher Sea Level : is the case base simulation, with the development lots and modified by using a linearly increasing mean sea level over the 100 year simulation period, to assess the effect of rising sea levels due to global warming.

Scenario 4 – Historic Low Lake Level: is the base case simulation with development, but modified by using a historical minimum lake level in order to stabilize the hydraulic gradient between the groundwater mound to the west and Lake Clifton.

4.9 QUERY 9: GROUNDWATER ALLOCATION

"How will groundwater allocation be limited to 1,500 kL/annum within the lots? "

Groundwater allocation will be limited to 1,500kL/annum within the lots with the use of legislation, the DoW has legislation in place for the Lake Clifton sub – area which states that:

- Under 0.2 ha of lawns and garden, stock water and domestic uses in the superficial aquifer do not require a license.
- All lots with over 0.2 ha of lawns and garden require a licence to install and abstract groundwater from the superficial aquifer.
- All artesian / confined aquifers (Leederville etc) for any usage require a licence both to construct a well and draw water. However, the DoW does not usually support the drawing of water from artesian aquifers.

An abstraction amount of 4,500 kL/annum was applied to the model. This was three times the allowable abstraction amount of kL/annum to allow consideration of a scenario involving overuse. The model showed there was very little change in groundwater contours if an abstraction of 4,500 kL/annum per lot occurred.

4.10 QUERY 10: GROUNDWATER DIVIDE

"The location of the groundwater divide changes seasonally in response to rainfall. Under what scenarios (inter-annual variability) would the location of the east-west groundwater divide presented in the model shift so that discharges from the houses would flow towards the Yalgorup Lakes system? How would this impact the Yalgorup Lake System?"

No inter-annual variability is considered to impact significantly on the location of the east-west groundwater divide. The simulations showed that the model is relatively

insensitive to changes in rainfall and abstraction, but sensitive to changes in sea level, nutrient loading and the hydraulic conductivity of aquifers. However, in all cases the impacts on Lake Clifton are consistent with the previous scenarios and support the conclusion that there is a low probability that the development as presented will have a measurable impact on Lake Clifton.

4.11 QUERY 11: LAKE CLIFTON AS A SALT MARSH

"Further detail should be provided to support that Lake Clifton functions as a salt marsh."

Hale and Butcher (2007) describe habitat components as open water, mudflats, samphire, aquatic plants, paperbark, and sedges.

4.12 QUERY 12: POLLUTANT AND NUTRIENT PARAMETERS

"Further justification for the pollutant and nutrient values presented in the model should be provided."

The pollutant and nutrient values presented in the model are Total Nitrogen per lot = 53 kg/yr (including ATU), this is four times the development scenario. The total phosphorus per lot = 12 kg/yr (including ATU), this is fifteen times the development scenario.

The total nitrogen and total phosphorus loadings were calculated for 24 lots each having a cleared area of 2,500m^2 which would include 11% garden beds (275 m^2) and 28% lawn (700m^2). It was also assumed that 50% of the residences would have dogs of which 35% (5.5 kg) of disposal would go onto each lot.

Scenario 4- Lake Clifton WL

It is predicted that by the 1/1/2110 the average water level at Lake Clifton will decrease in a linear fashion to 0.135 mAHD. This was calculated using DoW Lake Clifton lake level data to date to determine a linear trendline which. This was then extrapolated to estimate 2110 lake levels.

Scenario - 5, 6 and 7

Hydraulic Conductivity (K) is the measure of ease with which water can move through pore spaces in soils. Different soil types have different K values; the soil types used in the model correspond with the soil types found in the Lake Clifton area. The high and low range K values used in the model are half and double the calibrated K values used in the initial model:

- High (m/day);
- Safety Bay Sand 20 – 40;

- Tamala Limestone 40 – 120;
- Low (m/day);
- Safety Bay Sand 5 – 10; and
- Tamala Limestone 10 – 30.

5 CLEARING OF NATIVE VEGETATION

5.1 QUERY 1: IMPACT OF CLEARING

"What is the potential long-term ecological impact of clearing, including both burning and slashing for fuel reduction on the native bush and fauna? Increased weeds, fragmentation, erosion and a changed fire regime have the potential to result in a loss of biodiversity and the degradation of vegetation condition and habitat over time."

Clearing has been restricted to the 2000 m² building envelopes and the strategic firebreaks, which have been proposed for the rural subdivision to minimise the clearing and fragmentation of native vegetation. No further clearing will be undertaken or permitted.

All residents will be provided with information on controlling and managing weeds on their properties. Development and uses will be restricted to the building envelope, with the balance of the lot being required to remain undeveloped and unable to be used for 'rural' purposes. Weed control within the firebreaks will be the responsibility of the Strata Title Company.

Strategic firebreaks will be coated with a hard limestone. The Strata Title Company will be responsible for the maintenance of firebreaks.

5.2 QUERY 2: CLEARING IN TEC BUFFERS

"It is noted that clearing within the buffers of Threatened Ecological Communities is proposed, such as for fire management purposes. The potential impacts and overall effectiveness of the buffers if this should occur should also be discussed and quantified."

The fire break has been realigned to run through the TEC buffer. The existing fire break cuts through the actual TEC area. No impact on the TEC is anticipated as there is enough buffer area to protect the TEC.

5.3 QUERY 3: REGIONAL CONTEXT

"The site is not put into a regional context in relation to EPA Guidance Statement No. 10 (EPA 2004) and the distribution of significant features on and off site was not fully addressed. In addition the full survey data is not provided in electronic form which has been a long-standing expectation stated in EPA Guidance Statement 51."

EPA Guidance Statement No. 10 relates to the Level of Assessment for proposals within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region. As a proposal already determined to be assessed at the PER level, the Scoping Document was developed to address the pertinent factors to be addressed in preparation of the PER, consistent with Guidance Statement 51. The PER discusses the site in terms of

Vegetation Complexes and Floristic Community Types which provide a regional context for the site.

Guidance Statement No 51 states that Environmental Impact Assessment documents be provided in electronic form with mapped data in a digital form. It is not clear what is meant by 'full survey data in electronic form'. The data is included within the Flora and Vegetation report which provides an Appendix to the PER. ENV provides the DEC with data in accordance with the 'Licence to Take Flora for Scientific or Other Prescribed Purposes' under Section 23C of the *Wildlife Conservation Act 1950*. Data could be provided if specifically requested.

5.4 QUERY 4: POTENTIAL IMPACTS TO TUARTS

"How will clearing and any potential impacts to Tuarts (Eucalyptus gomphocephala) be mitigated?"

The reduced clearing footprint has been developed to ensure the Tuart communities will experience a minimal impact due to the clearing of the strategic firebreaks. The majority of the Tuart communities are present in the east of the site. Site inspection of building envelopes provided confirmation no Tuarts were going to be cleared.

The provision of an offset area situated between Boundary Lake and Lake Clifton (Figure 4) will also reduce the impact upon the Tuart communities. The offset area will be vested as conservation. Further discussed in Section 6.3.

There are no anticipated hydrological impacts from the proposed subdivision upon the Tuart Communities.

6 PROTECTION OF CONSERVATION SIGNIFICANT SPECIES

6.1 QUERY 1: LOCAL AND REGIONAL SIGNIFICANCE OF FAUNA

"Adequate understanding of the local and regionally significance of fauna is not provided within the PER. The section in the report dealing with conservation significant fauna only deals with statutory listed species and fails to address those species listed by Government of Western Australia (2000) as declining on the Swan Coastal Plain. A considerable number of species which should be considered are included in Appendix D. Their status in the project area needs to be stated and impacts of the proposal on them should be addressed. A full copy of the survey data in electronic form should be provided."

Fauna are discussed within the report in reference to various levels of significance including International, National, State and locally significant. The Environmental Factors within the Scoping Document indicated that the further studies would be conducted to determine the significance of the site to fauna protected under the *Wildlife Conservation Act 1950* and the *Environment Protection and Biodiversity Protection Act 1999*. The PER addresses species subject to these acts as well as Priority species listed by the DEC and other species of note.

Guidance Statement 56 indicates that reports should be provided in electronic form with mapped data in digital format. It also notes that "… the EPA intends to develop guidance in the near future on the requirements for submission of data from biological surveys." These requirements have not yet been specified. ENV provides the DEC with survey data consistent with the Instructions for the Fauna Survey Returns System. This data is provided as required by the Licence to Take Fauna for Scientific Purposes issued for the project survey under the *Wildlife Conservation Act 1950.*

6.2 QUERY 2: SURVEY METHODOLOGY

"Further detail and justification regarding the methodology to detect difficult to detect species including the western false pipistrelle, the western ringtail possum, the masked owl and the barking owl is required. "

Survey methodology for difficult to detect species included trapping program, nocturnal survey, nocturnal call-playback, general diurnal searches and echolocation recordings**.** The methodology of each technique is described in detail below.

Trapping Methodology

Ten trapping sites were established in the project area. Trapping sites were placed throughout the project area to sample different habitat types and microhabitats.

Each trapping site consisted of up to ten trap lines, with each trapping line comprising Elliott and cage traps to target mammal species; funnel and pit traps to target large reptile species, and pot traps to target small fossorial species. Each trapping line consisted of seven-metre fences, with one bucket trap at the centre of the fence, two pot traps halfway between the bucket trap and the end of the fence, and a funnel trap at each end. The trapping lines were positioned approximately 30m apart, with one Elliott trap and a cage trap at each trapping line. The trapping program was conducted during the spring survey, with traps being open for up to 10 nights. Each trapping site was subjected to an average of 56 trap-nights for bucket, cage and Elliott traps, and 108 trap-nights for funnel traps and pot traps. The total number of traps and trap replicates was 448 and the total number of trap nights is 3,864.

Nocturnal Surveys

Active nocturnal searches by foot, and car were conducted to target nocturnal fauna.

Foot traverses were conducted in the winter survey by walking along tracks and around ponds and other water sources, with the aid of spotlights and head torches, and looking for animals or their eye-shine. Foot traverses targeting the Western Ringtail Possum were conducted during nocturnal surveys, in habitat likely to support them (such as dense stands of *Agonis flexuosa*).

Car traverses were conducted in the spring survey by slowly driving along tracks in the study area and looking for fauna crossing the road or fauna eye-shine from bush adjacent to the road, with the aid of a spotlight.

Passive dusk surveys were conducted by remaining stationary for an hour at dusk and listing for calls of nocturnal (and diurnal) fauna.

Nocturnal Call-Playback

Owl and frog call-playback surveys were conducted during the winter survey. Winter was chosen since it is the breeding time for most south-western frog species, and owls are more likely to respond to owl call during the winter months, when they breed. Calls were broadcast on a high-powered portable CD player.

Owl call playback was conducted by playing calls for about 3 minutes followed by 5 minutes of passive listening, twice for each species at each call playback session. Calls of Barking Owls and Masked Owls were broadcast over 3 nights. While this level of owl call playback does not guarantee detection of all owls that might occur in the project area (Kavanagh and Peake 1993), a shorter survey in the breeding season such as this is good for determining if owls are breeding locally.

General Diurnal Searches

General diurnal searches were undertaken throughout the project area in the spring and the winter surveys for a total of 40 hours. Searches were conducted on foot, and an effort was made to cover most habitat types in the project area. Searches were carried out at points (within an area of approximately 200 m radius), and during longer walking traverses.

General diurnal searches consisted of the following survey techniques:

- ornithological (bird) searches;
- searches for the Western Ringtail Possum (*Pseudocheirus occidentalis*);
- herpetological (reptile) searches; and
- investigations of scats, tracks and other traces of fauna.

Ornithological surveys were conducted with the aid of binoculars, and targeted areas where bird activity was highest, such as around water bodies, flowering plants and patches of higher-quality habitat. Bird calls were also used to identify birds where possible.

Searches for the Western Ringtail Possum, and their traces were conducted during general diurnal searches by looking for Western Ringtail Possum scats, dreys and scratches on trees, in habitat most likely to support them (dense stands of *Agonis flexuosa*).

All other fauna detected during these surveys were recorded. At all times, fauna was opportunistically observed and recorded. Where conservation-significant species were found, GPS co-ordinates were recorded. During all general diurnal searches, scats, tracks and other traces of fauna were investigated.

Bat Echolocation Recordings

Bat recordings were undertaken at dusk and in early evening during the spring survey, using AnaBat II recording units, to document the presence of bat species in the area. The recording units convert ultrasonic echolocation signals produced by bats into audible electronic signals, which are recorded using mini-disc audio recorders and later analysed for species-specific calls. Tree hollows identified as potential roosting or maternal nesting sites were subjected to AnaBat recordings. AnaBat units were also set in areas likely to be used by bat species for foraging (e.g. drainage lines).

AnaBats were set over 4 nights. Anabat recordings were analysed by Mr. Bob Bullen (consulting mammalogist).

6.3 QUERY 3: IMPACTS ON FAUNA

"How will the impacts of the proposal, including fire management measures, on specially protected fauna (WC Act and EPBC Act) be mitigated?"

Mitigation of impacts on specially protected fauna has been undertaken through minimising the total area of vegetation clearing through strategic use of firebreaks and existing tracks, implementation of a Strata Management Company to minimise any consequential impacts, development of a weed management programme and a feral animal trapping and baiting programme. The residual impacts are considered low as the clearing proposed for the site represents approximately 8.7% of the site.

Any residual impacts of the proposal will be mitigated through the provision of an environmental offset. The proposed subdivision includes the potential clearing of 107 ha of Native Vegetation including 13.9 ha of White-tailed Black Cockatoo habitat (5.2 ha foraging and 8.7 ha breeding habitat). Cape Bouvard proposes to cede 84 ha of their landholding to the conservation estate and inclusion into the Yalgorup National Park. The offset area will be ceded at the time of subdivision to the Conservation Commission to be protected in perpetuity.

The area consists of both breeding and foraging habitat for Black Cockatoos and replaces those areas of habitat to be cleared with a ratio of 6 ha in conservation for every hectare cleared. Figure 2 shows the vegetation units which are within the conservation offset. The vegetation within the area is predominantly open woodland of *Eucalyptus gomphocephala, Agonis flexuosa, Banksia grandis, Banksia sessilis* and *Hibbertia hypericoides.* This vegetation is common throughout the proposal area and the proposed offset offers a preferable 'like for like' vegetation offset. For vegetation conditions within the conservation offset see Figure 3.

Additionally, the proposed offset area is located alongside the eastern and western boundary of Boundary Lake. This provides an increased buffer (approximately 180m) on the eastern side and a continuous area of conservation between Boundary Lake and Lake Clifton. Although no waterbird habitat is proposed to be cleared as part of the proposal, the provision of the additional buffer area to Boundary Lake will provide an additional setback distance to waterbird habitat.

6.4 QUERY 4: GRACEFUL SUN MOTH SURVEY

"Has any further survey work confirmed the presence/absence of the Graceful Sun Moth within the site?"

ENV conducted Graceful Sun Moth (GSM) surveys on four separate dates with a minimum of four days separation in March 2010, on warm days (25.6°C-33.2°C), between 10:00 am to 3:00 pm and had wind speeds generally below of 5 m/s (1.32-2.54 m/s). A total of 116 GSM were recorded in the GSM survey area indicating that the species occurs throughout the coastal beach portions of the Clifton Beach Property. A

complete report detailing the methodology and findings of the GSM survey is included as Appendix D to this report.

In summary, the GSM was found to inhabit the coastal area where the sedge *Lomandra maritima* grows. Within the coastal area *Lomandra maritima* is prolific and grows throughout the Quindalup Dunes occupying an area of approximately 210 ha within the site. Upon review of aerial photography a similar vegetation type is found to the north and south within the Yalgorup National Park occupying an area of approximately 1000 ha. The habitat for the GSM is abundant within the local area and already in a conservation reserve.

The Proposal will not cause any impacts to the current distribution of GSMs within the site as the existing tracks and firebreaks will be maintained. Approximately 5 ha of GSM habitat will be cleared as a result of the Proposal which constitutes 2% of the total available habitat within the site.

6.5 QUERY 5: NOISE

"What are the potential impacts to fauna from noise pollution post development?"

The introduction of 24 survey strata lots is unlikely generate any significant noise as there are no permitted landuses that will cause noise.

6.6 QUERY 6: LIGHT

"Is there a potential for impact on nocturnal fauna (including owls and marsupials) on an increase of light pollution post subdivision?"

The introduction of 24 survey strata lots is unlikely generate any significant light pollution as they are proposed for residential use. The only lights introduced are from individual homes and will consist of domestic lights only. The roads will not have street lamps.

6.7 QUERY 7: DOMESTIC PETS

"How will fauna and avifauna be protected from residents and domestic pets?"

The Level Two Fauna Survey found that the site is currently occupied by feral animals including the house mouse (*Mus musculus),* rabbit (*Oryctolagus cuniculus)*, red fox (*Vulpes vulpes*), dog (*Canis lupis familiaris*) and pig (*Sus scrofa*). The proponent will undertake a feral animal management program aiming to reduce the amount of feral animals within the site.

Upon the introduction of the feral animal management program it is anticipated that this will reduce the total amount of feral animals within the site in turn, limiting impacts to both fauna and avifauna and mitigating any impacts from domestic pets.

7 OPENING OF ACCESS TO REMOTE AREAS

7.1 QUERY 1: BEACH ACCESS POINT

"What potential impacts are expected from beach access points from each lot? How will these potential impacts be managed?"

The strata management company will be responsible for the foreshore management plan. As part of the subdivision development there will be wooden steps provided (one per two lots) which the Strata management company will maintain as part of the common area.

7.2 QUERY 2: CONSTRUCTION OF ROAD

"The subdivision will provide access trail bike riders and 4WD to remote area. Will the construction of 5km of road through the National Park be required? How will this be controlled post development?"

The proposal is a private development therefore access will be restricted to the individual landowners only.

7.3 QUERY 3: ACCESS TO NATIONAL PARK

"How will access to Yalgorup National Park be controlled?"

As for 7.2, the subdivision will have a private road that is accessed by the individual landowners only. The road will be fenced with open weave fencing to allow safe passage of fauna.

8 STRATEGY FOR FIRE MANAGEMENT

8.1 QUERY 1: WATER FOR BUSHFIRE FIGHTING

"How will water for bushfire fighting purposes be sourced?"

Water for fire fighting purposes will be sourced initially from the fire tanks stationed in strategic locations throughout the subdivision. These 50,000 litre tanks are to be filled initially from existing ground water (if allowed) and refilled as and when used for fire fighting from ground water from existing sources. If this approach is not allowed, water will need to be sourced from an off-site resource. It is the responsibility of the Strata Title Company to ensure tanks are kept filled.

8.2 QUERY 2: FIREBREAK MAINTENANCE

"Who is responsible for maintaining firebreaks? What mechanism will ensure firebreaks will be maintained, particularly given the susceptibility of the Quindalup dunes to erosion?"

Strategic firebreaks only will be constructed on the perimeter of the strata scheme with internal firebreaks following roads rather than boundaries (Figure 1). The firebreaks will be hard coated with limestone to prevent erosion. The by laws can stipulate maintenance responsibilities and these can be regulated by the Body Corporate.

8.3 QUERY 3: SECOND EGRESS

"The proposal does not appear to have a safe two way access and egress available."

An alternative engineered fire safety strategy is being developed in consultation with FESA making a two way egress not necessary.

8.4 QUERY 4: CLEARING FOR FIRE MANAGEMENT

"Clearing for fire management should be agreed with the City of Mandurah, Shire of Waroona, the Fire and Emergency Service Authority (FESA) and the amount of clearing and locations for firebreaks should be articulated."

This is articulated in the Fire Management Plan (Appendix B).

8.5 QUERY 5: WEED MANAGEMENT

"How will weed management occur along firebreaks?"

Weed management is the responsibility of the Strata Title Company.

8.6 QUERY 6: BURNING PROGRAM

"Who will monitor and dictate the burning program post development?"

Should burning be required to reduce fuel loads it will be the responsibility of the Strata in conjunction with appropriate fire management expertise to monitor and dictate a burning program.

8.7 QUERY 7: FUEL REDUCTION

"How do future landowners assess the amount of fuel reduction required to achieve a level of 6-8 tonnes/ha?"

It is the responsibility of the Strata Company to maintain the required level of fuel loads around all infrastructures.

8.8 QUERY 8: FIRE MANAGEMENT PLAN

"There is a general concern that the fire management regime will be imposed on Yalgorup National Park which may both impact biodiversity and result in additional cost to the State. This offsite impact has not been adequately considered."

The fire management plan envisages that the proposal will be self contained.

9 LOGISTICS OF MANAGEMENT AND IMPLEMENTATION STRATEGY

9.1 QUERY 1: NOTIFYING LANDOWNERS OF LEGISLATIVE RESPONSIBILITIES

"Describe the mechanism for notifying landowners of legislative responsibilities to Declared Rare Flora and Conservation significant fauna. How will the activities of future landowners be monitored and regulated and by whom?"

The by laws can stipulate responsibilities of landowners towards Declared Rare Flora and Conservation significant fauna. These responsibilities can be regulated by the Body Corporate.

9.2 QUERY 2: THREATENED ECOLOGICAL COMMUNITIES

"How will the proponent ensure that Threatened Ecological Communities, Priority Flora, and wetland vegetation clearing will be consistent with the commitments in the PER?"

The by laws stipulate the responsibilities of the landowners towards Threatened Ecological Communities, Priority Flora and wetland vegetation clearing. It is the responsibility of the Body Corporate to ensure clearing will be consistent with the commitments in the PER. Caveats will be placed on the titles.

9.3 QUERY 3: ONGOING MANAGEMENT

"Further detail is required regarding how ongoing management of the subdivision will occur including responsible parties and implementation of a local planning policy and a number of management plans."

The by laws can stipulate the responsibilities of the Strata Company with respect to the maintenance of all common property roads, fire fighting equipment and common buildings. These responsibilities can be regulated by the Body Corporate.

9.4 QUERY 4: ADDITIONAL CLEARING

"How will additional clearing beyond that specified in the PER be prevented?"

The by laws can point to the responsibilities of landowners in regards to additional clearing beyond that specified in the PER. These responsibilities can be regulated by the Body Corporate.

9.5 QUERY 5: OTHER RESTRICTIONS

"How will landowners be informed of other restrictions on their property such as boundary fencing, clearing, wetland buffers, domestic animals, groundwater abstraction, and significant flora? Who will monitor the activities of the future landowners to ensure the desired outcome was achieved?"

The by laws can stipulate responsibilities of the Strata Company with respect to the compliance of all landowners with boundary fencing requirements, clearing restrictions, wetland buffer requirements, the prohibition of domestic animals and livestock, groundwater abstraction and protection of significant flora. These responsibilities can be regulated by the Body Corporate.

9.6 QUERY 6: ENVIRONMENTAL MANAGEMENT PLAN

"Further details regarding an environmental management plan should be provided including how it will be prepared, implemented, associated timeframes and ongoing responsibilities."

An environmental management plan (EMP) will be prepared for the site detailing future management of subdivision in relation to significant vegetation, rare flora, fauna, and the surrounding natural environment (i.e. Yalgorup National Park). Preparation, development and implementation of the EMP will be the responsibility of the Strata Title Company. The Body Corporate will be reporting annually on its environmental and fire performance obligations and these are made available to the local authority and DEC on an annual basis. The EMP will be prepared prior to subdivision of the site, the ultimate timing of construction has not yet been determined. The EMP will be prepared with the involvement of the Department of Environment and Conservation.

The following outcomes will be achieved through the Environmental Management Plan:

- Strategy for maintenance of vegetation condition and diversity;
- A weed management programme including monitoring, contingency measures and performance criteria;
- A baiting and trapping programme to control feral animals including methodology, monitoring, contingency measures and performance criteria;
- Construction management guidelines; and
- Guidelines for future landowners regarding the conservation values of the area and advice on legislative requirements with respect to Declared Rare Flora and Fauna.

9.7 QUERY 7: FORESHORE MANAGEMENT PLAN

"Further details regarding a foreshore management plan should be provided including how it will be prepared, implemented, associated timeframes and ongoing responsibilities."

A foreshore management plan (FMP) will be developed to help to ensure the conservation of the natural environment and biodiversity of the coastline adjacent to the subdivision. Preparation, development and implementation of the EMP will be the responsibility of the Strata Title Company. The FMP will be prepared prior to subdivision of the site, the ultimate timing of construction has not yet been determined. The FMP will be prepared with the involvement of the Department of Environment and Conservation and the Department of Planning.

The following outcomes are anticipated from the Foreshore Management Plan:

- Further description and justification of foreshore reserves and allowable uses within them;
- A programme for weed management, rehabilitation, and/or revegetation that may be required;
- Identification and management strategies for any areas requiring dune stabilisation and erosion control;
- Locations and description of controlled pedestrian and vehicle access points; and
- Descriptions of any additional infrastructure (lighting, rubbish disposal) or signposting that may be required.

9.8 QUERY 8: URBAN WATER MANAGEMENT PLAN

"Further details regarding an urban water management plan should be provided including how it will be prepared, implemented, associated timeframes and ongoing responsibilities. Additionally, the urban water management plan should be referred to the Department of Water, Shire of Waroona, and City of Mandurah."

It is expected that the urban water management plan (UWMP) will be prepared in response to a condition of the subdivision approval. The Strata Title Company will prepare the UWMP and it will be submitted to the DoW for its approval to clear the condition. The UWMP will be prepared immediately upon the approval from the Minister and it will be implemented by the Strata Company. Timing will be dictated by the timing of implementation of the project and thus cannot be described at this date.

An Urban Water Management Plan (UWMP) will provide a strategy for total water cycle management within the subdivision and demonstrate its adherence to water sensitive urban design and consideration of the natural environment. The UWMP will be

prepared consistent with the parameters outlined in *Better Urban Water Management* (Western Australian Planning Commission, 2008).

An Urban Water Management Plan will provide the following outcomes:

- An outline of design objectives;
- A strategy for fit for purpose water planning and water conservation;
- A management strategy for surface water and groundwater to ensure pre-development regimes will be adhered to;
- A programme for nutrient management within the subdivision;
- An implementation strategy and;
- Guidelines for any monitoring programs including methodology, contingency measures and performance criteria.

9.9 QUERY 9: WETLAND MANAGEMENT PLAN

"The scope of the proposed Wetland Management Plan should be clarified including the scope, content, application, and identification of the responsibilities for each of the relevant parties."

The scope of the Wetland Management Plan will be to manage recreational use, protect wetland vegetation, weed and feral animal control, protection of habitat for water birds and migratory birds, protect Thrombolites and maintain the hydrology of the wetlands.

The wetland management plan will be consistent with the DEC's guidelines in preparing a wetland management plan (DEC, 2008). The plan will be developed by the Strata Management Company prior to subdivision.

The following outcomes will be achieved within the Wetland Management Plan:

- A specific vision to ensure the wetland's values and attributes are conserved;
- Locations and details of any infrastructure required to protect wetland values (ie. Fencing, signposting);
- Rehabilitation or weed management that may be required;
- A description of a community education program; and
- Guidelines for future monitoring programs, including methodology, contingency measures and performance criteria.

10 REFERENCES

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Government of Western Australia (2000). Bush Forever Volume 2: Directory of Bush Forever Sites. Department of Environmental Protection, Perth.

Hale, J and Butcher, R. (2007) *Ecological Character of the Peel Yalgorup wetland of international importance*. Department of Conservation and Land Management, Western Australia.

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Western Australian Planning Commission (2003) *Statement of Planning Policy No. 2.6: State Planning Policy.* Government Gazette Western Australia 10 June, 2003.

Western Australian Planning Commission (2005) *Draft Guidelines for the Determination of Wetland Buffer Requirements*. State of Western Australia December 2005

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FIGURES

N

0 200 400 600 800

Metres

Legend

- Study Area
- Lot Boundaries
- Carnaby's Cockatoo Habitat
- Proposed Offset Boundary
- Building Envelope
- Fire Bunker

Total Proposed Clearing

- Building Protection Zone/Hazard Seperation Area
- 6m wide firebreak
- 4m wide firebreak (Existing)
- 20m wide firebreak
- 6m wide driveway

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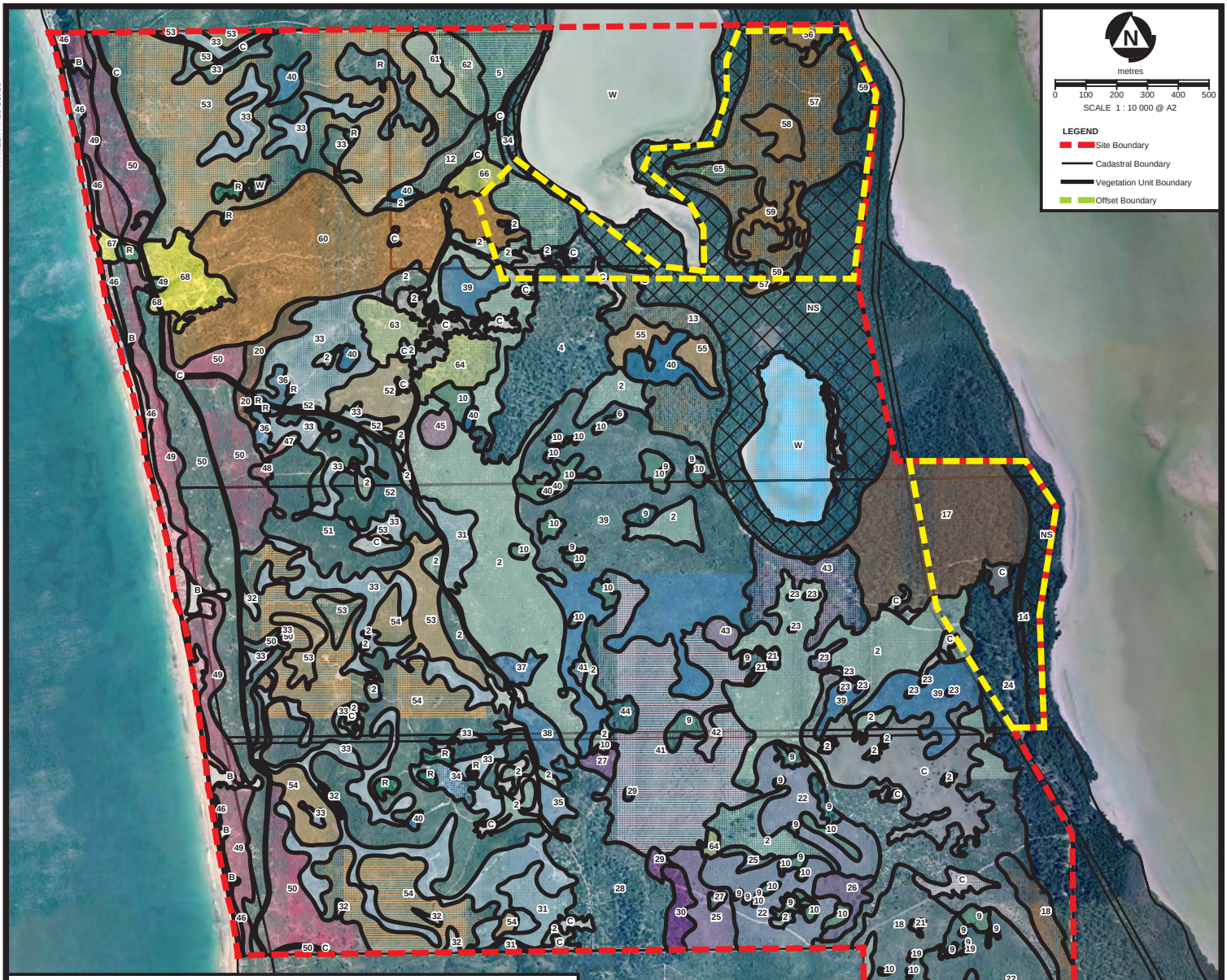
CLIENT	JOB NO.
Cape Bouvard Investments	10.080
AUTHOR:	DRAWN / DATE
S. Smart	S. Rho / 07-01-2011
SCALE	PROJECTION
1:16,000 @ A3	GDA 94 MGA 50

Proposal Footprint

Clifton Beach Response to Submissions

FIGURE 1

PRINTED: Fri 15 Oct 10



VEGETATION UNITS LEGEND

1 Open Woodland of *Eucalyptus gomphocephala* and *Agonis flexuosa* over *Hibbertia cuneiformis*, *Xanthorrhoea preissii*.
2 Shrubland of *Xanthorrhoea preissii*.
3 Open Tree Mallee of *Eucalyptus petrensis* over *Xanthorrhoea preissii*, *Templetonia retusa*, *Hakea prostrata*, *Melaleuca systena*, *Hibbertia cuneiformis* with scattered *Eucalyptus gomphocephala*.
4 Woodland of *Banksia attenuata* over *Macrozamia riedlei*, *Xanthorrhoea preissii*, *Parietaria debilis*, *Geranium retrorsum* and *Daucus glochidiatus* with scattered *Eucalyptus gomphocephala*.
5 Low Woodland of *Agonis flexuosa* over *Acacia rostellifera*, *Hibbertia cuneiformis*.
6 Low Shrubland of *Hakea prostrata*, *Melaleuca systena*, *Xanthorrhoea preissii*, *Banksia sessilis*, *Templetonia retusa* and *Hibbertia hypericoides*.
7 Open forest of *Eucalyptus gomphocephala*, *Agonis flexuosa* over *Xanthorrhoea preissii*.
8 Low Woodland of *Eucalyptus marginata*, *Agonis flexuosa*, *Xanthorrhoea preissii*, *Hibbertia hypericoides*, *Eucalyptus gomphocephala*, *Banksia grandis*.
9 Pockets of *Eucalyptus petrensis*.
10 Pockets of *Melaleuca huegelii*.
11 Individual *Xanthorrhoea preissii* in clearing.
12 Woodland of *Agonis flexuosa* over *Xanthorrhoea preissii* and *Hibbertia cuneiformis*.
13 Open Woodland of *Agonis flexuosa* and *Eucalyptus gomphocephala* (scattered).
14 Low Woodland to Open Heath of *Melaleuca viminea*, *Melaleuca naphiophylla*, *Melaleuca cuticularis* over *Melaleuca teretifolia*, *Gahnia trifida* and *Juncus kraussii* subsp. *australiensis*.
15 Open Woodland of *Agonis flexuosa* over *Melaleuca systena*, *Acacia rostellifera*, *Hibbertia cuneiformis* and *Xanthorrhoea preissii*.
16 Tall Open Scrub of *Melaleuca systena*, *Acacia rostellifera*, *Xanthorrhoea preissii*, *Banksia sessilis* with *Eucalyptus gomphocephala* (scattered).
17 Open Woodland to Woodland of *Agonis flexuosa*, *Eucalyptus gomphocephala* over *Xanthorrhoea preissii*, *Acanthocarpus preissii*, *Acacia rostellifera*, *Spyridium globulosum*, *Clematis pubescens* and *Phyllanthus calycinus*.
18 Open Low Heath of *Melaleuca systena*, *Templetonia retusa* with scattered *Xanthorrhoea preissii* and *Hakea prostrata* with patches of *Melaleuca huegelii*.
19 Stand of *Eucalyptus decipiens* subsp. *decipiens*.
20 Low Woodland of *Agonis flexuosa* over *Parietaria debilis*, *Spyridium globulosum*, *Lobelia tenuior* over *Hibbertia cuneiformis*.
21 Pockets of *Eucalyptus foecunda*.
22 Open Heath of *Hakea prostrata*, *Melaleuca systena*, *Trymalium ledifolium*, *Templetonia retusa*, *Banksia sessilis* with scattered *Eucalyptus decipiens* subsp. *decipiens*, *Eucalyptus foecunda* and *Eucalyptus petrensis*.
23 Pockets of *Eucalyptus gomphocephala*.
24 Open Woodland of *Agonis flexuosa*, *Eucalyptus gomphocephala*, *Banksia attenuata* and *Banksia grandis* over *Xanthorrhoea preissii* and *Macrozamia riedlei*.
25 Shrubland of *Melaleuca systena*, *Hakea prostrata*, *Banksia sessilis*, *Melaleuca huegelii*, *Xanthorrhoea preissii* and *Grevillea preissii*.
26 Tree Mallee of *Eucalyptus decipiens* subsp. *decipiens* over *Melaleuca systena*, *Xanthorrhoea preissii*, *Templetonia retusa*, *Daucus glochidiatus* and *Hardenbergia comptoniana*.
27 Woodland of *Eucalyptus gomphocephala*, *Xanthorrhoea preissii* and *Melaleuca systena*.
28 Woodland of *Agonis flexuosa* over *Acacia rostellifera*, *Clematis pubescens*, *Hibbertia cuneiformis*, *Acanthocarpus preissii* and *Melaleuca systena*.
29 Pockets of *Eucalyptus marginata*.
30 *Melaleuca huegelii*, *Melaleuca systena*, *Templetonia retusa*, *Clematis pubescens*, with scattered *Eucalyptus gomphocephala*, *Xanthorrhoea preissii* and *Eucalyptus petrensis*.
31 Tall Shrubland of *Acacia rostellifera*, *Xanthorrhoea preissii* and *Acacia saligna*.
32 Pockets of **Trachyandra divaricata*.
33 Low Shrubland of *Melaleuca systena*, *Lomandra maritima*, *Templetonia retusa*, *Phyllanthus calycinus* and *Acanthocarpus preissii*.
34 Pockets of *Agonis flexuosa*.
35 Shrubland of *Xanthorrhoea preissii*, *Banksia sessilis* with scattered *Nuytsia floribunda*.
36 Low Shrubland of *Templetonia retusa*, *Parietaria debilis*, *Phyllanthus calycinus*, *Melaleuca systena*, *Clematis pubescens*, *Acanthocarpus preissii* and *Trachymene pilosa*.
37 Open Woodland of *Eucalyptus gomphocephala* over *Xanthorrhoea preissii*.
38 Tall Shrubland of *Acacia rostellifera*, *Melaleuca systena* and *Templetonia retusa*.
39 Shrubland of *Melaleuca systena*, *Templetonia retusa*, *Hakea prostrata* (scattered), *Xanthorrhoea preissii*, *Banksia sessilis* and *Phyllanthus calycinus*.
40 Pockets of *Acacia rostellifera*.
41 Open Heath of *Melaleuca huegelii*, *Xanthorrhoea preissii*, *Templetonia retusa*, *Melaleuca systena*, *Hibbertia hypericoides*, *Hardenbergia comptoniana*, *Clematis pubescens* with pockets of *Eucalyptus petrensis*, *Eucalyptus foecunda* and *Eucalyptus argutifolia*.
42 Open Heath of *Melaleuca huegelii* and *Melaleuca systena*.
43 Open Heath of *Acacia rostellifera*, *Melaleuca huegelii*, *Templetonia retusa*, *Melaleuca systena* and *Clematis pubescens*.
44 Closed Tree Mallee of *Eucalyptus petrensis*, *Eucalyptus foecunda* and *Eucalyptus argutifolia*.
45 Woodland of *Banksia attenuata* over *Macrozamia riedlei*, *Xanthorrhoea preissii*, *Hibbertia huegelii*, *Geranium retrorsum* and *Daucus glochidiatus*.
46 Low shrubland of *Scaevola crassifolia*, *Olearia axillaris*, *Jacksonia furcellata*, *Ficinia nodosa*, *Spinifex hirsutus*, *Acacia cochlearis* and *Lepidosperma gladiatum*.
47 Open heath of *Acacia rostellifera*, *Melaleuca systena*, *Spyridium globulosum*, *Lomandra maritima* and *Acanthocarpus preissii*.
48 Woodland of *Eucalyptus gomphocephala* over *Spyridium globulosum*, *Lepidosperma gladiatum* and *Clematis pubescens*.
49 Open Heath of *Spyridium globulosum*, *Alyxia buxifolia*, *Olearia axillaris*, *Acanthocarpus preissii* and *Diplolaena dampieri*.
50 Closed Heath of *Acacia rostellifera*, *Spyridium globulosum*, *Phyllanthus calycinus*, *Melaleuca systena*, *Acanthocarpus preissii*, *Trachymene pilosa* and *Alyxia buxifolia* with scattered *Agonis flexuosa*.
51 Closed Tall Scrub of *Acacia rostellifera*, *Spyridium globulosum*, *Alyxia buxifolia*, *Melaleuca systena*, *Lomandra maritima* and *Acrotriche cordata*.
52 Closed Tall Scrub of *Acacia rostellifera*, *Melaleuca systena* and *Xanthorrhoea preissii*.
53 Low Open Heath of *Acacia rostellifera*, *Acanthocarpus preissii*, *Hibbertia cuneiformis*, *Melaleuca systena*, *Clematis pubescens* and *Acacia cochlearis*.
54 Low Open Forest of *Agonis flexuosa* over *Melaleuca systena*, *Spyridium globulosum*, *Acanthocarpus preissii*, *Lomandra maritima*, *Phyllanthus calycinus*, *Templetonia retusa*, *Acacia rostellifera*, with scattered *Olearia axillaris*.
55 *Woodland of Agonis flexuosa over Melaleuca systena*, *Acacia rostellifera* and *Templetonia retusa*.
56 Pockets of *Banksia sessilis*.
57 Open Forest of *Eucalyptus gomphocephala*, *Agonis flexuosa*, *Banksia grandis* and *Nuytsia floribunda* over *Banksia sessilis*, *Hibbertia hypericoides*, *Xanthorrhoea preissii*, *Melaleuca systena*, *Macrozamia riedlei*, *Hakea lissocarpha* with scattered *Eucalyptus decipiens* and *Banksia littoralis*.
58 Tall Open Scrub of *Banksia sessilis* with scattered *Xanthorrhoea preissii*, *Hibbertia hypericoides*, *Eucalyptus gomphocephala* and *Banksia grandis*.
59 Woodland of *Melaleuca cuticularis*, *Eucalyptus gomphocephala* and *Agonis flexuosa* over *Templetonia retusa*, *Gahnia trifida*, *Samolus junceus*, *Baumea vaginalis*, *Acacia rostellifera* and *Acacia truncata*.
60 Low Open Forest of *Agonis flexuosa* over *Spyridium globulosum*, *Hibbertia cuneiformis*, *Trachymene pilosa*, *Acanthocarpus preissii*, *Alyxia buxifolia* and *Acrotriche cordata*.
61 Open Heath of *Xanthorrhoea preissii*, *Melaleuca systena*, *Hakea prostrata* with planted *Eucalyptus platypus*.
62 Low Shrubland of *Hibbertia cuneiformis*, *Clematis pubescens*, *Templetonia retusa* and *Melaleuca systena* with scattered *Agonis flexuosa*.
63 Tall Shrubland of *Acacia rostellifera*, *Banksia sessilis*, *Spyridium globulosum* and planted trees.
64 Open Woodland of *Agonis flexuosa* over *Xanthorrhoea preissii* and *Acacia rostellifera*.
65 Shrubland of *Acacia cochlearis*, *Melaleuca systena* and *Templetonia retusa*.
66 Low Shrubland of *Melaleuca systena*, *Templetonia retusa*, *Clematis pubescens*, **Trachyandra divaricata*, **Gomphocarpus fruticosus* and *Parietaria debilis*.
67 Low Open Shrubland of *Olearia axillaris*, *Spyridium globulosum*, *Templetonia retusa*, **Trachyandra divaricata* and *Tetragonia decumbens*.
68 Open Shrubland of *Spyridium globulosum*, *Olearia axillaris*, *Alyxia buxifolia*, *Leucopogon parviflorus*, *Acanthocarpus preissii*, *Diplolaena dampieri*, *Acacia truncata* and *Acrotriche cordata*.

W Water
C Cleared
R Rehabilitated areas, mostly with non-endemic species
Not Surveyed
B Blowout

CLIENT		JOB NO.	
Cape Bouvard Investments		10-080-f1.dgn	
AUTHOR	DRAWN	DATE	
S Smart	CR / TE	7-10-10	
SCALE	PROJECTION		
1:20 000 @ A4	GDA49 MGA50		

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Cape Bouvard Investments
Clifton Beach Rural Subdivision
Vegetation Units
FIGURE 2

Legend

- Study Area
- Proposed Offset Boundary
- Lot Boundaries

Vegetation Condition

- Excellent
- Very Good - Excellent
- Very Good
- Good
- Degraded
- Completely Degraded

N

0 200 400 600 800

Metres

CLIENT		JOB NO.
Cape Bouvard Investments		10.080
AUTHOR:	DRAWN	DATE
S.Smart	S.Smart	8-10-2010
SCALE	PROJECTION	
1:16,000 @ A3	GDA 94 MGA 50	

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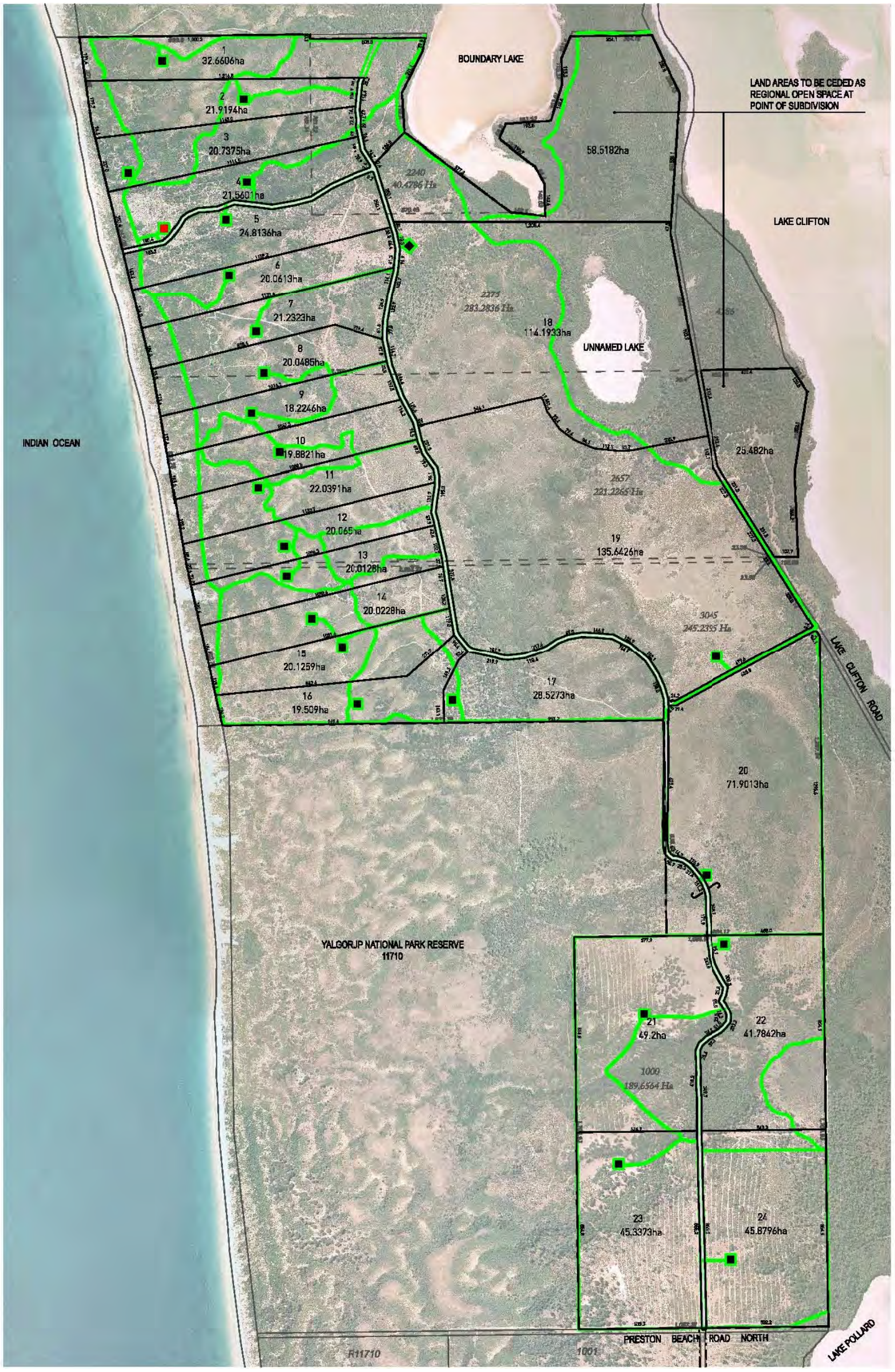
Vegetation Conditions

Clifton Beach Rural Subdivision

FIGURE **3**



SUBDIVISION BOUNDARY AREA
BUILDING ENVELOPE
FIRE BREAKS (EASEMENTS ON TITLES)
FIRE BUNKER
INTERNAL ROADS (EASEMENTS ON TITLES)

CLIENT		JOB NO.
Cape Bouvard		10-080-4.dgn
AUTHOR	**DRAWN**	**DATE**
S. Smart	T Ellis	13-01-2011
SCALE	**PROJECTION**	
N/A	GDA49 MGA50	

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Proposed Subdivision & Offsets

Clifton Beach Rural Subdivision

FIGURE 4

APPENDIX A

LETTERS FROM LOCAL AUTHORITIES

PERTH
SYDNEY

Our Ref: 708-096

9 July 2010

Chief Executive Officer
City of Mandurah
PO Box 210
MANDURAH WA 6210

Attention: Ms Fiona Mullin

Chief Executive Officer
Shire of Waroona
PO Box 20
WAROONA WA 6215

Mr Ross Davidson

TOWN PLANNING
AND URBAN DESIGN

Dear Fiona and Ross

LOTS 2240, 2275, 2657, 3045 AND 1000, CLIFTON BEACH

I refer to our meeting on the 21 June 2010 and in particular, our discussion in response to the Public Environmental Review (PER) undertaken for a proposed rural subdivision of the abovementioned site.

The City of Mandurah and Shire of Waroona expressed a number of concerns relating to the enforcement of controls to address planning and environmental matters. Specifically, concerns were raised with regards to the proposition that a Local Planning Policy, as a mechanism to implement development standards and address environmental and ongoing management matters, would be an imposition on Council resources and in effect be statutorily inappropriate.

Discussions held with the Department of Planning (Mr Cameron Bulstrode), have identified that a more appropriate method to addressing the planning and environmental matters raised by the two Local Authorities would be to undertake a survey-strata subdivision of the site.

A survey-strata for a rural subdivision of the site would effectively result in the creation of one lot comprising 24 strata titles. The one lot would be private property (situated within the City of Mandurah and Shire of Waroona local government areas), with access into the subdivision via a private road controlled such that it would not be open to the general public.

In undertaking a survey-strata subdivision of the site, conditions of subdivision can be applied to address relevant planning, environmental and fire management controls. In addition, communal infrastructure items and relevant management matters can be identified within strata by-laws with responsibility for regulation and enforcement undertaken by a strata management company (or Body Corporate).

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The Planning Group WA Pty Ltd
ABN 36 097 273 222

The following details the envisaged approach to addressing the relevant planning and environmental matters.

Fire Management

The preparation of a Fire Management Plan (FMP) to address fire management measures can be undertaken as a condition of subdivision and implemented through strata company by-laws regulated by the Body Corporate.

The FMP will identify relevant fire control mechanisms to be undertaken on the site. It is envisaged these would include:

- The provision of strategic firebreaks to the perimeter of the strata scheme and along internal roads (rather than lot boundaries); and
- The identification of fire hazard zones around dwellings.

Implementation of the FMP together with ongoing costs associated with the maintenance of firebreaks and fire fighting infrastructure (e.g: pumps, water storage tanks) can be enforced through by-laws regulated by the Body Corporate.

Environmental Management

Conditions of subdivision approval can be applied to address relevant environmental requirements and management matters relating to the site including any requirement to rehabilitate degraded areas of the site or preparation of any environmental management plans.

It is envisaged that strata by-laws will be used to stipulate responsibilities of the Strata Company with regards to a range of environmental matters which can be regulated through the Body Corporate. These can include:

- Identifying responsibilities of landowners towards the protection of Declared Rare Flora and Conservation significant fauna;
- The fencing of conservation areas to ensure their protection;
- The provision of buffers to wetland areas;
- Identifying responsibilities of landowners including clearing as specified in the PER; and
- The provision of ongoing water monitoring/extraction, with the results being lodged with the Department of Water.

Development Control and Management of Communal Facilities

The identification of building envelopes described by GPS coordinates and annotated on the survey Strata Plan will be used to control the location and extent of new development on each strata lot. Developments must comply with the Strata Title by-laws and thus developments can only be approved within the building envelopes.

Ms Fiona Mullins
City of Mandurah

Mr Ross Davidson
Shire of Waroona

Lots 2240, 2275, 2657, 3045 and 1000, Clifton Beach

Additionally it is proposed that strata by-laws will be used to address a range of land use and development matters as well as responsibilities for the provision and ongoing maintenance of communal facilities. Strata by-laws will be used to stipulate responsibilities of the Strata Company (regulated through the Body Corporate) with regards to a range of matters including:

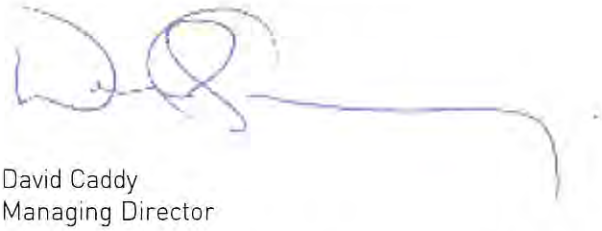
- Landowner requirements with regards to the provision and maintenance of boundary fencing;
- Restrictions/prohibitions on domestic animals and/or livestock;
- Restrictions on land use permissibility which may be required under the Rural zone;
- The maintenance of common property roads, fire fighting equipment, common buildings and fencing; and
- The management and disposal of domestic rubbish.

To enable Cape Bouvard Investments to progress the above approach, we seek confirmation as to whether the survey strata of the rural subdivision, enforced via subdivision conditions from the WAPC and strata titling by-laws as outlined above, is considered acceptable to the City and Shire in addressing the various planning and environmental issues raised.

Should you have any queries in relation to the above, please do not hesitate to contact the undersigned.

YOURS SINCERELY

TPG TOWN PLANNING AND URBAN DESIGN



David Caddy
Managing Director

cc. Cameron Bulstrode, Department of Planning
Peter Van Gent, Cape Bouvard Investments

SHIRE OF WAROONA SEA TO SCARP

Our Ref: SD119271
6th August 2010

The Planning Group WA Pty Ltd
Attn: David Caddy
PO Box 7375
Cloisters Square
PERTH WA 6850

Dear David

LOTS 2240, 2275, 2657, 3045 AND 1000 PRESTON BEACH

With reference to your letter of the 9 July 2010 on a modified subdivision proposal for the properties above, I wish to advise that Council appreciated the opportunity to discuss the modified proposal with representatives from TPG, Cape Bouvard Investments and FESA. In addition a recent inspection of the land in company with Mr Peter Van Gent was carried out and this provided valuable insights into the project.

In respect to preliminary comments from Council, the modified proposal appears to achieve a more satisfactory outcome. There is a much lighter footprint on the land and particularly the vegetation, which is by and large in very good condition and well representative of coastal taxa. By not having to put in lot boundary firebreaks for each individual lot as originally proposed and by upgrading existing tracks into strategic firebreaks, a considerable amount of clearing is avoided.

Furthermore, the fact that the majority of the land will be common property and under the control of the Strata Management Company will prevent even the unintentional clearing by landowners as often happens with larger lots.

From Council's perspective the fact that the internal subdivisional roads will be private and hence not maintained by Council is an important difference between the original proposal and this modified one. However, the issue of only one access from the public road system is still a matter of concern and is yet to be resolved.

Without prejudice, Council is generally supportive of the direction in which the project now appears to be heading. Naturally there is much still to be done, especially in connection with environmental issues, but setting that aside the proposal has much to commend it.

Should you have any further queries they will need to be addressed to the new Manager of Planning Services, Mr Louis Fouche who will commence on 9 August 2010.

Your Sincerely

ROSS DAVIDSON
MANAGER PLANNING SERVICES

PERTH
SYDNEY

Our Ref: 708-096

08 October 2010

Chairman
Environmental Protection Authority
Locked Bag 33
CLOISTERS SQUARE WA 6850

TOWN PLANNING
AND URBAN DESIGN

Attention: Leanne Thompson

Dear Leanne

ADDITIONAL PLANNING INFORMATION FOR PUBIC ENVRIONMENTAL REVIEW - LOTS 2240, 2275, 2657, 3045 AND 1000, PRESTON BEACH ROAD NORTH, CLIFTON BEACH

Cape Bouvard Investments (CBI) has requested TPG Town Planning and Urban Design (TPG) provide a response to the planning related queries identified in your email correspondence to Peter van Gent. We are pleased to provide the following information for the proposed rural subdivision of the abovementioned site.

The proposal will not require an amendment to the Shire of Waroona and the City of Mandurah's Planning Schemes to allow 'Grouped Dwellings' to occur in the rural zones. This is because the proposed subdivision will not contain common property or 'Grouped Dwellings'.

The survey strata subdivision will contain a single house on each of the survey-strata lots. Easements will be provided over the internal private roads and firebreaks, with the fire hub being contained within its own survey strata lot. A copy of the proposed rural survey-strata concept is provided as an attachment to this correspondence.

As no common property will form part of the subdivision, the proposal meets the Western Australian Planning Commission's (WAPC) Residential Design Codes definition of a 'Single House' which is a permitted land use under both of the local planning schemes.

Irrespective of the above solution, we note the WAPC has previously approved a strata subdivision with common property on a rural zoned site on the corner of Hall Road and Tallathalla Road, Waroona. This was approved without the need to amend the Shire of Waroona's local planning scheme. This example would seem therefore inconsistent to the initial advice provided by the Department of Planning to the Environmental Protection Authority.

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The Planning Group WA Pty Ltd
ABN 36 097 273 222
www.tpgwa.com.au

Ms Leanne Thompson
Environmental Protection Authority
Lots 2240, 2275, 2657, 3045 and 1000, Clifton Beach

Notwithstanding the above, the rural survey strata subdivision approach is considered the most suitable solution for this site in terms of environmental and fire management. We also reiterate from our previous correspondence that this survey strata model has been accepted by the City of Mandurah, the Shire of Waroona and the Department of Planning as a preferred planning mechanism.

On the basis of the above information and the professional advice received from surveyors, we do not foresee any planning or technical issues when implementing this concept. Should further issues arise, we are confident a number of planning solutions are available to allow the proposal to be implemented. Should you have any queries in relation to the above, please do not hesitate to contact the undersigned.

YOURS SINCERELY

TPG TOWN PLANNING AND URBAN DESIGN

David Caddy
Managing Director

cc. Cameron Bulstrode, Department of Planning
Peter van Gent, Cape Bouvard Investments

Ms Leanne Thompson
Environmental Protection Authority
Lots 2240, 2275, 2657, 3045 and 1000, Clifton Beach

Attachment 1: Concept Rural Survey Strata Subdivision

Enquiries: Cale Luxton
Your Ref: 708-096
Our Ref: SUB119271 450878 CAL

10 August 2010

Mr D Caddy
PO Box 7375 Cloisters Square
Perth WA 6850

Dear David

Lot 2250, 2275, 2657, 3045 and 1000 Clifton Beach

In response to your correspondence dated 9 July 2010 regarding the concerns raised by the City relating to the enforcement controls to address development standards and environmental matters, I can offer the following information.

In principle the City considers strata by-laws governed by the strata management company as a more appropriate method of addressing the environmental and development considerations required on the subject site as opposed to the introduction of a local planning policy.

Notwithstanding the above, please find attached a copy of Council's submission on the PER report (EPA Assessment Number 1440). These comments remain consistent with the City's position on the proposed subdivision.

Should you have any queries please contact Cale Luxton on 9550 3281 or via Cale.luxton@mandurah.wa.gov.au.

Yours sincerely

Fiona Mullen
Manager
Planning and Land Services

enc City of Mandurah's submission on PER report
cc: Cameron Bulstrode, Department of Planning
Ross Davidson, Shire of Waroona

Administration Centre: 3 Peel Street Mandurah
Postal Address: PO Box 210, Mandurah WA 6210
Tel: (08) 9550 3777 Fax: (08) 9550 3888
Email: council@mandurah.wa.gov.au Website: www.mandurah.wa.gov.au

Attachment 2: Proposed Submission on PER

Chairman
Environmental Protection Authority
Locked Bag 33
Cloisters Square WA 6850

Attention Leanne Thompson

Dear Chairman

Submission on EPA Assessment Number 1440 – Rural Subdivision, Lots 1000, 2240, 2275, 2675 and 3045 Preston Beach Road, Lake Clifton – Public Environmental Review

Thank you for the opportunity to provide comment on the Public Environmental Review for the proposed Rural Subdivision of Lots 1000, 2240, 2275, 2675 and 3045 Preston Beach Road, Lake Clifton.

The City of Mandurah does not support the proposed subdivision on the basis that it will result in significant environmental impacts within this highly complex and interdependent system. This extremely sensitive ecological area is adjacent to the Peel-Yalgorup Ramsar system and surrounded by Yalgorup National Park providing a unique area that supports the critically endangered Thrombolite community as well as flora, fauna and avi-fauna species and communities protected under International, Commonwealth and State legislation. The City of Mandurah's contends that the measures proposed within the Public Environmental Review will not provide adequate protection of these values, as detailed below.

Conservation of Native Vegetation:

Native vegetation and its values for the conservation of the wetlands, migratory birds, Thrombolites, declared rare and priority flora species as well as species of National Significance will be significantly impacted upon should the proposed subdivision be implemented. Loss and fragmentation of habitat will occur through clearing for firebreaks, roads, fire management provisions and fencing. It can be reasonably expected that there will be an elevated risk of fire occurrence through arson and carless behaviour. It can justifiably be expected that weed species will be introduced through garden escapees and edge effects which will make the natural values less resilient to outcompeting weed species. The risk of introducing disease will be increased through vehicle access and introduction of diseased soil/mulch etc.

There is some inconsistency within the PER as to the area of land to be cleared [4.4 % of the total site vs 3.6% of the total site].

The Ecological Character Description of the Peel-Yalgorup Ramsar System, prepared on behalf of the Peel Harvey Catchment Council, recommends that no vegetation be cleared from the Ramsar site. The clearing for the proposed subdivision is likely to have a detrimental effect on the distribution and productivity of terrestrial fauna through reduced and fragmented habitat.

The PER does not provide measures to adequately protect these values, either through the proposed design, introduction of Local Planning Policy or proposed Management Plans.

Conservation of Wetlands:

The proposed subdivision will have a significant impact on the ability to conserve the natural values of the wetlands/lakes. Currently the location is isolated from most of the detrimental impacts of human activity and surrounded by protected National Park. The sites isolation and proximity to Yalgorup National Park, along with the positive management processes of the current landowner, is assisting to protect the conservation values of the wetlands. Opening this area to people, both residents and visitors, through implementation of roads and

Nutrients/Pollutants

The water flow is from the east towards the lake system, therefore any increase in pollutants and/or nutrients will impact on the Ramsar system, particularly as the freshwater lense is only 5 metres below the surface in some parts.

Potential sources include garden fertiliser, non-maintained or poorly implemented effluent, animal waste, detergents, insecticides, herbicides, detergents. The PER only considers effluent management and does not appear to appropriately recognise the probable increase in nutrients from other sources and/or provide protective measures.

Protection of Yalgorup National Park

The PER states that a 50 – 100 metre buffer will be provided around the perimeter of National Park to protect the Park values. This is not adequate protection as impacts including increased pedestrian access, trail bikes, weed escapees, increased risk of fire events and domestic animals will all have detrimental impacts which do not either recognise or respect boundaries as clearly demonstrated in more accessible areas of the National Park that are currently being impacted upon.

Thrombolites

In December 2009 the Commonwealth Minister for the Environment, Arts and Heritage listed the *"Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)"* as critically endangered. Critically endangered is defined as *"If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future"*. The Minister's decision followed extensive expert and public consultation and consideration of advice from the Threatened Species Scientific Committee (TSSC). The conservation advice outlines a range of priority actions to provide guidance on how best to manage, restore and protect the ecological community.

The *Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)* has been listed in the critically endangered category because:

- its geographic distribution is very restricted and it is subject to ongoing threats,
- the loss and decline of functionally important species is very severe,
- the reduction in integrity of critical ecological processes is very severe, and
- the rate of continuing detrimental change is severe and projected to continue in the immediate future.

Threats to the thrombolite community include groundwater extraction, increased salinity levels, eutrophication, changes to surrounding vegetation and the introduction of fish species that are not native to the Lake Clifton environment.

The purpose of listing this ecological community under the EPBC Act is to help prevent its decline and to provide support to on-ground efforts that ensure its long-term survival.

EPA Bulletin No. 4 [May 2009] indicates that the Thrombolites "face an extremely high risk of total loss in the immediate future".

Therefore, given the Thrombolites status and vulnerability it is irresponsible to allow any actions that will result in a change to the system supporting the Thrombolites that is likely to result in their extinction.

The proposed educative basis of the proposed Wetland Management Plan is likely to have limited success. Behavioural changes are only moderately influenced through education and awareness dependent on the individual and this is not an effective enough tool to ensure protection of the wetland values. There is also no ability to monitor the ongoing exchange of information as land exchanges hands over time.

Fire Management:

The proposed design will have significant detrimental impact on the natural environment, both through the need to clear vegetation to accommodate fire management as well as an increase in probability of fire events resulting from arson and careless behavior through the introduction of residents and visitors to a currently restricted and isolated area.

The City, in consultation with Fire and Emergency Services Association of W.A. has reviewed the PER and Fire Management Plan and Provide the following comment.

- ***Firebreaks***

  The proposed design is considered to present a high level of fire threat, with an associated unacceptable level of danger to life, property and ecological values should a fire occur in this location. It is considered that the option for a combination of proposed internal and/or strategic firebreaks is not sufficient to enable adequate access/egress for fire management. Should the proposal be considered to be implemented it is proposed that the City would require internal firebreaks on all properties and additional strategic fire breaks in accordance with the City's fire break regulations. This requirement will increase the area of land required to be cleared to install the firebreaks.

  The removal of vegetation for firebreaks in accordance with the proposed design would be within the 300 metre lake buffer; the 50 metre wetland buffer; TEC buffers; through areas of Declared Rare Flora and significant fauna habit including areas of Carnaby's Cockatoo habitat and potential Graceful Sunmoth habitat, therefore having a significant impact on the ecological values of the site.

  The installation of firebreaks will have a detriment impact through the regular introduction of machinery into the area to firstly install and then regularly maintain the firebreaks. This action brings with it the risk of introducing disease such as dieback and Armaleria which could then spread throughout the area. It will also bring with it 'edge effects' which, as consistently demonstrated, reduces the vegetation condition through the access of weed species into areas that would otherwise be well protected from the spread of weed seed.

- ***Access***

  The proposed design is considered to be an unacceptable level of risk to residents and visitors, domestic animals and stock in respect to egress routes should a fire occur. FESA have recommended the installation of a secondary egress route being constructed to the North. It is further recommended that, should the subdivision be approved that the egress roads to the North and South be constructed of a minimum of 6m of trafficable surface with a 7m verge either side of the road, slashed and maintained to 100mm.

  Use of the beach as a safe haven in the event of a wildfire is not considered to be acceptable. This proposal assumes residents and visitors have vehicular access to the beach [4 wheel drive] and it is dependent on weather conditions, tides, location of the fire and the ability for people to be safely picked up from the car park or beach area.

- ***Fuel Reduction***

  The introduction of the subdivision will result in the further removal of significant flora and habitat to allow for the proposed fuel reduction as suggested in the fire management plan. The City's Local Laws allow for a building protection zone, in addition to building envelopes and firebreaks. Implementation of this protection

Geology and Landform maps are provided within the PER but these are at a very large scale and are not shown on the Development Constraints to enable accurate assessment of these. For example, Figure 37 doesn't show where the Vasse landform or Quindalup dunes are located within the proposed subdivision making it difficult to determine the impact on these areas. There should be no development within the areas of mobile Quindalup dunes or Vasse landforms in accordance with the Coastal and Lakelands Planning Strategy.

Development Management Zone

The PER provides for a Development Management Zone which includes a proposed Building Envelope of 2000 square metres to be determined by landowner. The Development constraints are not adequately mapped to show all constraints and clearly show the limited areas in which building envelopes might be provided to enable assessment of impacts of the envelopes.

Remoteness – Access to services

The remoteness of the proposed subdivision will place a significant reliance on vehicles to access day to day needs such as grocery shopping, access to places of employment and education as well as unforseen instances such as emergency health care.

APPENDIX B

DRAFT FIRE MANAGEMENT PLAN

Draft

FIRE MANAGEMENT PLAN

Clifton Beach Rural Subdivision

Lake Clifton West

City of Mandurah

Shire of Waroona

FirePlan WA

August 2010 V2

TABLE OF CONTENTS

1.0 PURPOSE OF THE MANAGEMENT PLAN

The purpose of this Bushfire Management Plan is to detail the Fire Management methods and requirements that will be implemented within the proposed development. The aim of the Bushfire Management Plan is to reduce the occurrence of and minimise the impact of bush fires thereby reducing the threat to residents, fire fighters and the environment in the event of a fire within or near the development. The aim of this Fire Management Plan is to document fire prevention requirements of the development.

2.0 PROPOSED DEVELOPMENT LOCATION AND DETAILS

The subject land is Lots 1000, 2240, 2275 2657 & 3045 Preston Beach Lake Clifton this fire management plan is to be part of the Clifton Beach Structure Plan application.

The site is located on the western side of Lake Clifton and is between Lake Clifton and the Indian Ocean. Access to the site is via Preston Beach Road. A National Park is located on the northern boundary. There is no public access through the National Part to the north.

3.0 SITE DETAILS

The site is currently vegetated with coastal heath and varies between 1– 4 metres in height with vegetation taller in the swales and lower on the tops of vegetated sand dunes.

There is a wetland area located in the North eastern corner of the site associated with two small lakes. It is proposed that if the subdivision is approved the wetland area will be fenced off from the remainder of the development.

There is also a small wetland in the southern portion of the site also on the eastern boundary.

Priority flora is located in the site and is required not to be damaged by the installation of fire protection safety measures.

Slopes are undulating and vary between relatively flat (0-5 degrees) in the eastern half of the site to steep sand dunes in the western portion of the site. Although it is steep in the sand dune area down slopes will compensate for up slopes making fire s behalf in undulating fashion. However some of the dwellings will be located on the higher sites and slope will be a factor in determining the dwelling construction standard in accordance with AS 3959-2009 Construction of Buildings in Bush Fire Prone Areas.

4.0 STATUTORY CONDITIONS

The northern two thirds of the site is located in the City of Mandurah and the remainder in the Shire of Waroona.

The Western Australian Planning Commission, Shire of Waroona and City of Mandurah require the preparation of a ‘Bushfire Management Plan’ as part of the development proposal. This document has been prepared to satisfy that requirement in accordance with *Planning for Bush Fire Protection 2010.*

As fire management strategies may require altering to meet changing climate, weather patterns, environment and land use needs landowners/occupiers are advised that provisions of the Bush Fires Act 1954 may still be enforced in addition to this Fire Management Plan.

The Shire of Waroona and City of Mandurah in conjunction with landowners will be responsible for initiating a review of this fire management plan as it may see necessary to do so.

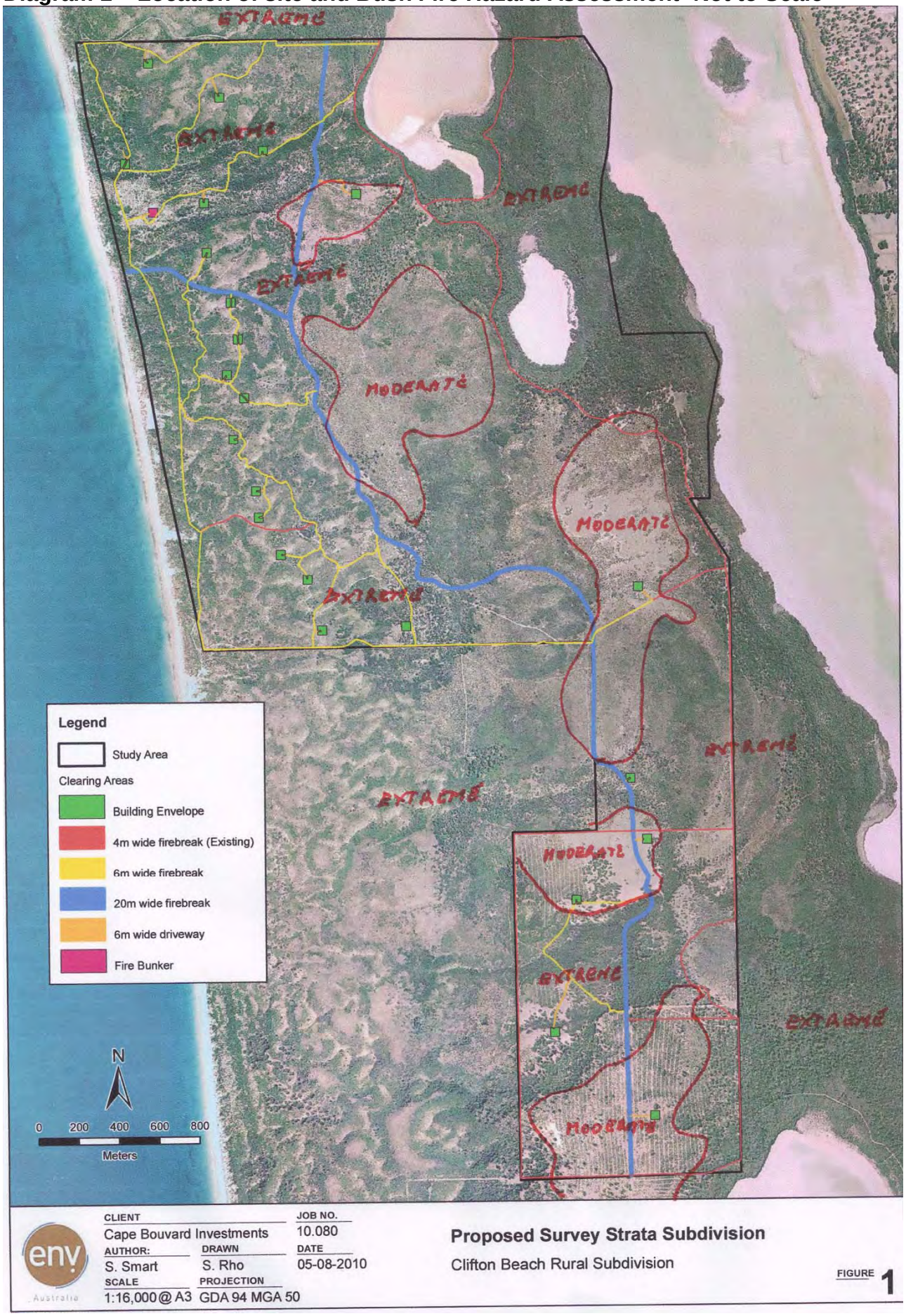
5.0 BUSH FIRE HAZARD ASSESSMENT

Bush Fire Hazard Assessment is determined by rating the vegetation type in accordance with Table 1 and Figure 2 of Planning for Bush Fire Protection 2010. It is also based on the underlying assumption that land in Western Australia is predominantly undulating with relatively short, steep inclines. The bush fire hazard assessment specifies 3 three levels low, moderate and extreme.

The Bush Fire Hazard Assessment for the proposed development area is rated *'Extreme'* in the coastal heath land that is 2-4 metres in height and moderate in some pockets of low heath lands and areas that have been previously partly cleared. See Diagram 1.

The Mediterranean climate experienced by this area is such that the majority of rain falls in late autumn through to early spring. This rainfall supports substantial vegetation growth which dries off in Summer/Autumn.

Diagram 1 – Location of site and Bush Fire Hazard Assessment- Not to Scale



6.0 Fire Mitigation

In this Section of the Fire Management Plan when complying with the Acceptable Solution detailed in *Planning for Bush Fire Protection* 2010 it will be shown as (A2.1) meaning Acceptable Solution 2.1 of the guidelines.

Fire Protection of this development will not require fire protection requirements to be implemented in the National Park to protect residents or conservation values of this site. However it is expected that the National Park will be managed in line with community expectation as is required of any Landowner in the districts of Lake Clifton.

It is proposed that this development will be a Survey Strata Titles with portions, of the site being Common Land. A strata Company will be formed to manage both the common land and to ensure that the requirements of this fire management plan is complied with on behalf of the Strata Tile owners. The Strata Company will appoint a Strata Manager who will be the point of contact on behalf of the landowners and responsible for ensuring compliance.

The proposed development has been designed so as to take into account the following fire mitigation measures:-

- Location of Development.
- Vehicle Access.
    - Roads, Battle Axe access, Firebreaks, Private Driveways
- Water Supplies.
- Siting of Development.
    - Building Protection Zones, Hazard Separation Zones, Hazard Reduction, Planting of trees, Dwelling Construction Standards
- Design of Development.

6.1 LOCATION OF DEVELOPMENT.

This proposed development is located on land that the Bush Fire Hazard Assessment is rated as moderate and extreme (A1.1). The proposed development will have building protection zones and hazard separation zones established around proposed Dwellings and construction standards of dwelling will be in accordance with AS 3959-2009.

6.2 VEHICLE ACCESS.

6.2.1 Public Roads

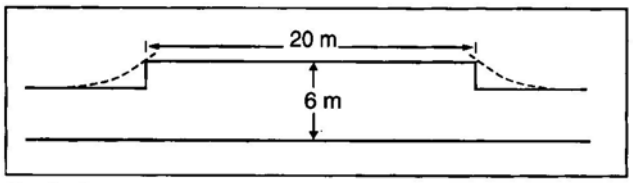
Access to the site will be via Preston Beach Road with a central road up the centre of the site and a loop road along the northern, western and southern boundaries of the site by widening existing access/firebreaks thus creating a loop road system within the site. Access to each dwelling will be off this road system and will comply with the Public Road standards detailed in A2.2. i.e. cleared to 6 metres wide, 6 metre wide trafficable surface and vertically cleared to 4 metres or as specified to a higher standard by the relevant Local Government Authority.

There is no two ways in and out of this site. A separate Fire Safety Strategy by engineering company Complete Fire Design will be responsible developing a fire strategy to meet compliance with Planning for Bush Fire Protection.

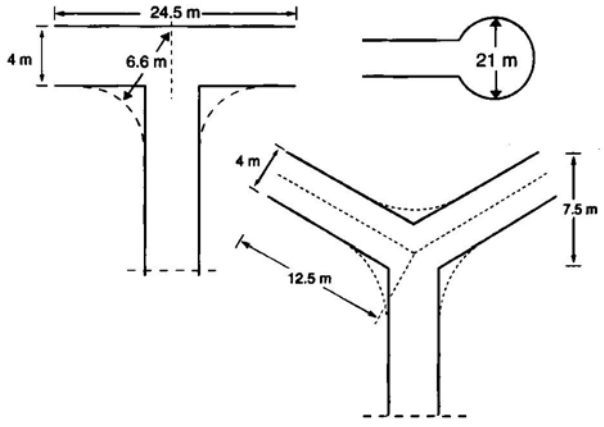
In the longer term and as part of the Preston Beach townsite northern expansion, there is no alternative second access other than access from Forest Highway via Preston Beach Road, a second access will need to be provided which will also service this development.

6.2.2 Firebreaks

As this site will have common land managed by a Strata Manager it is proposed that the area will be broken up through a system of Roads and firebreaks. Firebreaks will be a minimum of 4 metres wide with a 4 metre trafficable surface (road base material may be used in heavy loose sandy sections) and pruned to 4 metres vertical clearance. Firebreaks will have passing bays every 200 metres and turn around areas every 500 metres in accordance with the diagram below. (A2.9). The strata manager will be responsible for ensuring firebreak maintenance is carried out.



Passing bay measurements.



Turn around area measurements.

6.3 WATER SUPPLIES.

6.3.1 Domestic Water Supply

Each dwelling is to supply their own domestic water (minimum 120,000 litre tank) or as determined by the Shire of Waroona or City of Mandurah, for potable and other uses.

Each property shall at all times store a minimum of 10,000 litres of water for structural fire fighting purposes and each owner shall be responsible to replenish water used by fire fighters at the property owner's cost.

To enable standardisation of access to this supply, each private domestic vessel shall be fitted with a minimum 38mm Gate Valve and a 38 mm female camlock fitting with a blanking cap. This coupling and valve shall be installed and maintained in a correct operating condition at all times at the property owner's expense.

The domestic vessel shall be located in an area that will enable fire appliances to backup onto hardstand area to within 8 metres from the tank. Access is to be suitable for a large 15 tonne fire appliance with a 21 metre turning circle or as shown in the diagram in Section 6.2.2. Ensure fittings comply with Static Water Supplies and Hard Suction Connections (FESA Publication 2004, FESA Website)

6.3.2 Water For Fire Fighting

Two 50,000 litres concrete water tank is to be proved by the developer and tank is to be on the main north- south access road one located in the northern portion of the south and the second d in the southern portion of the site. The outlet of each tank is to be located downhill from the tank and a hardstand is to be provided in an expanded road reserve so that fire appliances can park off the carriageway while refilling. The lockable overhead fill or fire hydrant is to be installed to the satisfaction of the Shire of Waroona and City of Mandurah.

The following standards are required:-

- The hardstand for the fire appliance must be able to carry a 15 tonne GVM (minimum) fire appliance the Shire of Waroona and City of Mandurah may require a Compaction Certificate.
- The developer is to fill the tanks in the first instance and it is the responsibility of the Strata Company to ensure that these tanks are full of water at all times. Refilling of tanks will be either from limited ground water or by using contractors to cart water into the sites, this will be the responsibility of the Strata Company;
- A security fence is to be installed by the developer around the tank to the satisfaction of the Shire of Waroona and City of Mandurah.;
- Galvanised or copper pipe is to be used above ground, although PVC pipe may be used if buried 300 mm below the ground;
- Couplings area to be in accordance with the FESA Static Water Supplies and Hard Suction Connections (FESA Publication 2004, FESA Website);

6.3.2 Fire Service

There is a Bush Fire Brigade located in the existing Preston Beach townsite in the Shire of Waroona. There is no Fire Brigade within the City of Mandurah that could make a timely response to any bush fire on this site.

The developer is to provide the Strata Company with a Light Tanker fire unit to act as a first responder to a fire on the site. This unit would be then supported by the Preston Beach Brigade. It is recommended that the Strata Company fire appliance and residents of this site become Part of the Preston Beach Brigade so they are covered as volunteers under the Bush Fires Act 1954 and when attending a fire would have the Powers and Responsibilities under the Bush Fires Act 1954. This can be further explored at a later stage of the Planning process for the subdivision of this site and discussed in detail with the Shire of Waroona, City of Mandurah, Preston Beach Brigade and FESA.

6.4 SITING OF DEVELOPMENT

Proposed habitable buildings within the site will be located within the proposed Development Site Plan as shown in Appendix A. (A4.1).

As this site is remotely located it is essential that adequate protection through fuel modification is established around each dwelling so that they will withstand a bush fire occurring on the site with the assistance of little outside support.

Threatened Ecological Communities (TEC) and Declared Rare Flora (DRF) occur within this site and will be protected. Where populations of TEC and DRF occur within Building Protection Zones and Hazard Separation Zones it is not intended to remove these populations but rather to protect them with a buffer of vegetation around them and then a 20 metre slashed low fuel zone. The strata manager will be responsible for the protection of TEC and DRF as part of the commitments and obligations following the PER number 1440.

6.4.1 Building Protection Zone. (BPZ)

The aim of the Building Protection Zones is to reduce the amount of accumulated bush fire fuel and to lower the intensity of the impact of a bush fire by flame contact or radiated heat.

Non flammable features such as internal access roads, landscaped gardens should form part of Building Protection Zones. Isolated trees and shrubs may be retained within Building Protection Zones. A Building Protection Zone of 30 metres is to be constructed within the development site around all buildings. (see Appendix A) as follows (A4.3):

- Bush Fire fuels to be maintained at or below 2 tonnes per hectare and dry grass must be maintained below a height of 50mm;
- The first 5m around all buildings are to be cleared of all flammable material. Reticulated gardens may be located in this zone;

- The spacing of trees should be 10-15metres apart to provide for a separation of 5metres between crowns;
- Trees area to be under/low pruned at least to a height of 2 metres;
- No tall shrub or tree is to be planted within 2 metres of a building including windows;
- There are no tree crowns over hanging the building;
- Shrubs within the building protection zone have no dead material within the plant;
- Some clumps of plants may be retained provided they do not exceed 10 metres long and 5 metres wide. Each clump must be separated by 20 metres of low fuel as detailed in 1st dot point of this section.
- Trees in the Building protection zone have no dead material within the plant's crown or on the bole (tree trunk)
- Fences and sheds within the Building protection zone are to be constructed using non combustible materials (e.g. colourbond iron, brick, limestone);
- Branches, must be removed at least 2 metres back from the eaves of all buildings;
- All leaves, twigs, logs, branches must be removed from within the building protection zone. Annual falls of leaf litter must be raked up and removed or burnt.
- It is the responsibility of the developer to install the Building Protection Zone around each building envelope prior to the sale a Strata Title and maintain to the required standard until Sold.
- It is the Strata Companies responsibility to ensure that the Building Protection Zone is maintained to the above standard in perpetuity.

6.4.2 Hazard Separation Zone (HSZ)

To provide additional fire protection to reduce the impact of bush fires upon the development site including ember attack. As the occurrence of bush fires in this district may occur and will burn in accordance with the prevailing weather and fuel conditions at the time, it is proposed to have a Hazard Separation Zone around each dwelling to the following standards. (Acceptable Solution A4.4):

- An area of 70 metres outside the Building Protection Zone
- Bush fire fuels within the HSZ should be kept below 4-6 tonnes per Ha.
- All dry grass and heath lands must be slashed at or below 100-150mm. Some vegetation can be left in clumps not to exceed 0.25ha.

- Tree crowns area minimum of 10 metres apart.

- It is the responsibility of the developer to install the Hazard Separation Zone around each building envelope prior to the sale a Strata Title and maintain to the required standard until Sold.

- It is the Strata Companies responsibility to ensure that the Building Protection Zone is maintained around each dwelling to the above standard in perpetuity.

6.4.4 PLANTING OF TREES

Planting of trees and vegetation within the Development site will be in accordance with the developments Landscape Plan approved by the Shire of Waroona and City of Mandurah and complying with the requirements of the Building Protection Zone and Hazard Separation Zone standards detailed in this Fire Management Plan.

6.4.5 Dwelling Standards

New dwellings on each lot shall be designed and built to conform with:

- The Shire of Waroona or City of Mandurah Specification and Requirements.
- Australian Standards AS 3959 - 2009.

As this site is remotely located it is essential that adequate protection through fuel modification (Building Protection Zone and Hazard Separation Zone detailed above) is established around each dwelling and that the dwelling construction standard is increased so that they will withstand a bush fire occurring on the site with the assistance of little outside support.

All dwellings are to be constructed and comply with AS 3959-2009 *BAL-19* Section 3.0 and Section 6.0.

6.5 Design of Development

This development is located in an area with a bush fire hazard assessment rated as *low*. Building envelopes are located within fuel modified area [the Building Protection Zone 30 metres wide and the Hazard Separation Zone is 70 metres wide totaling 100 metres] surrounded by a *moderate* or *extreme* bush fire hazard level. The width of the building Protection Zone and Hazard Separation Zone with a BAL 19 dwelling construction exceeds that required by *Planning for Bush Fire Protection* Edition 2

The development complies with acceptable solutions A4.1, A4.2, A4.3 and A4.4 there are no special design Requirements.

70 SUMMARY

7.1 OVERALL FIRE THREAT

The design of this development and the facilities constructed at the time of development are such that with implementation of this Fire Management Plan, fire threat to persons and property within the proposed development is significantly reduced.

7.2 LAND OWNER'S RESPONSIBILITIES – Strata Company Responsibilities.

To maintain the reduced level of risk and threat of fire, the owners/occupiers of lots created by this proposal will be responsible for undertaking, complying and implementing measures protecting their own assets from the threat and risk of bush fire.

- Maintain road system, firebreaks on the site by the dates shown on the Shire of Waroona or City of Mandurah Firebreak Notice as detailed in Section 6.2
- Maintain in good order and condition all property fencing and gates ensuring that vegetation does not encroach over the firebreak;
- Maintain reticulated water supply within the Resort area as detailed in Section 6.3;
- Ensure Building Protection Zones, Hazard Separation Zones, Planting of trees and shrubs and construction standard of habitable building are implemented and maintained as detailed in Section 6.4

7.3 DEVELOPER'S RESPONSIBILITIES

Prior to proposed development being given final approval by the W. A. Planning Commission the developer shall be required to carry out works as described below. Subsequent to Final Approval to subdivide, the responsibilities to the provision of fire fighting facilities on lots passes to the Strata Manager..

- Lodging a 70A 'Notification' on the Certificate of Title of this proposed development. The Notification shall alert purchasers of land and successors in Title of the responsibilities of this Fire Management Plan.
- Construction of Roads, access and firebreaks as detailed in Section 6.2;
- Provision of water tanks and light tanker for fire fighting as detailed in Section 6.3.
- Install and maintain Building Protection Zone and Hazard Separation Zone.

7.4 SHIRE OF WAROONA & CITY OF MANDURAH RESPONSIBILITIES

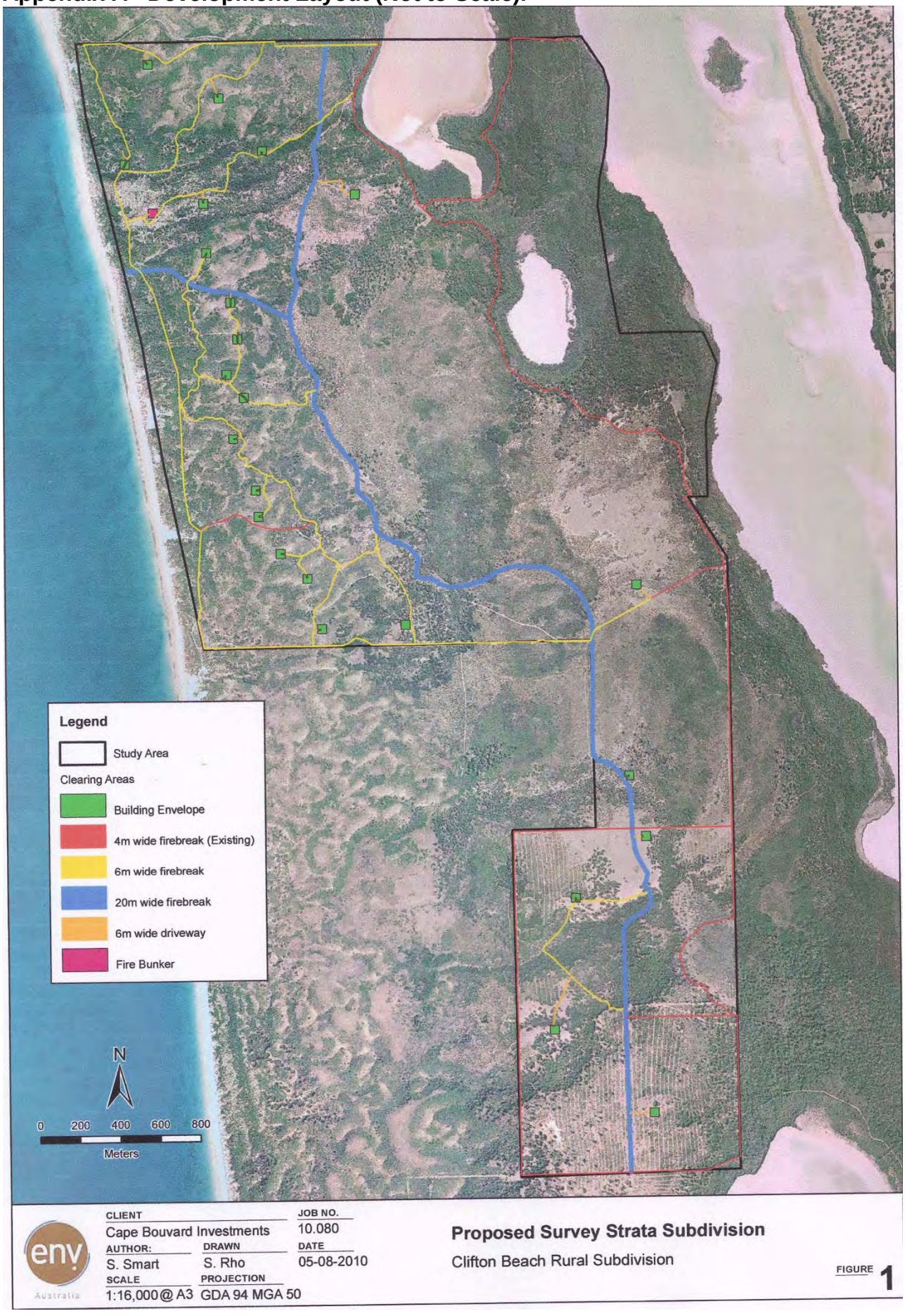
The responsibility for compliance with the law rests with individual property owners and occupiers and the Strata Manager.

The following conditions are not intended to unnecessarily transfer some of the responsibilities to the Shire of Waroona or the City of Mandurah.

Respective Local Governments shall remain responsible for:

- Developing and maintaining District Fire Fighting Facilities.
- Provide advice on appropriate techniques to achieve bush fire hazard reduction for individual properties.
- Maintaining in good order the condition of the district water tanks and the apparatus for firefighting purposes.
- Ensure that the Strata Title owners through the Strata Manager comply with this fire management plan

Appendix A - Development Layout (Not to Scale).



FIRE MANAGEMENT PLAN

PROPERTY DETAILS: Lot/Loc Clifton Beach Rural Subdivision
Street/Road Shire of Waroona & City of Mandurah

Compliance checklist for performance criteria and acceptable solutions

Element 1: Location

Does the proposal comply with the performance criteria by applying acceptable solution A1.1?	**Yes**	X	**No**	

Element 2: Vehicular Access

Does the proposal comply with the performance criteria by applying acceptable solution A2.1? **Ring road system within the development site**	**Yes**		**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.3?	**Yes**	X	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.4? No Battleaxe access	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.5? **No Private driveways**	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.6? **No emergency access required.**	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.7?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.8? **No gates required.**	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.9?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A2.10? **No signs required**	**Yes**	x	**No**	

Element 3: Water

Does the proposal comply with the performance criteria by applying acceptable solution A3.1?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A3.2?	**Yes**		**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A3.3?	**Yes**		**No**	

Element 4: Siting of Development

Does the proposal comply with the performance criteria by applying acceptable solution A4.1?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A4.2?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A4.4?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A4.5? No shielding required	**Yes**		**No**	x

Element 5: Design of Development

Does the proposal comply with the performance criteria by applying acceptable solution A5.1?	**Yes**	x	**No**	
Does the proposal comply with the performance criteria by applying acceptable solution A5.2?	**Yes**		**No**	

Applicant Declaration:

I declare that the information provided is true and correct to the best of my knowledge.

Name of Person Preparing the Fire Management Plan:

Full Name: __B W Harris FirePlan WA _____ Date: 9.08.2010_____

Developer:

Full Name: _____ Signature: _____

Date: _____

APPENDIX C

LAKE CLIFTON GROUNDWATER & SOLUTE TRANSPORT MODEL SENSITIVITY ANALYSIS AND ADDITIONAL SCENARIOS

Lake Clifton Groundwater Flow and Solute Transport Model Sensitivity Analysis and Additional Scenarios

Lake Clifton Groundwater Flow and Solute Transport Model Sensitivity Analysis and Additional Scenarios

July 2010

Prepared For

ENV Australia

CyMod Systems Pty Ltd
ABN 072 954 824

P.O. Box 917, Armadale, WA, 6992
61 (0) 8 9399 2600

2010012.001

EXECUTIVE SUMMARY

ENV Australia (ENV) is undertaking an environmental assessment of a proposed land development on the west side of Lake Clifton, in Western Australia. As part of this assessment, they are assessing the potential impact the development may have on underlying groundwater and water quality, and on Lake Clifton due to landuse changes. The assessment of potential impacts due to landuse changes on the hydrogeological environment in the vicinity of lake uses numerical groundwater and solute transport models to quantitatively estimate the impact on water levels and water quality due to changes in recharge and nutrient loading associated with increased habitation in the area.

ENV Australia (ENV) undertook an extensive monitoring regime at Lake Clifton to gain a quantitative understanding of the surface and groundwater processes at the site. ENV installed eight bores in the southern end of the site in November 2007, namely MW1 through MW8. In addition to the bores installed by ENV, nine bores previously installed by Cape Bouvard Investments were included in the monitoring schedule, namely CB3E, CB3W, CB5, CB7, CB9, CB13E, CB13W, CB15 and CB17 (Preston, 1997). These 17 bores were used to improve the geological and hydrogeological understanding of the area, and to provide calibration data (water levels and water quality) for the numerical groundwater models.

The Lake Clifton Aquifer Model System, Version 1.0 (LCAMS V1) is designed as a flow and solute transport model to assess the impact of various development scenarios on lake water quality. The active model domain is 10 km long and 10.42 km wide. Horizontally, the finite-difference grid consists of 100 rows and 200 columns. The LCAMS V1 grid is variable, with rectangular elements (i.e. nodes) ranging in size from 30m x 100m to 250m x 100m. The use of 30m x 100m elements provides sufficient resolution for allowing the accurate consideration of the spatial position of existing and proposed bores and the simulation of solute transport sources.

The most significant calibration error in the constant-density flow model is the delay in maximum water levels in the lakes compared to measured data, after winter rainfall. The model predicts maximum water levels in October 2008 (which is consistent with other observations on the Swan Coastal Plain). However, in the case of Lake Clifton, measured maximum water levels occur in August. Nonetheless, the calibration in most bores is consistent with the measured response except in CB9, which does not show the same trends as other bores in the area. The importance of CB9 is limited with respect to the calibration of the model as it is on the periphery of the model area, and has been given a higher level of uncertainty than other bores, as specific data on the geology in this area is unavailable.

A flow and solute model of the Lake Clifton area has been constructed, verified and recalibrated. The verification and recalibration of the flow model indicates that the groundwater model is a reasonable analogue to the aquifer system in the area.

The majority of recharge and groundwater from the site will flow into Lake Clifton based on the location of the groundwater divide between the lake and the ocean. The extent of impact on Lake Clifton from development will depend on the where development is located in relation to this divide and whether the change in recharge and abstraction rates appreciably shifts the divide. The long term model, under average rainfall conditions shows that the groundwater divide is about 1 km inland, or 2.5 km from Lake Clifton.

The sensitivity scenarios modelled using LCAMS 1.0 are shown below.

Scenario	Description	Recharge Sequence	Loadings
	Base case – 24 special rural lots	Average CSIRO calculated rainfall	As used in previous scenarios
1	Lower rainfall reduced to 92% of average	Dry CSIRO calculated rainfall	As used in previous scenarios
2	Higher rainfall – increased to 109% of average	Wet CSIRO calculated rainfall	As used in previous scenarios
3	Lake level constant, 1.3 m sea level rise over 100 years	Average CSIRO calculated rainfall	As used in previous scenarios
4	Lowest historical lake levels	Average CSIRO calculated rainfall	As used in previous scenarios
5	Double hydraulic conductivity	Average CSIRO calculated rainfall	As used in previous scenarios
6	Half hydraulic conductivity	Average CSIRO calculated rainfall	As used in previous scenarios
7	Quadruple nitrogen loading to 16 times Phosphorus Loading to	Average CSIRO calculated rainfall	Double those used in previous scenarios
8	Triple unlicensed abstraction to 4500 kL/annum	Average CSIRO calculated rainfall	As used in previous scenarios

LCAMS V1 Modelling Scenarios

The scenarios were then run using the recalibrated model under steady state conditions for 100 years. A period of 100 years was chosen to provide a reasonable timeframe for solute transport to occur, based on estimates of advective transport of particles. For the purposes of simulation the scenario was started 2010.

The simulations showed that the model is relatively insensitive to changes in rainfall and abstraction, but sensitive to changes in sea level, nutrient loading and the hydraulic conductivity of aquifers. However, in all cases, the impacts on Lake Clifton are consistent with previous scenarios and support the conclusion that there is a low probability that the development as presented will have a measureable impact on Lake Clifton.

The lack of sufficient time series water quality and water level data prevents verification of the constant density flow model, as well as the solute transport model. It is recommended that monitoring at the site be continued for both groundwater level and water quality to obtain sufficient data with which to verify the model in the future. In addition, the sensitivity of the model to aquifer hydraulic conductivity suggests that pumping tests of the aquifer should be undertaken to confirm the range of hydraulic conductivity of the aquifer, as used in the model.

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1 INTRODUCTION

ENV Australia (ENV) is undertaking an environmental assessment of a proposed land development on the west side of Lake Clifton, in Western Australia. As part of this assessment, they are assessing the potential impact the development may have on underlying groundwater and water quality and on Lake Clifton due to landuse changes. The assessment of potential impacts due to landuse changes on the hydrogeological environment in the vicinity of lake uses numerical groundwater and solute transport models to quantitatively estimate the impact on water levels and water quality due to changes in recharge and nutrient loading associated with increased habitation in the area.

ENV contracted CyMod Systems to develop linked saturated flow and solute models of Lake Clifton and the surrounding areas from data collected by ENV. The numerical models are used to assess the impacts on water levels and water quality on Lake Clifton due to the proposed future landuse changes as supplied by Cape Bouvard.

This report describes the construction and calibration of a saturated variable density groundwater flow and solute transport model.

2 MODELLING OBJECTIVES

The objectives for developing the groundwater models are:

1) Confirm the conceptual hydrogeological model of the lake and aquifer;
2) Verify the model and recalibrate as required; and
3) Assess the sensitivity of the model to change in selected parameters, which reflect known uncertainties in the model

3 MODEL RECALIBRATION AND VERIFICATION

Calibration of a model compares model predictions and measured data over a selected period, to allow the adjustment of aquifer parameters to minimise error. However, complete elimination of model error is not possible. The residual error between measured and predicted heads or concentration is indicative of deficiencies either in the calibration process or the conceptual model. The deficiencies in the calibration process typically relate to inappropriate calibration bores, errors in data, and numerical limitations inherent in the model implementation. Deficiencies in the conceptual model typically manifest themselves as systematic errors over large areas, localised areas of high error, and errors that are intractable or insensitive to parameter variations.

The evaluation of calibration error provides a basis on which to modify the conceptual hydrogeological model, improve data fidelity and optimise available resources to efficiently minimise model error. The verification of a numerical model is difficult and suffers from the same limitations as demonstrating that a groundwater model is a unique. Verification of a model is best described as assessing whether the model has any predictive capability, by testing it against data that is independent from the calibration data. The Lake Clifton model was verified using data from November 2008 to April 2010.

A review of the verification simulation shows that the error in this model is similar to the error in the calibration model, suggesting that the calibrated model has some predictive capability. Appendix A shows the verification hydrographs for selected bores. Given that the verification period presents an entirely different hydrological regime than the calibration period, the results of the verification further support the conclusion that the model has some predictive capability. The average absolute error is a measure of the fit of the model, and is 4.0% for the verification flow model. This percentage error is consistent with the accepted modelling guidelines which generally recommend a percentage error less than 5.0%.

The error in the verification model is similar in nature to that found in the calibration model, and tends to be for the same bores. However some error has also been introduced through recharge model, as lake water levels tend to be high in 2009/2010 and groundwater levels too low. This suggests that some remedial calibration of these outstanding bores may be effective in reducing model error. In the absence of an improved rainfall recharge model, it is unlikely the present model can be significantly improved upon.

Based on the results of the verification minor recalibration of the model was undertaken by adjusting recharge coefficient in the vicinity of bore that showed too high water levels in 2009/2010.

4 SCENARIO MODELLING

Once calibrated groundwater and solute transport models have been constructed and found to have some predictive capability, they can be used to simulate the aquifer response to different stresses and assess the efficacy of proposed management strategies. ENV developed a base case and nine scenarios for assessment using LCAMS V1. The development scenarios modelled using LCAMS V1.0 is shown in Table XX.

Scenario	Description	Recharge Sequence	Loadings
	Base case – 24 special rural lots	Average CSIRO calculated rainfall	As used in previous scenarios
1	Lower rainfall	Dry CSIRO calculated rainfall	As used in previous scenarios
2	Higher rainfall	Wet CSIRO calculated rainfall	As used in previous scenarios
3	Lake level constant, sea level rise over 100 years	Average CSIRO calculated rainfall	As used in previous scenarios
4	Lowest historical lake levels	Average CSIRO calculated rainfall	As used in previous scenarios
5	Half hydraulic conductivity	Average CSIRO calculated rainfall	As used in previous scenarios
6	Double hydraulic conductivity	Average CSIRO calculated rainfall	As used in previous scenarios
7	Double nitrogen loading Quadruple Phosphorus Loading	Average CSIRO calculated rainfall	Double those used in previous scenarios
8	Triple unlicensed abstraction	Average CSIRO calculated rainfall	As used in previous scenarios

Table 1: LCAMS V1 Modelling Scenarios

The base scenario represents a 100-year simulation of 24 special rural lots, as simulated in 2009 by CyMod Systems. Scenarios 1 and 2 were simulated using modified climate sequences to better characterise the effect of changing climate at Lake Clifton. Scenario 1 uses a dry rainfall sequence, while Scenario 2 uses a wet sequence. Scenarios 3 and 4 were simulated using modified lake and ocean water levels to maximise the hydraulic gradient that may occur between the lake and the ocean. Scenarios 5 and 6 were simulated using modified hydraulic conductivity to characterise the sensitivity of groundwater behaviour at Lake Clifton to changes in aquifer properties. Scenario 5 uses decreased hydraulic conductivity, while Scenario 6 uses increased conductivity.

Scenario 7 was simulated using increased nutrients loadings at the development lots to characterise model sensitivity to the use of fertiliser at Lake Clifton.

Scenario 8 was simulated using increased abstraction volumes at the development lots to characterise model sensitivity to pumping Lake Clifton. It was previously assumed that the development lots operate under the restriction that they may not operate licensed private abstraction wells, i.e. only unlicensed garden bores abstracting less than 1,500 kL/annum for domestic purposes may be utilised at the development. Scenario 9 assumes that bores abstracting up to 4,500 kL/month may be utilised.

The scenarios were run using the recalibrated model under steady state conditions for 100 years. A period of 100 years was chosen to provide a reasonable timeframe for solute transport to occur, based on estimates of advective transport of particles. For the purposes of simulation

the scenario was started 2010.

Average annual rainfall time series was provided by SILO for Lake Clifton and used to generate annual rainfall recharge in the scenarios. The wet and dry rainfall sequences are scaled from the average rainfall sequence using CSIRO scaling factors as used in the Southwest Sustainability Study (CSIRO 2010). Rainfall statistics for the three sequences are provided in Table 2.

Climate Sequence	Total Annual Rainfall		Total Annual Evaporation	
	mm/annum	% of Average	mm/annum	% of Average
Average	786	-	1632	-
Dry	717	91.2	1636	100.3
Wet	857	109	1635	100.2

Table 2: Scenario Climate Sequences

Abstraction is set at the annual licensed allocation as provided by the DoW in 2008, excluding the existing allocations for the development area. No licensed abstraction from any part of the development site is simulated, and existing allocations associated with the development area are not used.

The TN and TP loadings for development lots were simulated as constant rate mass loadings, within a single model cell for each of the 24 conservation blocks.

The scenario simulations were all run for 1 stress period, consisting of 200 timesteps, representing a period of 100 years. The flow model was run using MODFLOW-2000, while the transport model was run using MT3DMS. Model configurations with respect to run parameters are as described for the calibration simulation.

4.1 Base Case – No Special Rural Residential Development

The base case is a non-development, and does not include the 24 rural residential lots, as simulated in CyMod 2009. The parameters used in the base case simulation are shown in Table 3.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	-0.07 mAHD		As calibrated	As previously modelled	2008 Allocations unlicensed bores

Table 3: Base Case Simulation Parameters

Figure 1 shows the simulated head after 100 years, assuming average rainfall conditions, and no development. Figures 2 and 3 show the TN and TP concentrations, respectively, for the base case after 100 years of simulation.

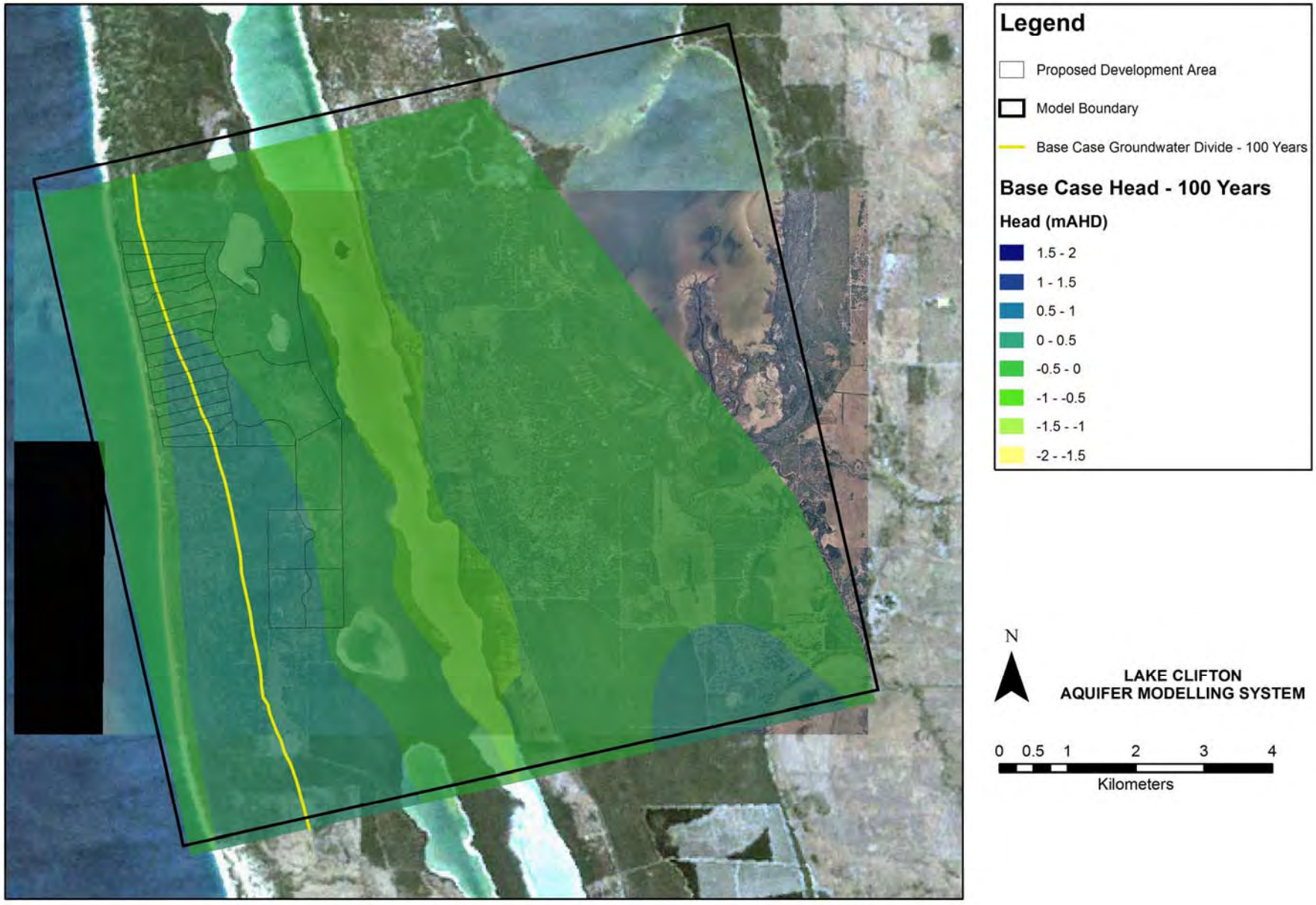

Figure 1: Base Groundwater Level and Groundwater Divide

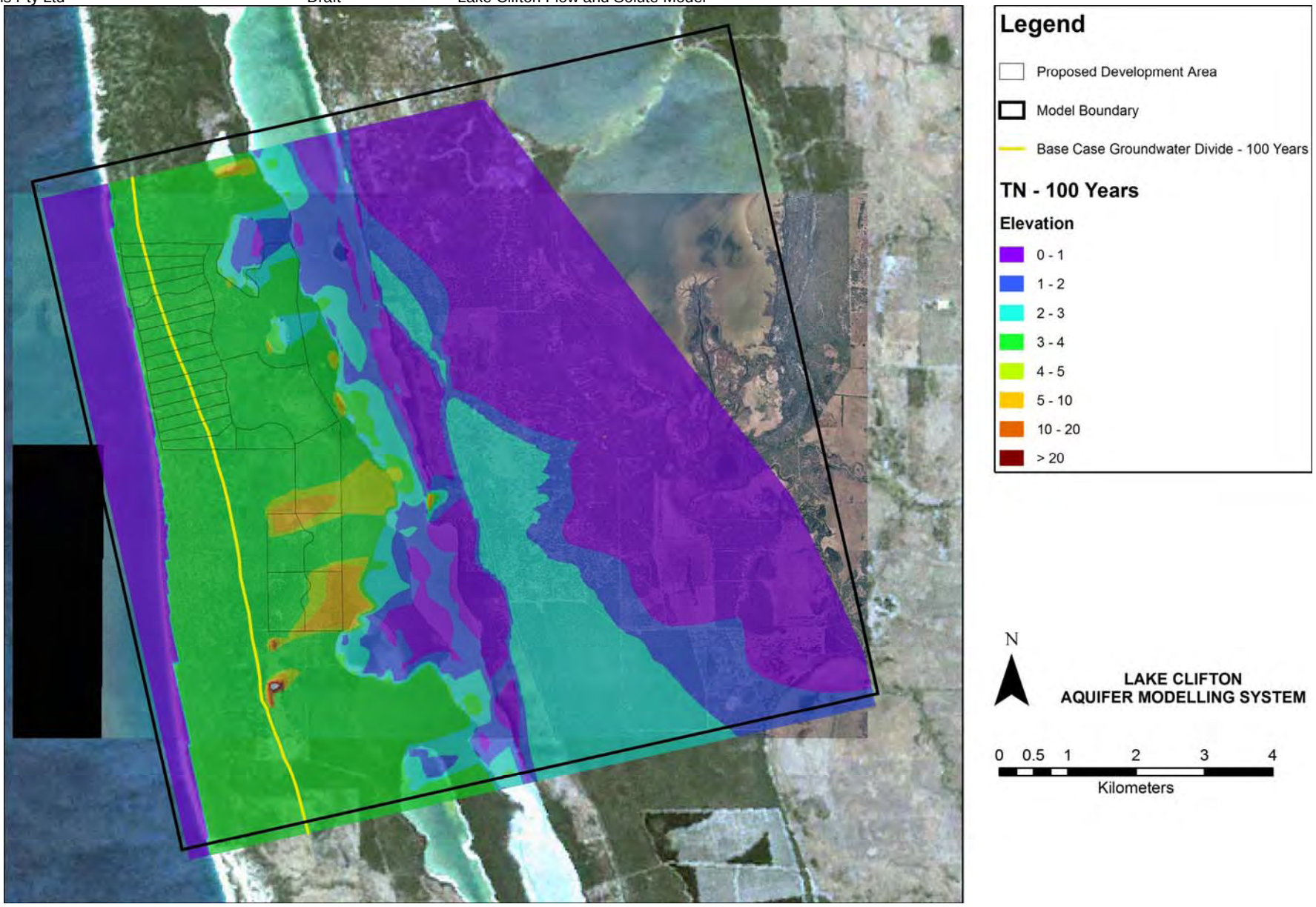

Figure 2: Base Case - Total Nitrogen Concentration

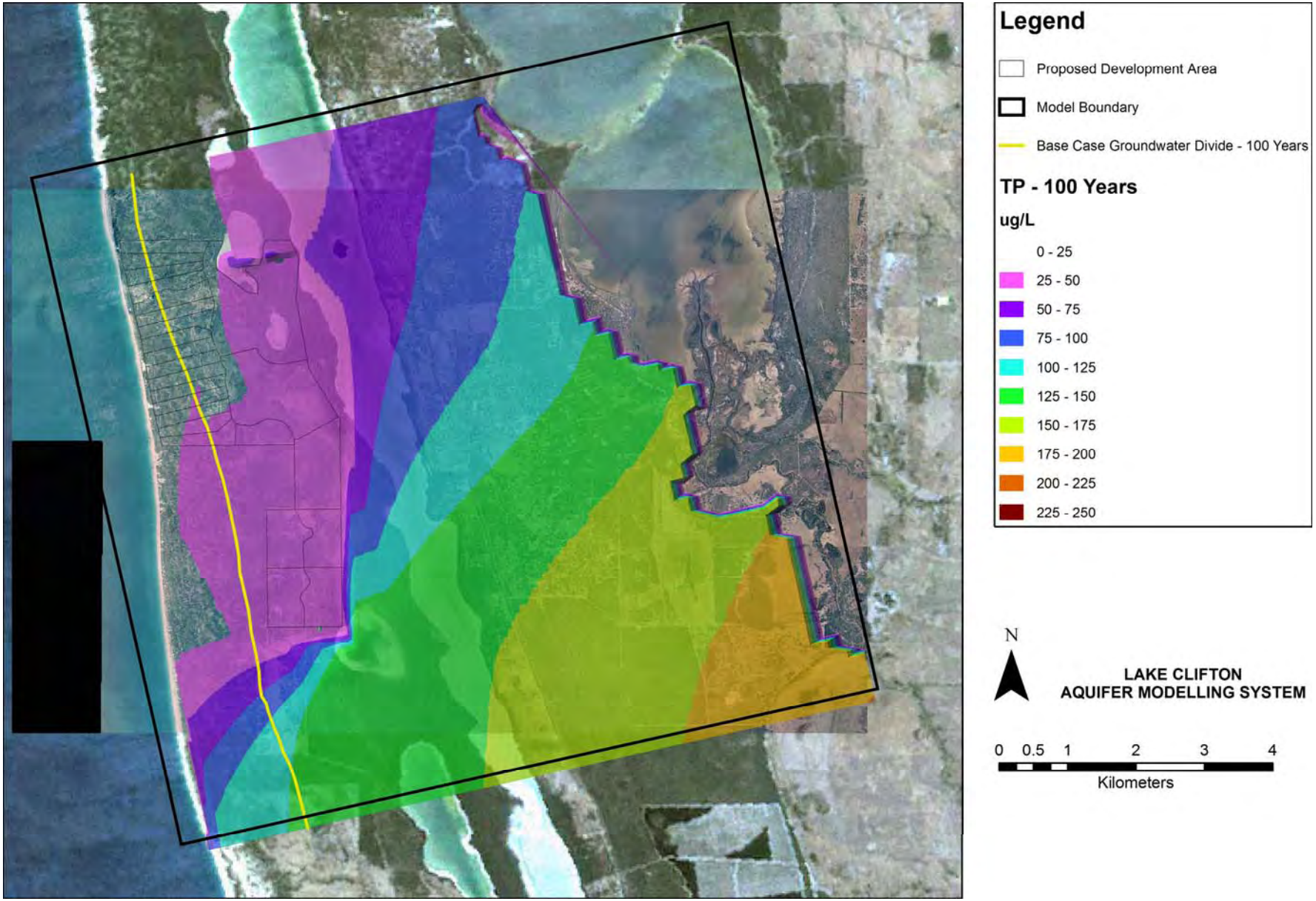

Figure 3: Base Case - Total Phosphorous Concentration

4.2 Scenario 1 – Dry Rainfall

Scenario 1 is the base case simulation, modified by using the average rainfall sequence from SILO, scaled to 925, to reflect a dry sequence as defined by CSIRO from their climate change analysis, CSIRO, 2010. The parameters used in the Scenario 1 simulation are shown in Table 4. Note that no change in nutrient loading, hydraulic gradient, hydraulic conductivity or abstraction occurs, other than for the 24 special rural residential developments.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
92% of average rainfall	Mean sea level		As calibrated	As previously modelled	2008 Allocations 1,500 kL/annum per lot

Table 4: Scenario 1 Simulation Parameters

Figure 4 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 5 shows the groundwater level impact due to drier climate after 100 years of simulation, compared to the base case. The lower average rainfall has resulted in lower water levels of from 0.01 to 0.08 m.

The solute transport simulation shows that TN increases in the areas of the mass loading. Solute entering the water table from 24 conservation lots moves eastward where it is diluted and biodegraded and may flow into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake. Due to the lower rainfall, groundwater velocity is lower, and TN concentrations tend be lower in Lake Clifton as less water enters the lake carrying TN.

Figure 6 shows the difference in TN concentration between the base case and Scenario 1, and represents the impact that a drier climate will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN on the order of 5-10 mg/L in the immediate vicinity of the development. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. Consequently, the changes in lake water quality can only be inferred from the simulated changes in groundwater TN concentrations. The results suggest less TN will migrate to the area of the lake due to the lower hydraulic gradient in the area, associated with lower water level.

Due to the relatively high adsorption of Phosphorus by the local soils, the effective change in TP in the aquifer is less than model resolution (i.e., 0.001 mg/L), and hence is inferred to be negligible. This is the case for all scenarios modelled (see Scenario 7).

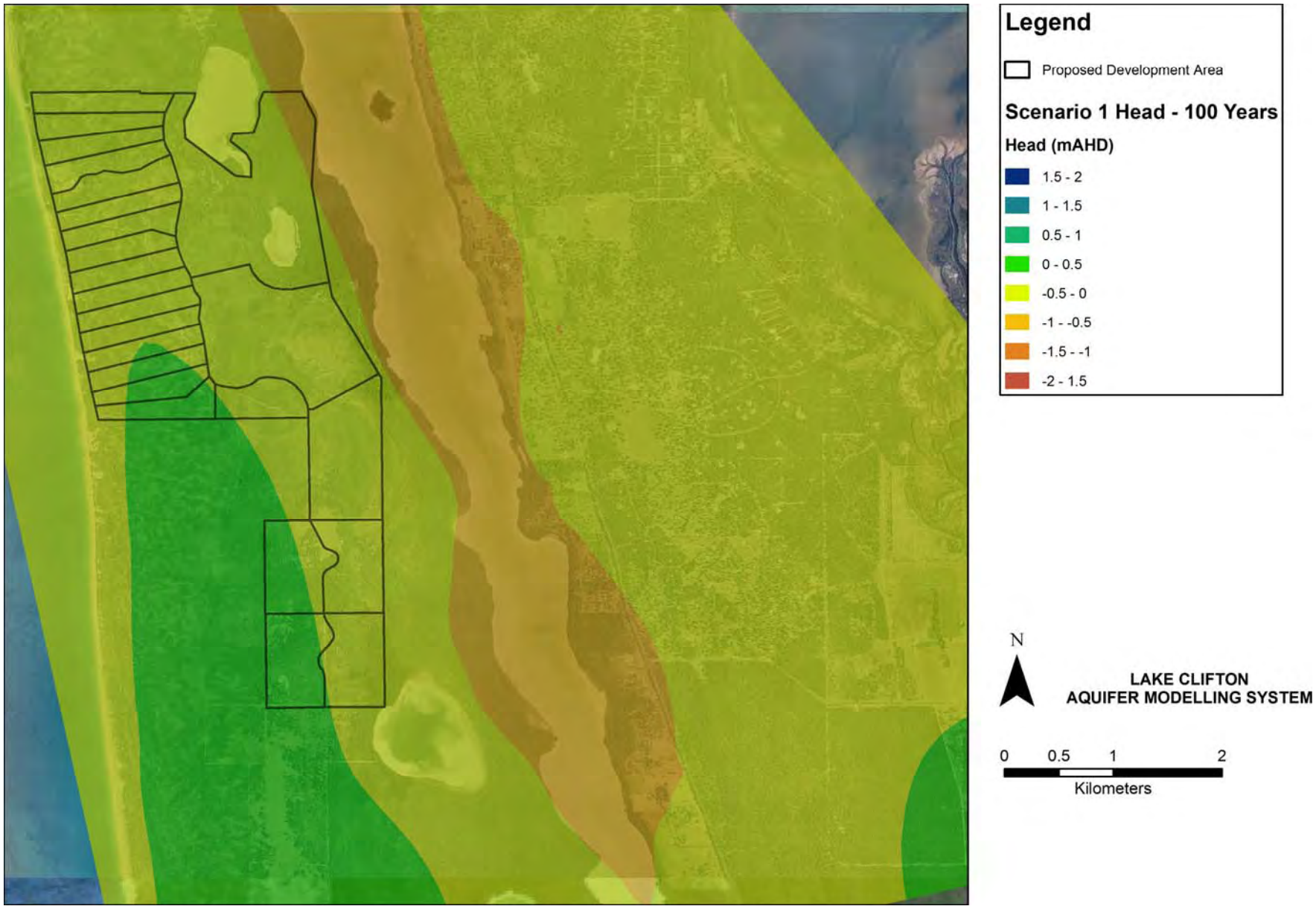

Figure 4: Scenario 1 Groundwater Level and Mean Groundwater Divide

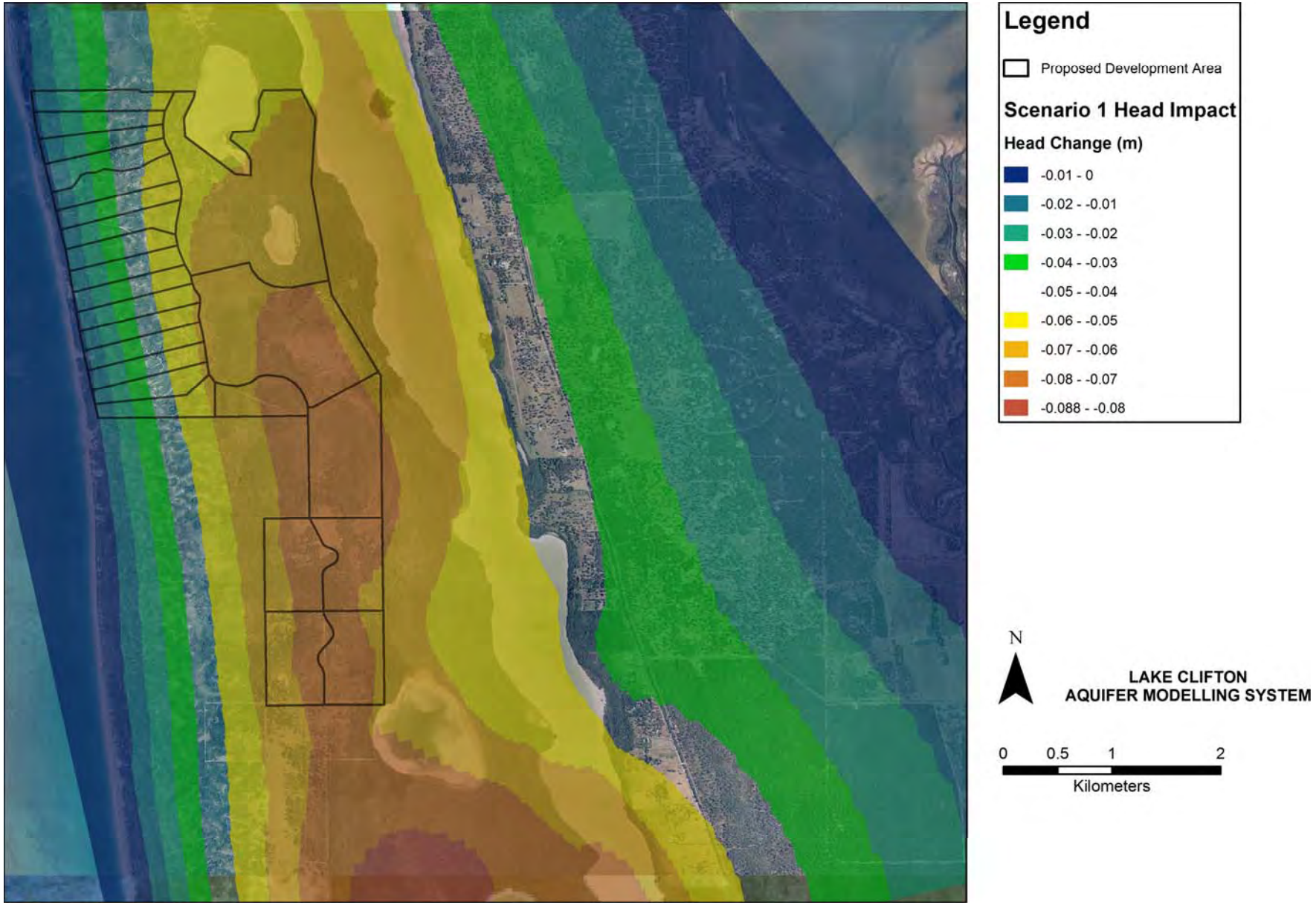

Figure 5: Scenario 1 Groundwater Impact

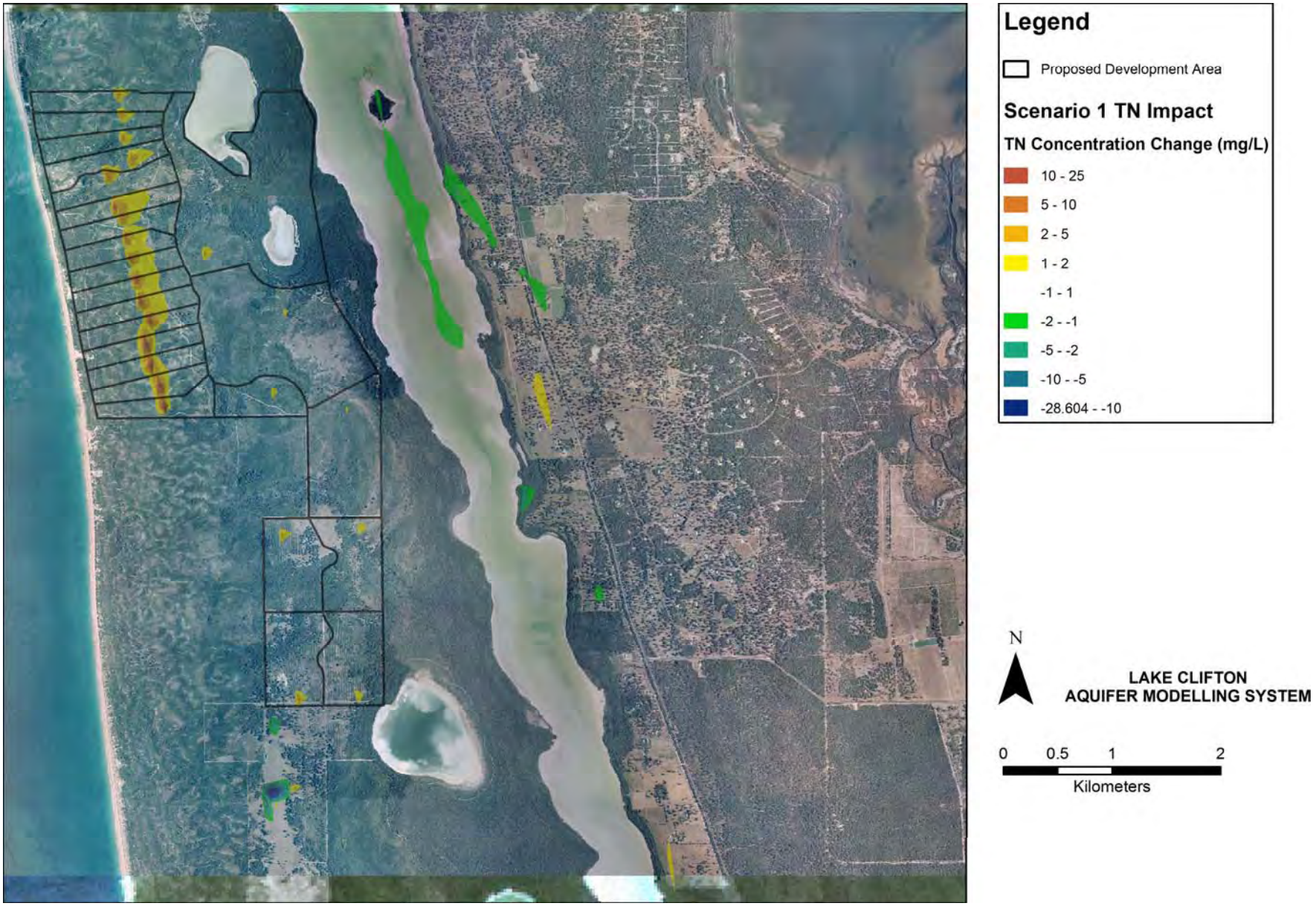

Figure 6: Scenario 1 Total Nitrogen Impact

4.3 Scenario 2 – Above Average Rainfall

Scenario 2 is the base case simulation, modified by using the wet rainfall sequence as defined by the CSIRO climate analysis. The parameters used in the Scenario 2 simulation are shown in Table 5. Note that no change in nutrient loading, hydraulic gradient, hydraulic conductivity or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
109% of average rainfall	-0.07mAHD		As calibrated	As previously modelled	2008 Allocations, 1,500 kL/annum unlicensed bores

Table 5: Scenario 2 Simulation Parameters

Figure 7 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 8 shows the groundwater level impact due to the wetter climate after 100 years of simulation. The higher average rainfall has resulted in higher water levels of from 0.01 to 0.09 m due to the wetter conditions.

The solute transport simulation shows that TN increases in the areas of the mass loading. Solute entering the water table from some of the 16 conservation lots moves westward, where it discharges to the ocean. Solute from the some of the 15 conservation lots and the other 8 lots east of the groundwater divide; flow into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake.

Figure 9 shows the difference in TN concentration between the base case and Scenario 2, and represents the impact that a wetter climate will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN on the order of 5-10 mg/L in the immediate vicinity of the development. The results suggest some additional TN will migrate to the area of the lake, but will likely result in no discernible impact on lake water quality. The difference between this scenario and scenario 1 is small indicating that variations in climatic conditions will not materially change the amount of nitrogen entering the lake.

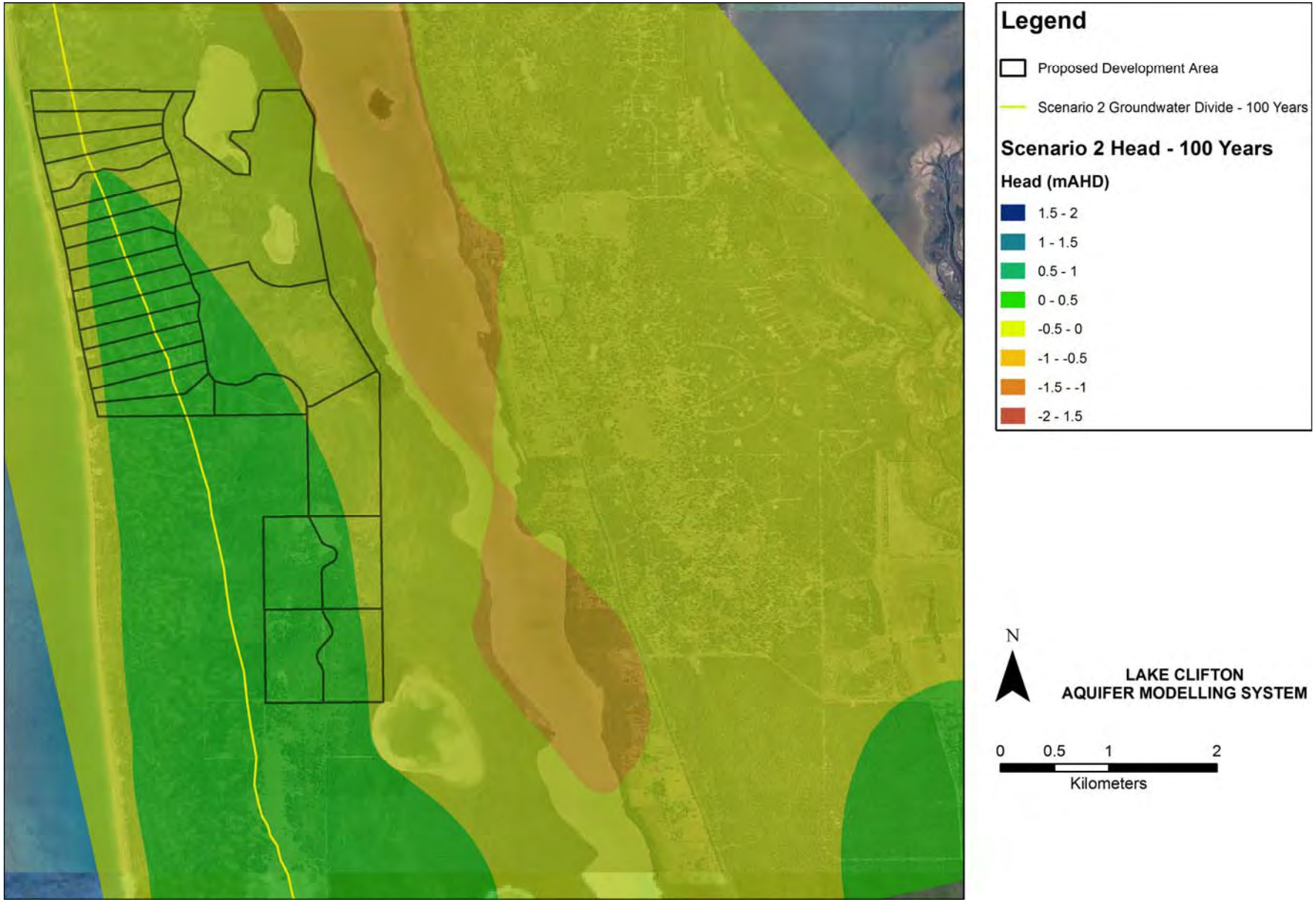

Figure 7: Scenario 2 Groundwater Level and Mean Groundwater Divide

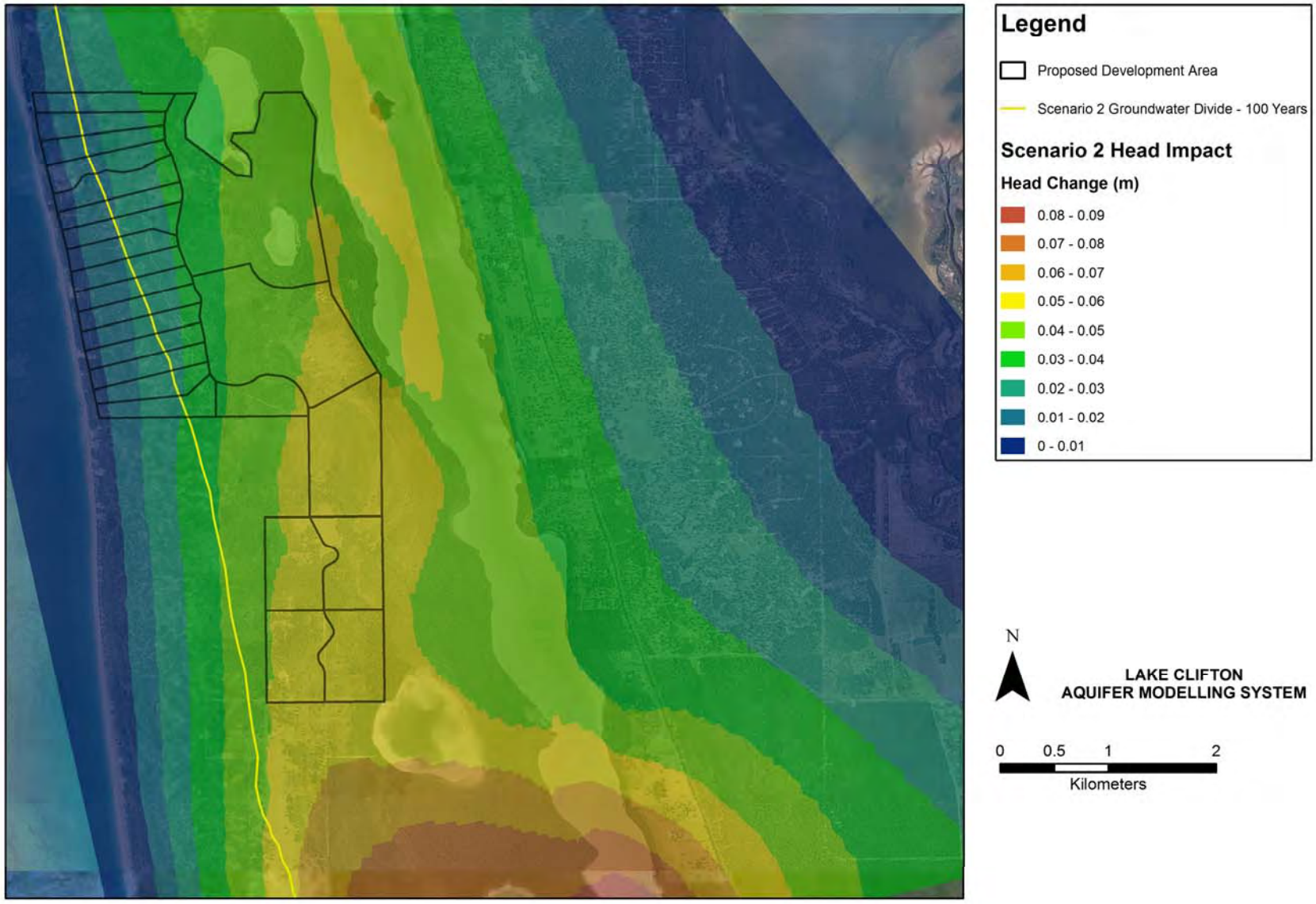

Figure 8: Scenario 2 Groundwater Impact

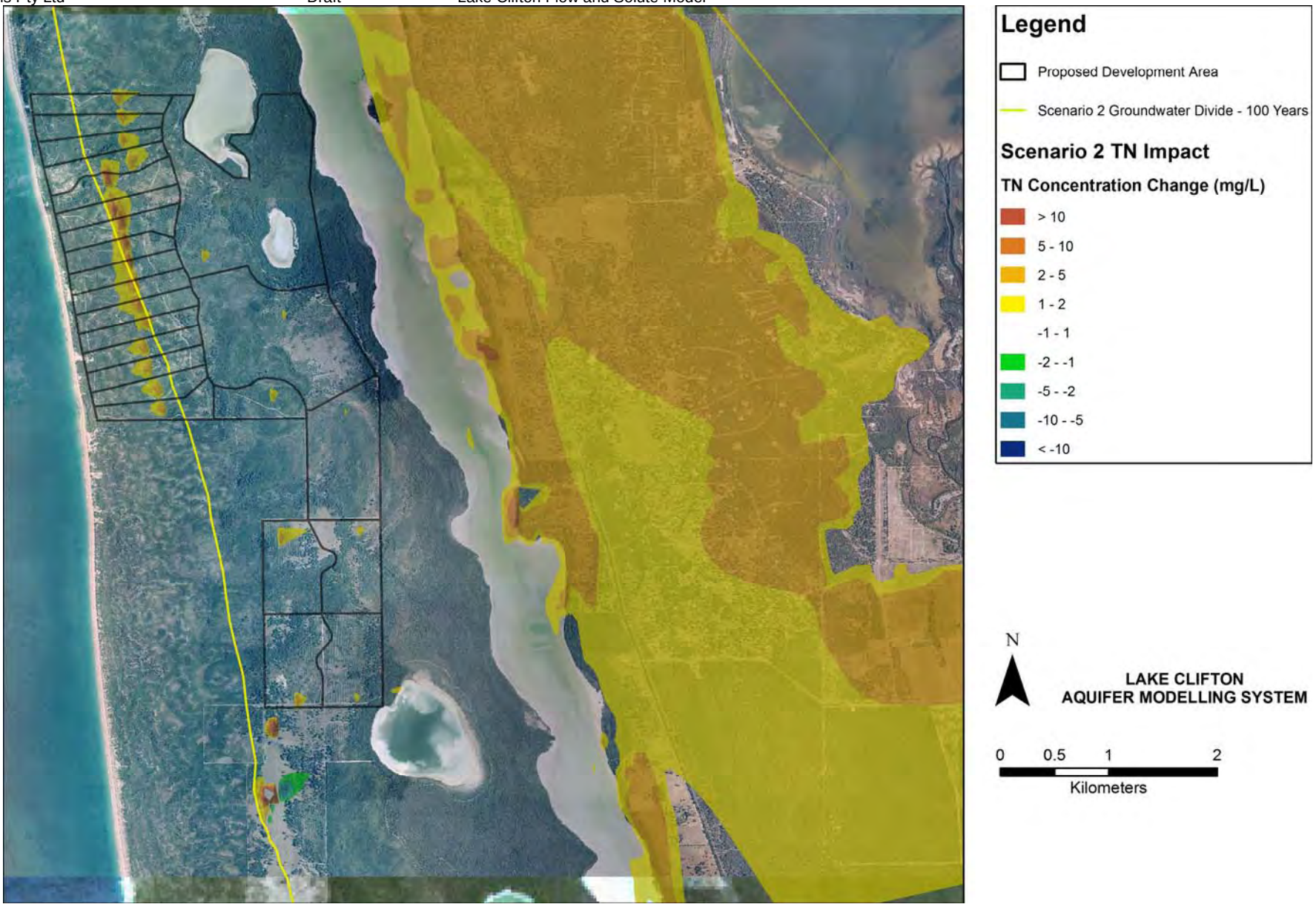

Figure 9: Scenario 2 TN Impact

4.4 Scenario 3 – Higher Sea Level

Scenario 3 is the base case simulation, with the development lots and modified by using a linearly increasing mean sea level over the 100 years simulation period, to assess the effect of rising sea levels due to global warming. The parameters used in the Scenario 3 simulation are shown in Table 6. Note that no change in nutrient loading, recharge, hydraulic conductivity or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	-0.07 to 1.23 mAHD	As calibrated	As calibrated	As previously modelled	2008 Allocations 1,500 kL/annum unlicensed bores

Table 6: Scenario 3 Simulation Parameters

Figure 10 shows the groundwater level at the end of the 100 year simulation period. Note that there is no groundwater divide in this case. The hydraulic gradient is towards the lake from the coast. Figure 11 shows the groundwater level impact due to the higher sea level after 100 years of simulation. Water levels have risen by as much as 1.2 m, with the lake rising 0.2-0.3 m.

The solute transport simulation shows that TN increases in the areas of the mass loading due to development are not significant. Solute entering the water table from 24 conservation lots moves eastward, where it discharges to the lake. Figure 12 shows the difference in TN concentration between the base case and Scenario 3, and represents the impact that a higher sea level will have on the area. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. The results suggest some additional TN will migrate to the area of the lake due to the steeper gradient towards the lake, with lake TN rising 1-2 mg/L compared to the base case.

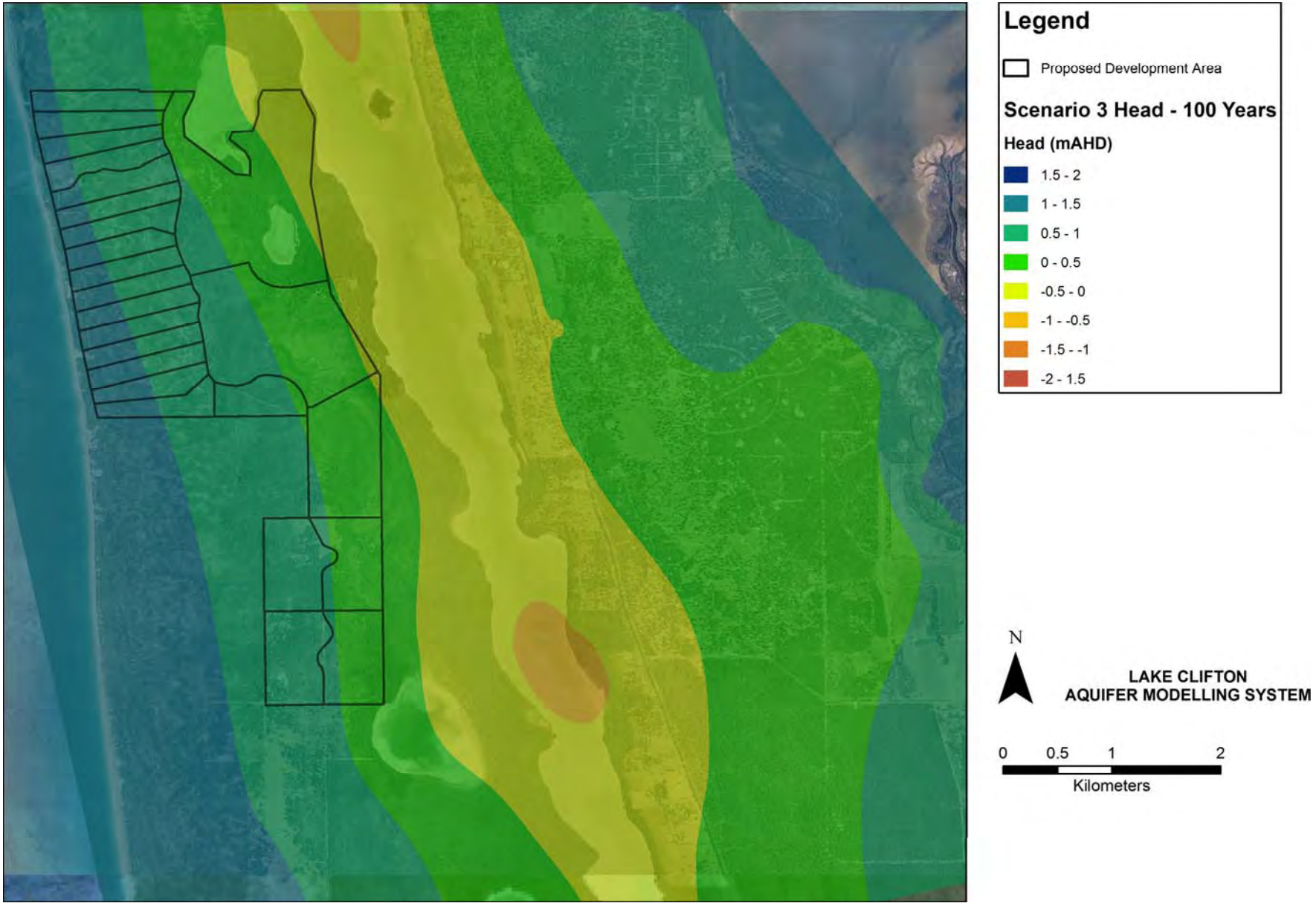

Figure 10: Scenario 3 Groundwater Level

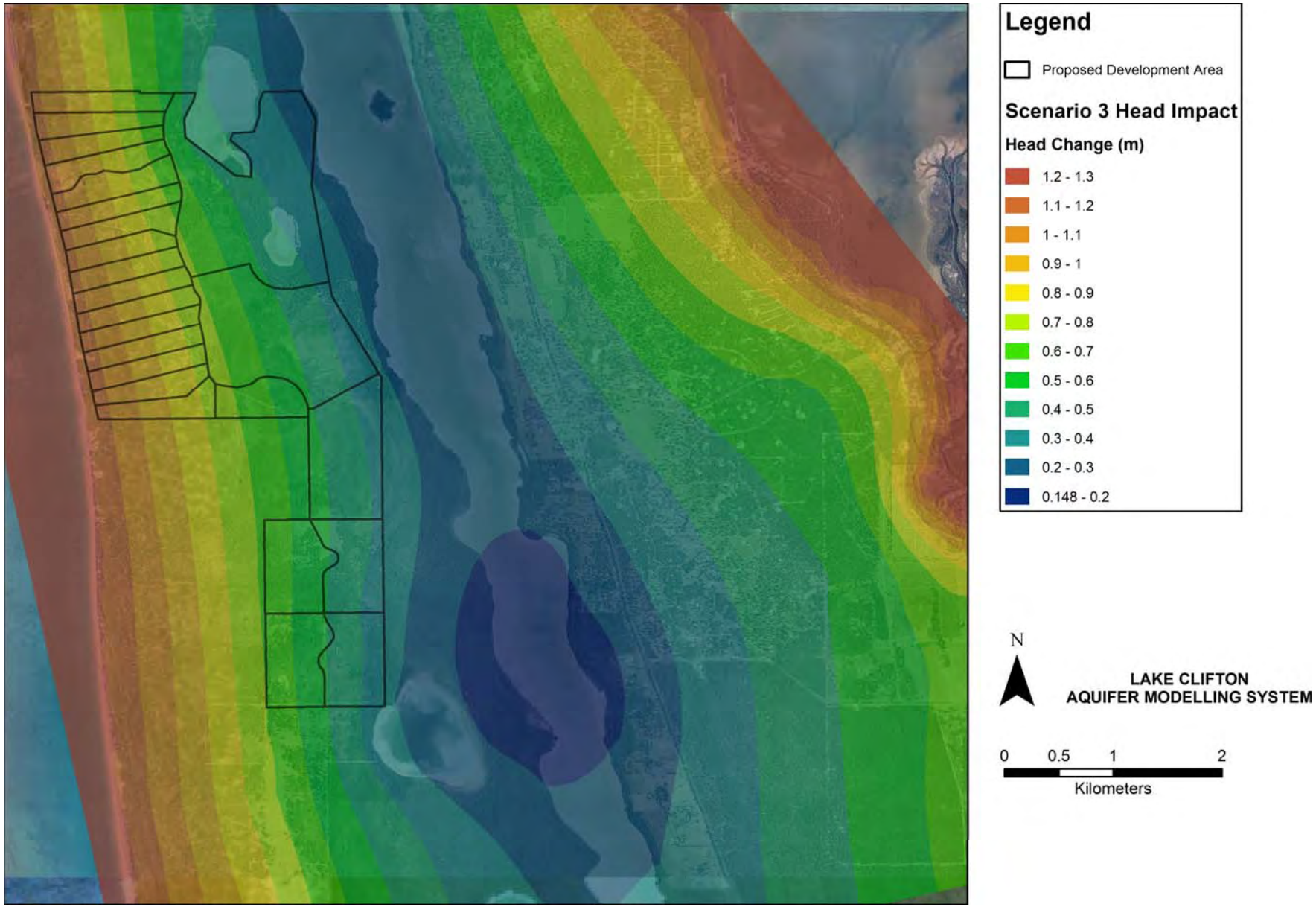

Figure 11: Scenario 3 Groundwater Impact

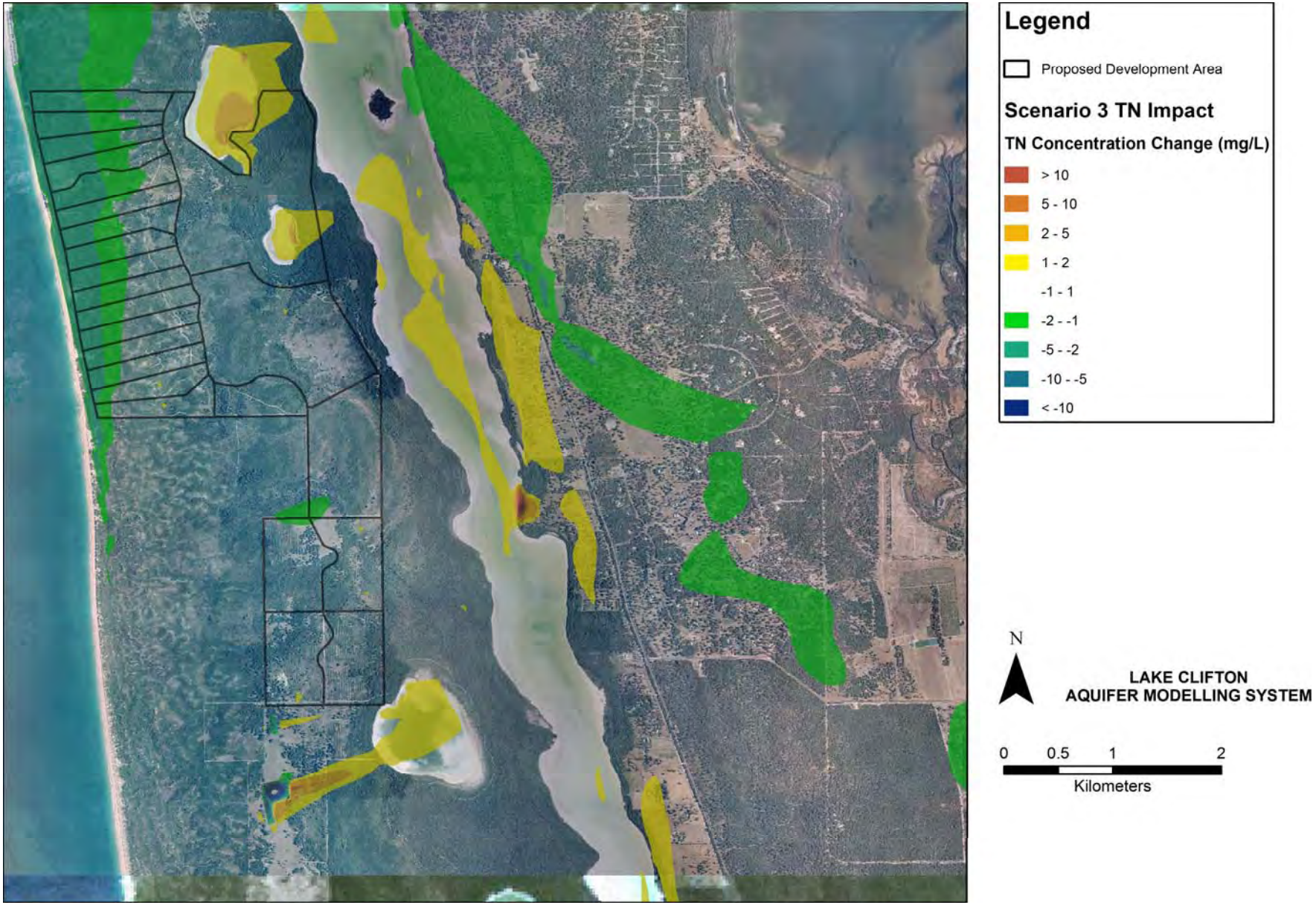

Figure 12: Scenario 3 Total Nitrogen Impact

4.5 Scenario 4 – Historic Low Lake Level

Scenario 4 is the base case simulation with development, but modified by using a historical minimum lake level in order to stabilize the hydraulic gradient between the groundwater mound to the west and Lake Clifton. The parameters used in the Scenario 4 simulation are shown in Table 7. Note that no change in nutrient loading, recharge, hydraulic conductivity or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	Mean sea level	-0.4 mAHD	As calibrated	As previously modelled	2008 Allocations, 1,500 kL/annum unlicensed bores

Table 7: Scenario 4 Simulation Parameters

Figure 13 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 14 shows the groundwater level impact due to the lower lake level after 100 years of simulation. The setting of the minimum lake level at historical minimums results in lake levels that are higher than those predicted by the model, resulting increased water levels in the aquifers, and less hydraulic gradient towards the lake. The groundwater divide moves to the east, given the flatter gradient, and reduced difference in heads between the ocean and the lake. Aquifer levels are higher due to the higher lake level.

The solute transport simulation shows that TN increases in the areas of the mass loading. Solute entering the water table from most of the 16 conservation lots moves westward, where it discharges to the ocean. Solute from the 8 lots east of the groundwater divide, flows into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake.

Figure 15 shows the difference in TN concentration between the base case and Scenario 4, and represents the impact that a higher lake level will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN on the order of 5-10 mg/L in the immediate vicinity of the development. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. Given the higher lake level and reduced flow to the lake, TN concentrations are reduced by 1-2 mg/L. The setting of the lake level infers a source of water that does not come from groundwater, hence the reduction in lake TN concentrations.

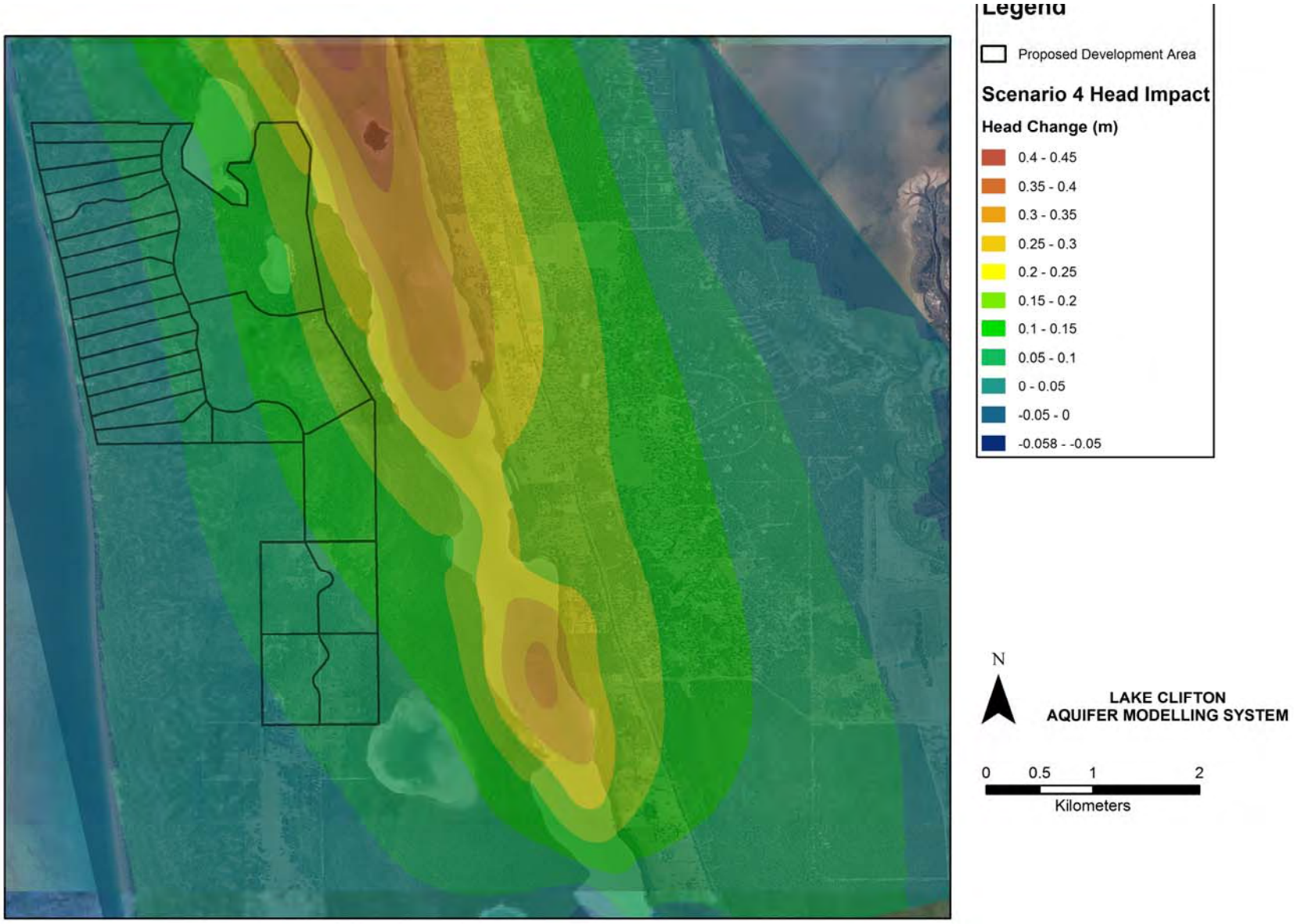

Figure 13: Scenario 4 Groundwater Level and Mean Groundwater Divide

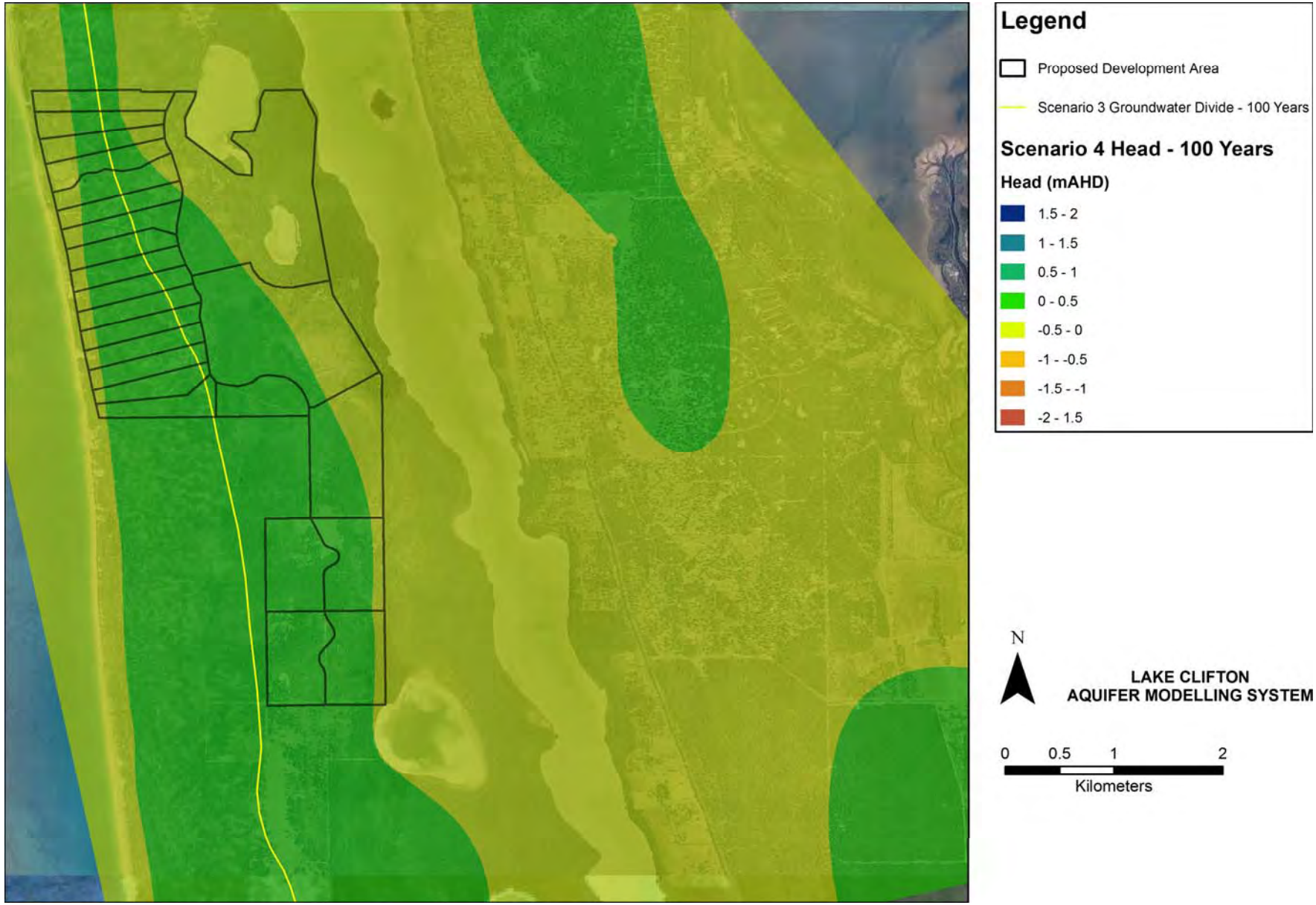

Figure 14: Scenario 4 Groundwater Impact

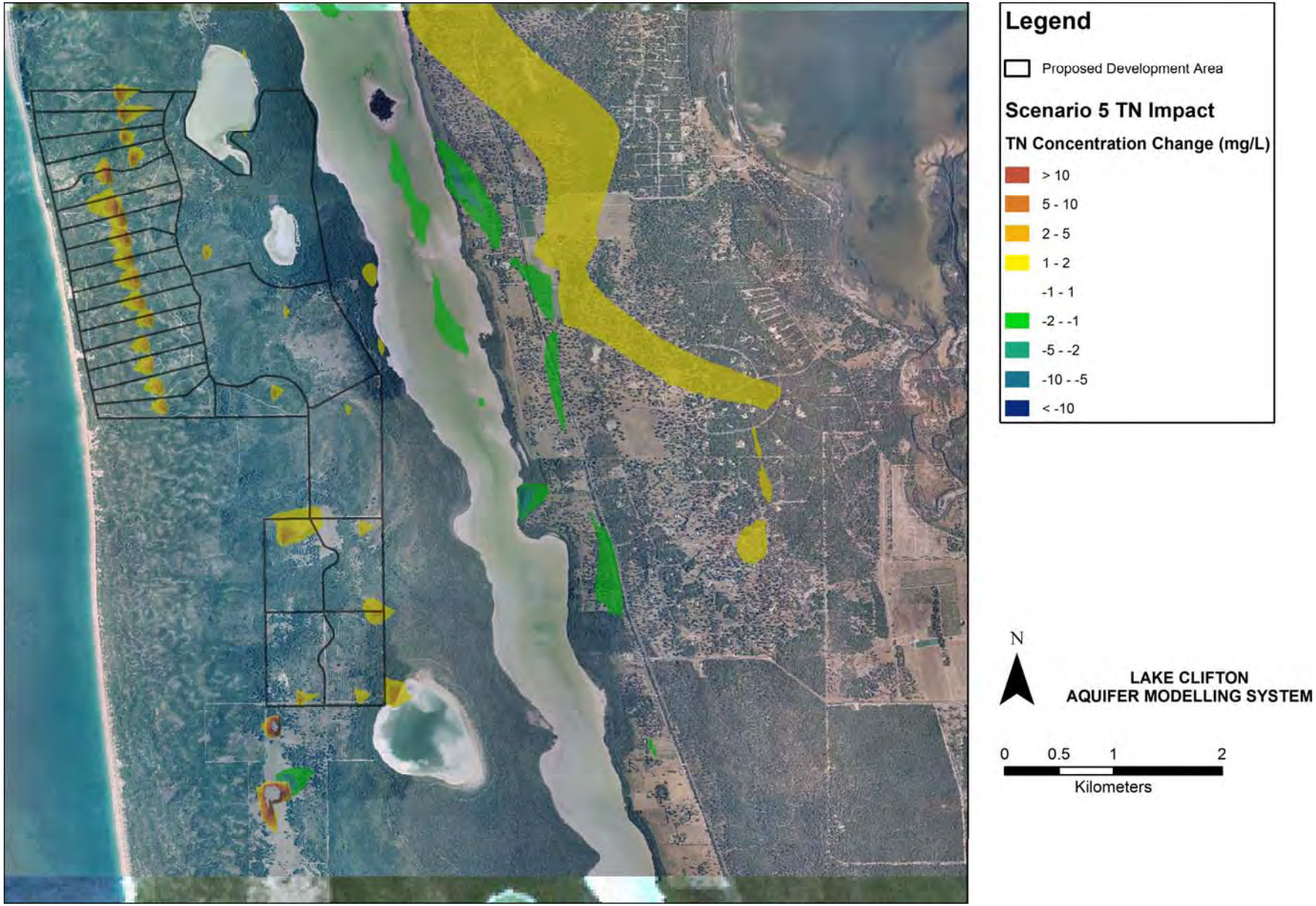

Figure 15: Scenario 4 Total Nitrogen Impact

4.6 Scenario 5 – Decreased Hydraulic Conductivity

Scenario 5 is the base case simulation with development, modified by decreasing the hydraulic conductivity in the vicinity of lake by a factor of 2. The parameters used in the Scenario 5 simulation are shown in Table 8. Note that no change in nutrient loading, recharge, hydraulic gradient or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	Mean sea level	Mean lake level	Half of calibrated values	As previously modelled	2008 Allocations, 1,500 kL/annum unlicensed bores

Table 8: Scenario 5 Simulation Parameters

Figure 16 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 17 shows the groundwater level impact due to decreased hydraulic conductivity after 100 years of simulation. Water levels rise where there is recharge, and decrease in the lakes due to reduced flows.

The solute transport simulation shows that TN increases in the areas of the mass loading due to lots. Solute entering the water table from most of the 16 conservation lots moves westward, where it discharges to the ocean. Solute from the 8 lots east of the groundwater divide, flows into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake.

Figure 18 shows the difference in TN concentration between the base case and Scenario 5, and represents the impact that decreased hydraulic conductivity will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN on the order of 5-10 mg/L in the immediate vicinity of the development. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. The results suggest that TN tend to stay in the vicinity of the lots, and not will migrate as quickly to the area of the lake, resulting in a decrease in lake TN concentrations of 1-2 mg/L.

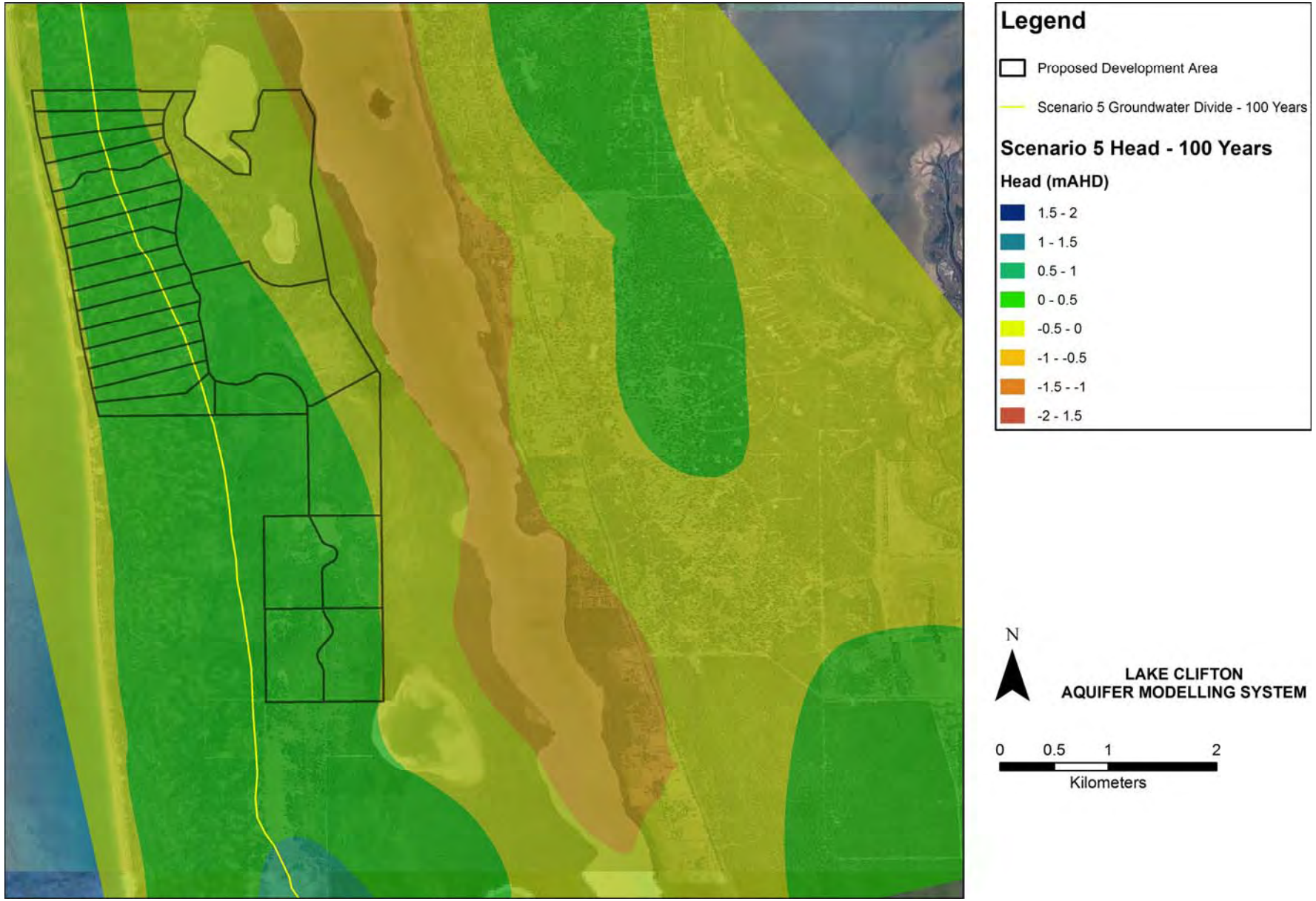

Figure 16: Scenario 5 Groundwater Level and Mean Groundwater Divide

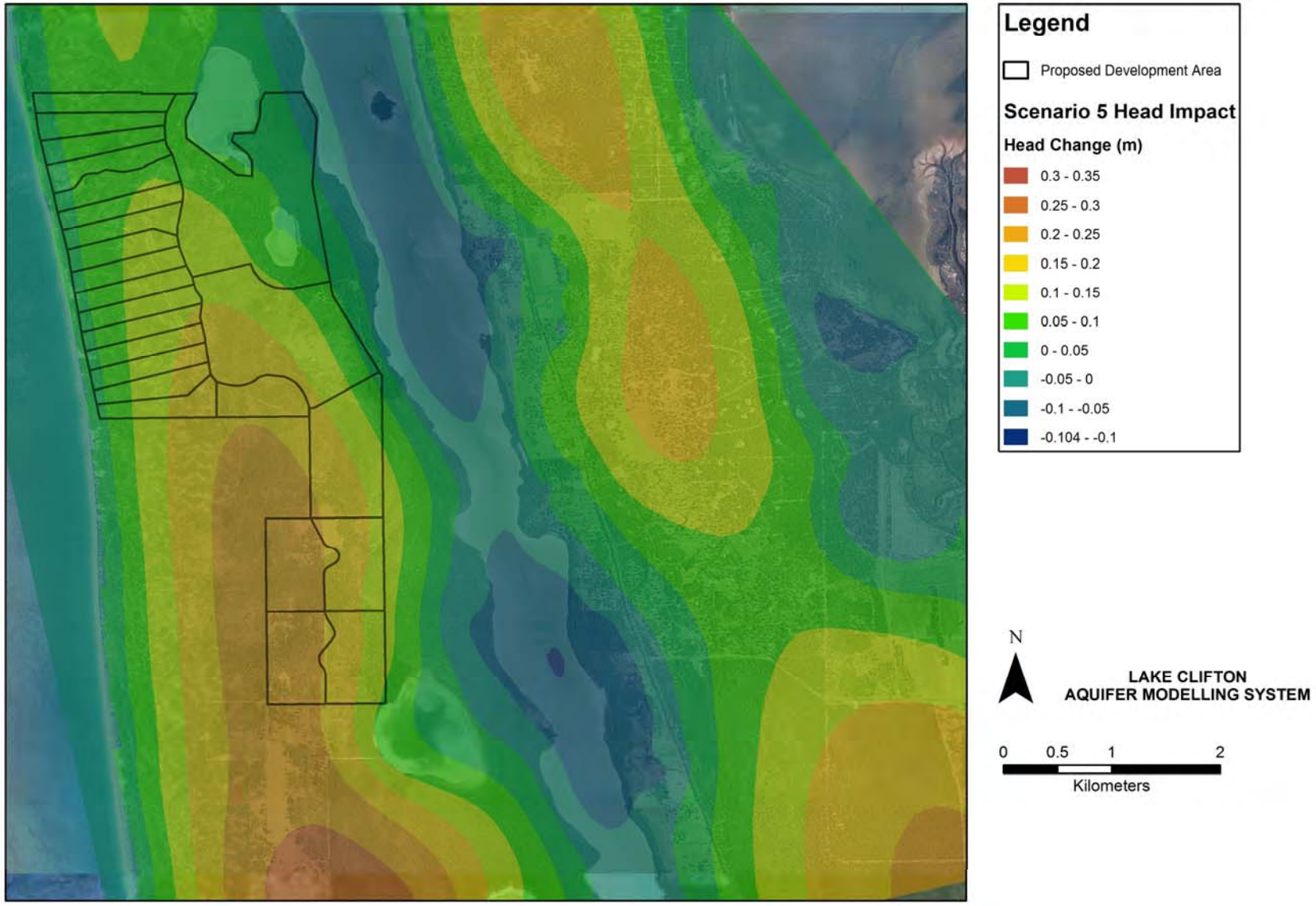

Figure 17: Scenario 5 Groundwater Impact

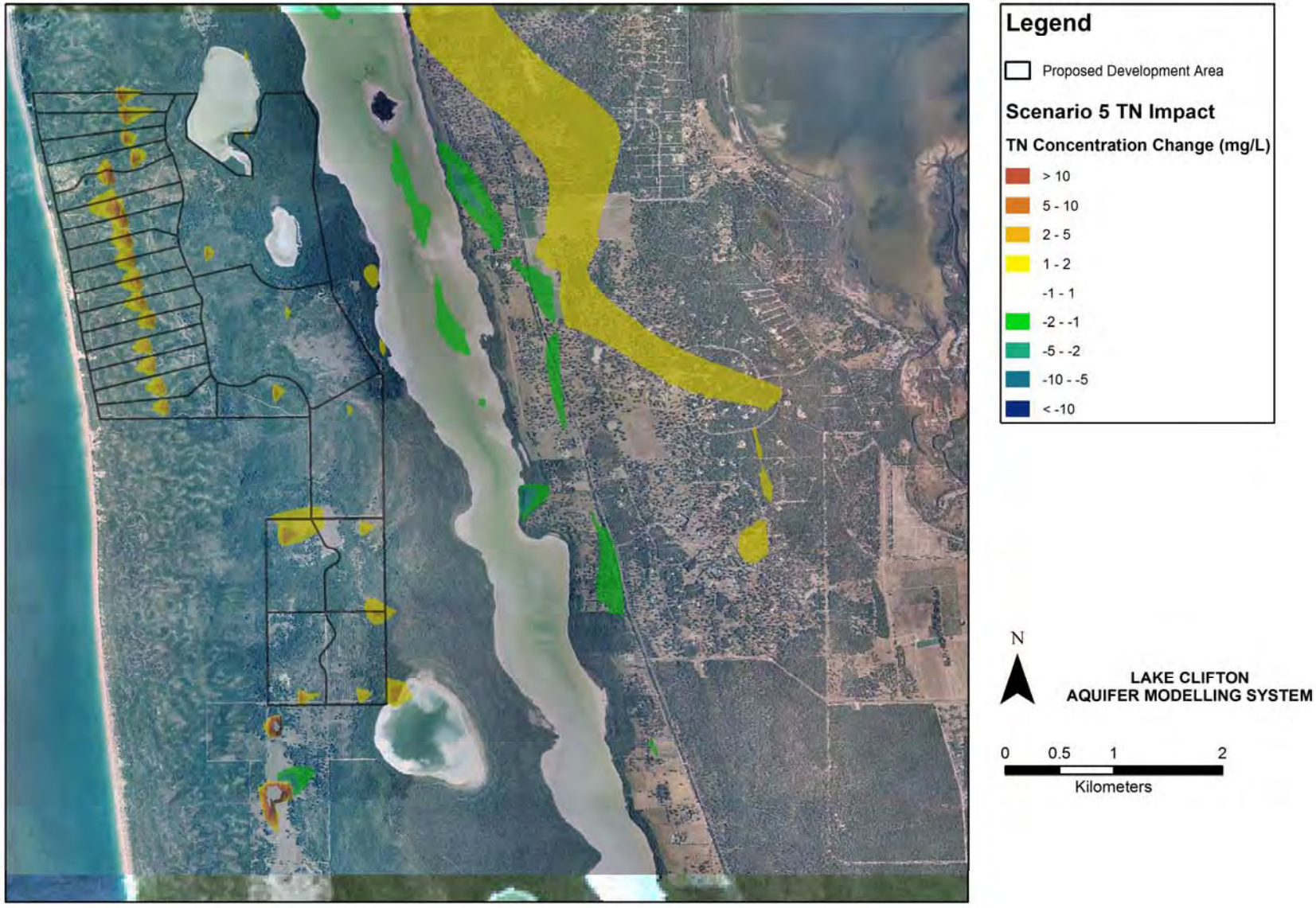

Figure 18: Scenario 5 Total Nitrogen Impact

4.7 Scenario 6 – Increased Hydraulic Conductivity

Scenario 6 is the base case simulation, modified by reducing the hydraulic conductivity in the vicinity of lake by a factor of 2. The parameters used in the Scenario 6 simulation are shown in Table 9. Note that no change in nutrient loading, recharge, hydraulic gradient or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	Mean sea level	Mean lake level	Half calibrated values	As previously modelled	2008 Allocations, 1,500 kL/annum unlicensed bores

Table 9: Scenario 6 Simulation Parameters

Figure 19 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 20 shows the groundwater level impact due to reduced hydraulic conductivity after 100 years of simulation. Groundwater levels in the aquifer have declined, while lake levels have risen in response to the increased hydraulic conductivity of the aquifer.

The solute transport simulation shows that TN increases in the areas of the mass loading. Solute entering the water table from 16 conservation lots moves westward, where it discharges to the ocean. Solute from the 8 lots east of the groundwater divide, flows into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake.

Figure 21 shows the difference in TN concentration between the base case with development and Scenario 6, and represents the impact that increased hydraulic conductivity will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN on the order of 2-5 mg/L in the immediate vicinity of the development. This increase is less than in other cases due to the higher hydraulic conductivity that allow model dilution and mixing of the plume.

The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. The results suggest some additional TN will migrate quicker to the area of the lake, with lake concentrations 1-2 mg/L higher than in the base case.

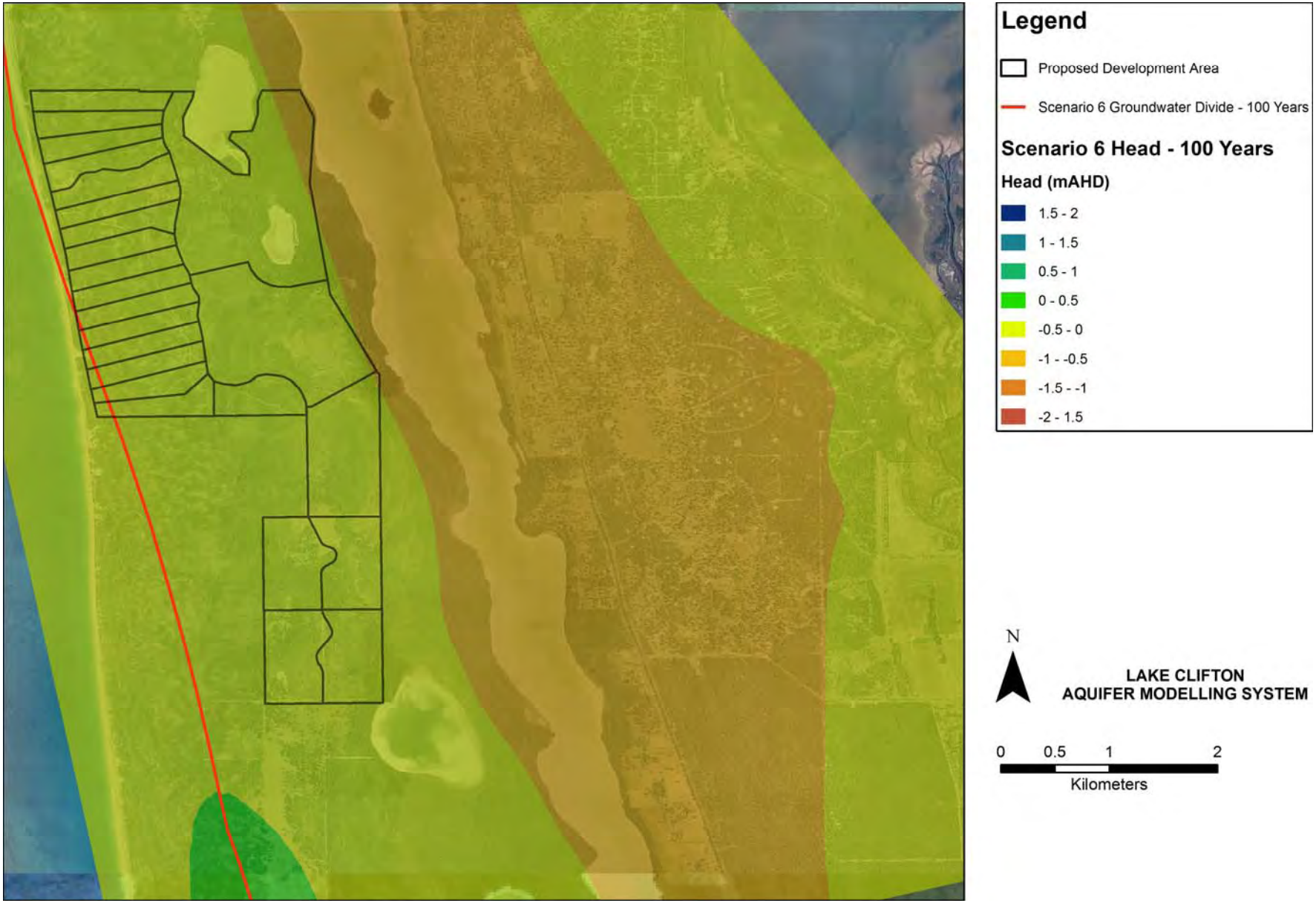

Figure 19: Scenario 6 Groundwater Level and Mean Groundwater Divide

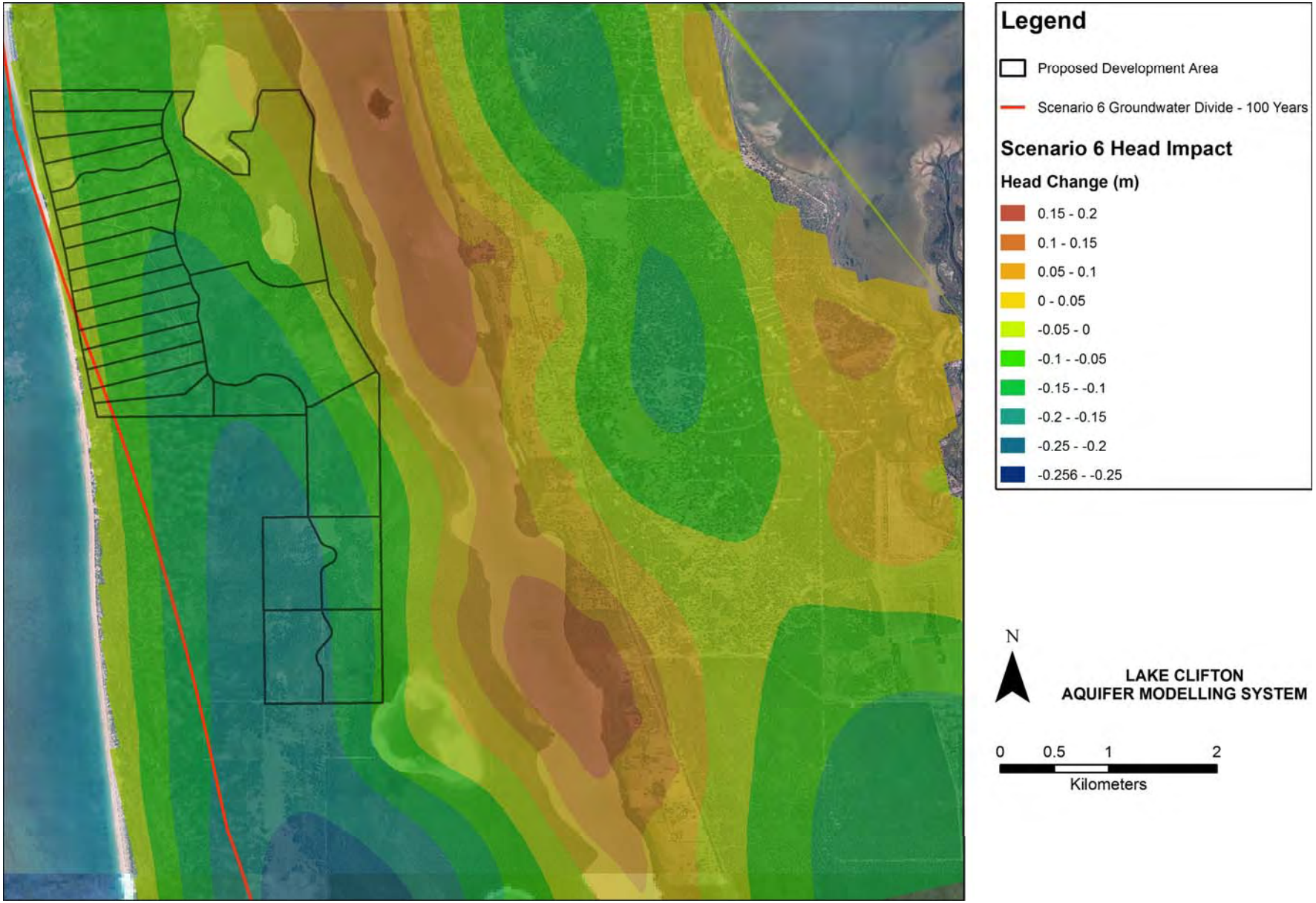

Figure 20: Scenario 6 Groundwater Impact

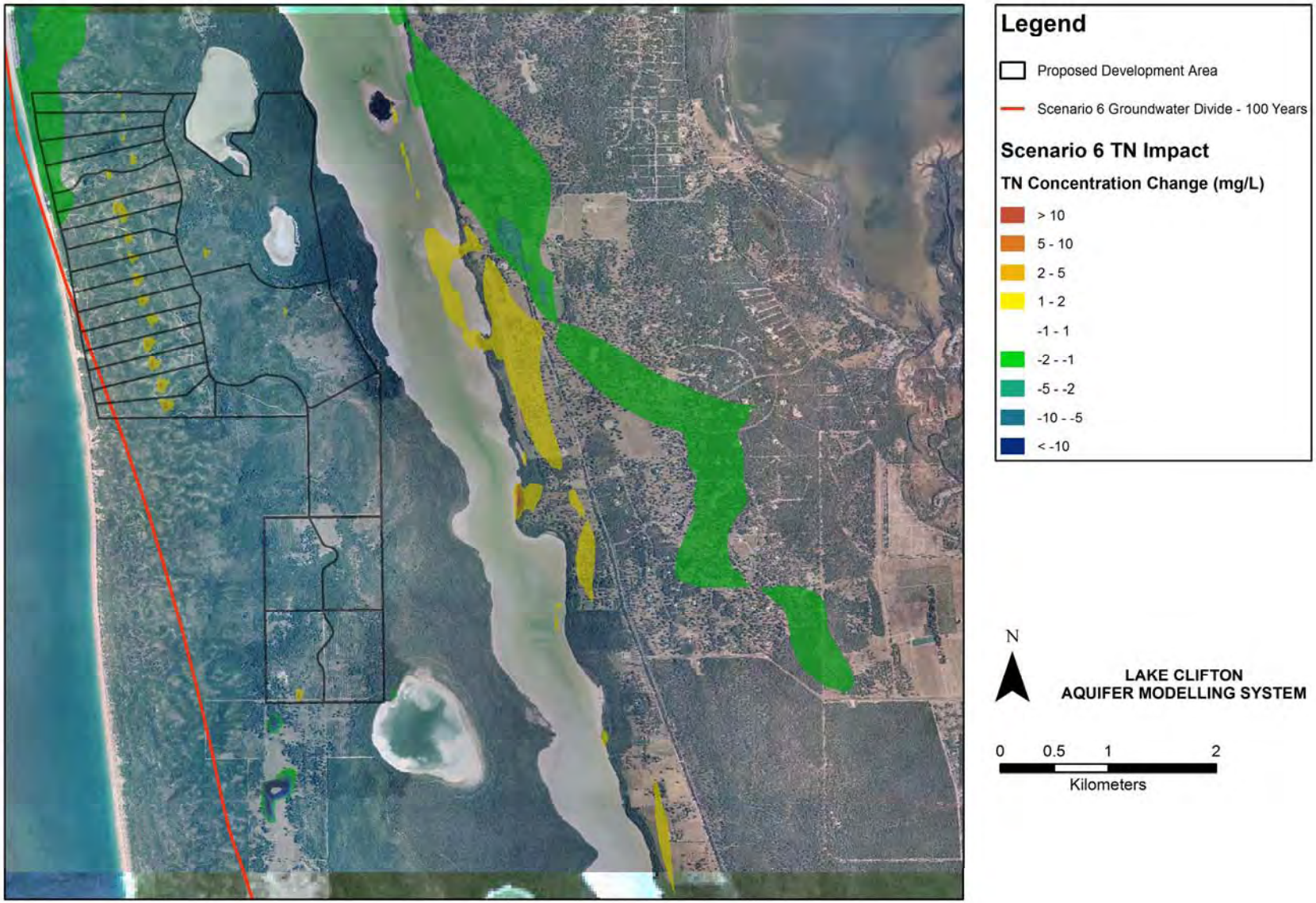

Figure 21: Scenario 6 Total Nitrogen Impact

4.8 Scenario 7 – Increased Nutrient Loadings

Scenario 7 is the base case simulation with development, modified by increasing the nutrient loadings at the 24 developmental lots by a factor of 4 for Nitrogen and 16 for phosphorus. The parameters used in the Scenario 7 simulation are shown in Table 10. Note that no change in recharge, hydraulic gradient, hydraulic conductivity or abstraction occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	Mean sea level	Mean lake level	As calibrated	TN=145 kg/annum TP=36 kg/annum	2008 Allocations, 1,500 kL/annum unlicensed bores

Table 10: Scenario 7 Simulation Parameters

Figure 22 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 23 shows the groundwater level impact due to increased nutrient loadings after 100 years of simulation. Since there are no changes to the flow model other than local abstraction, the only difference between this scenario and the base case is the very shallow cone of depression around the 16 conservation lots. The drawdown in this area is about 0.01 m

The solute transport simulation shows that TN increases in the areas of the mass loading, and compared to the original loadings, the plumes are more extensive and of higher concentration. Solute entering the water table from most of 16 conservation lots moves eastward, where it discharges to the lakes. Solute from the 8 lots east of the groundwater divide also flows into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake.

Figure 24 shows the difference in TN concentration between the base case and Scenario 7, and represents the impact that increased nutrient loadings will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots, with increases in TN greater than 10 mg/L in the immediate vicinity of the development. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. The results suggest TN concentrations in the lake change by less than 1 mg/L at the end of 100 years.

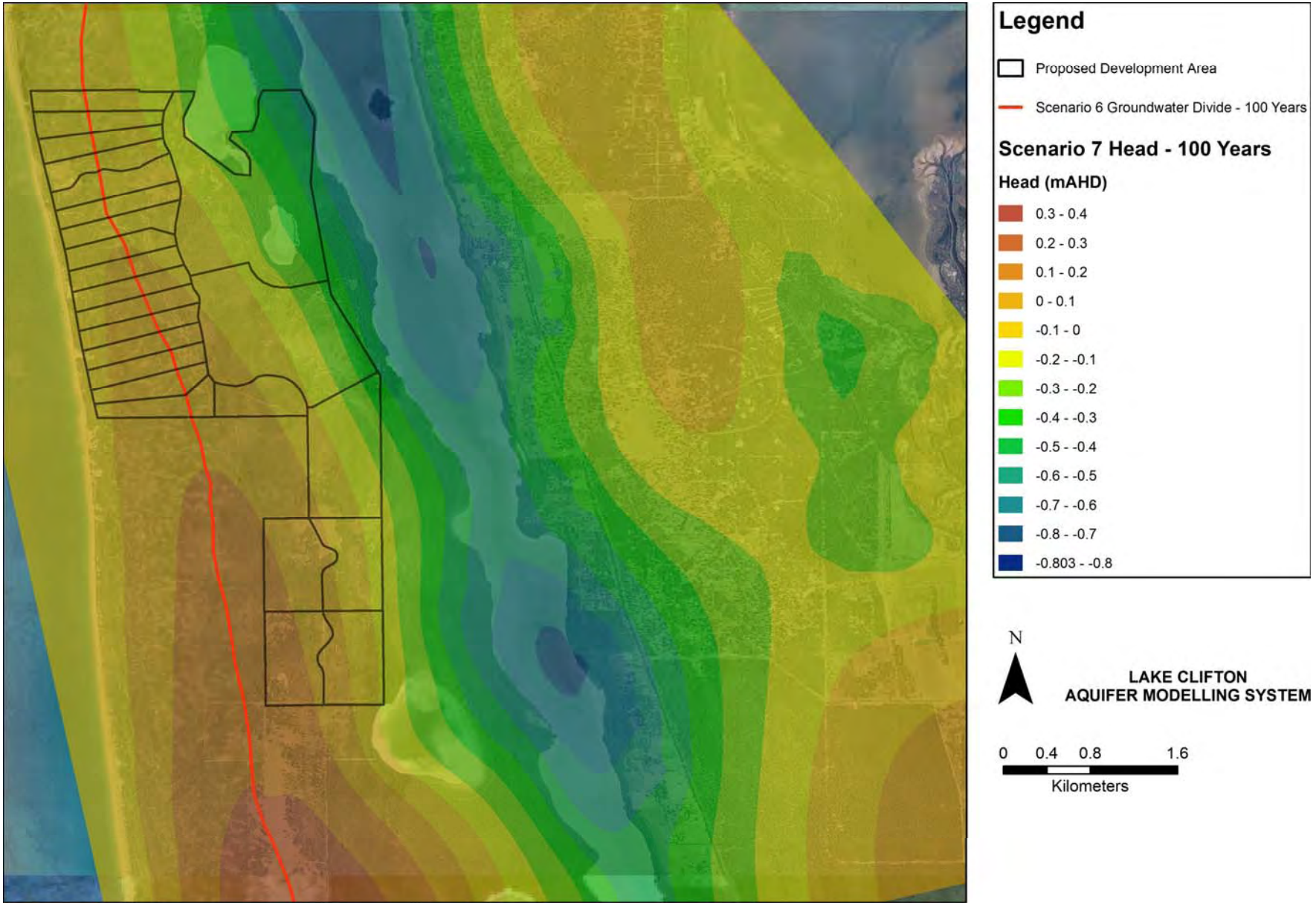

Figure 22: Scenario 7 Groundwater Level and Mean Groundwater Divide

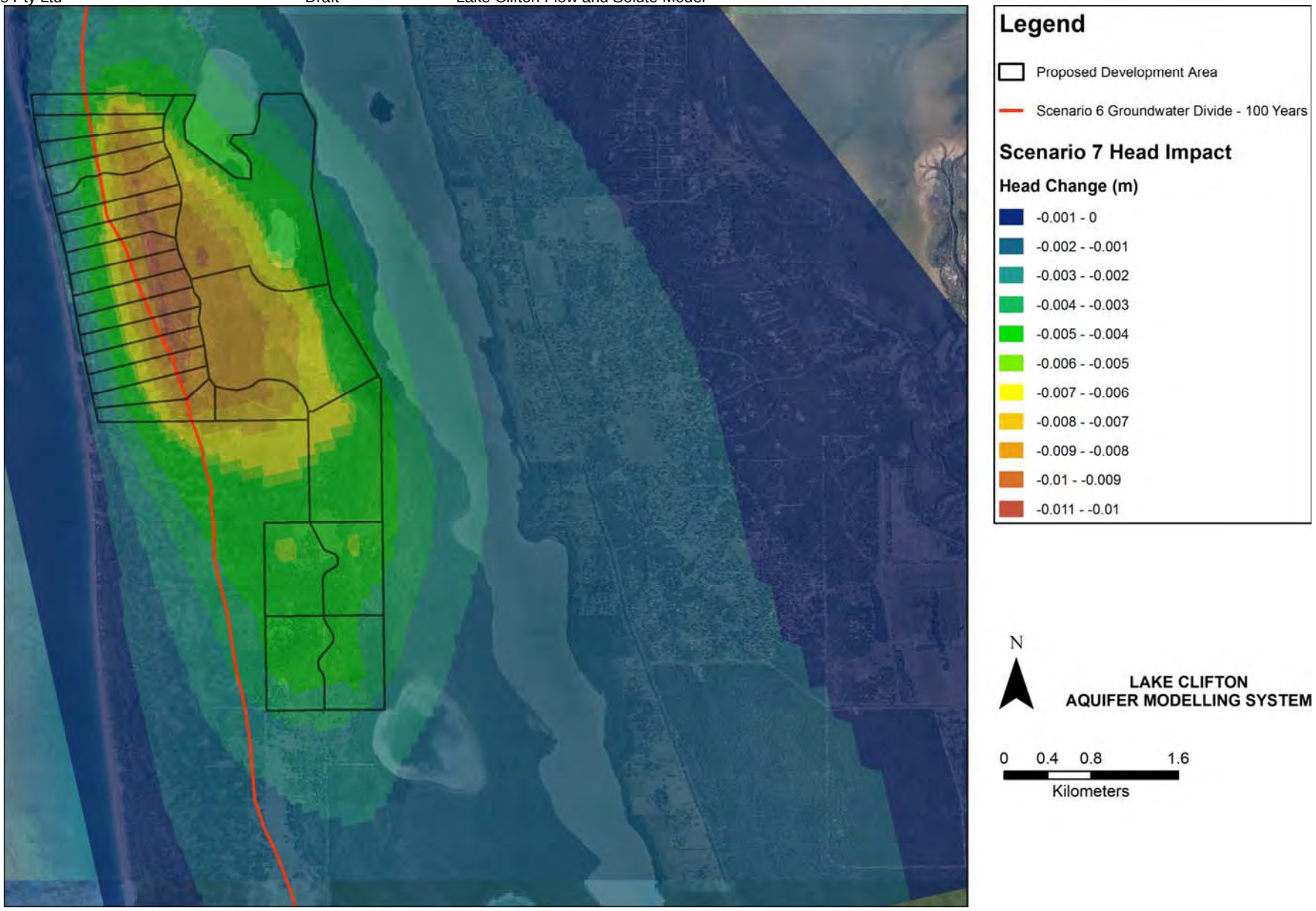

Figure 23: Scenario 7 Groundwater Impact

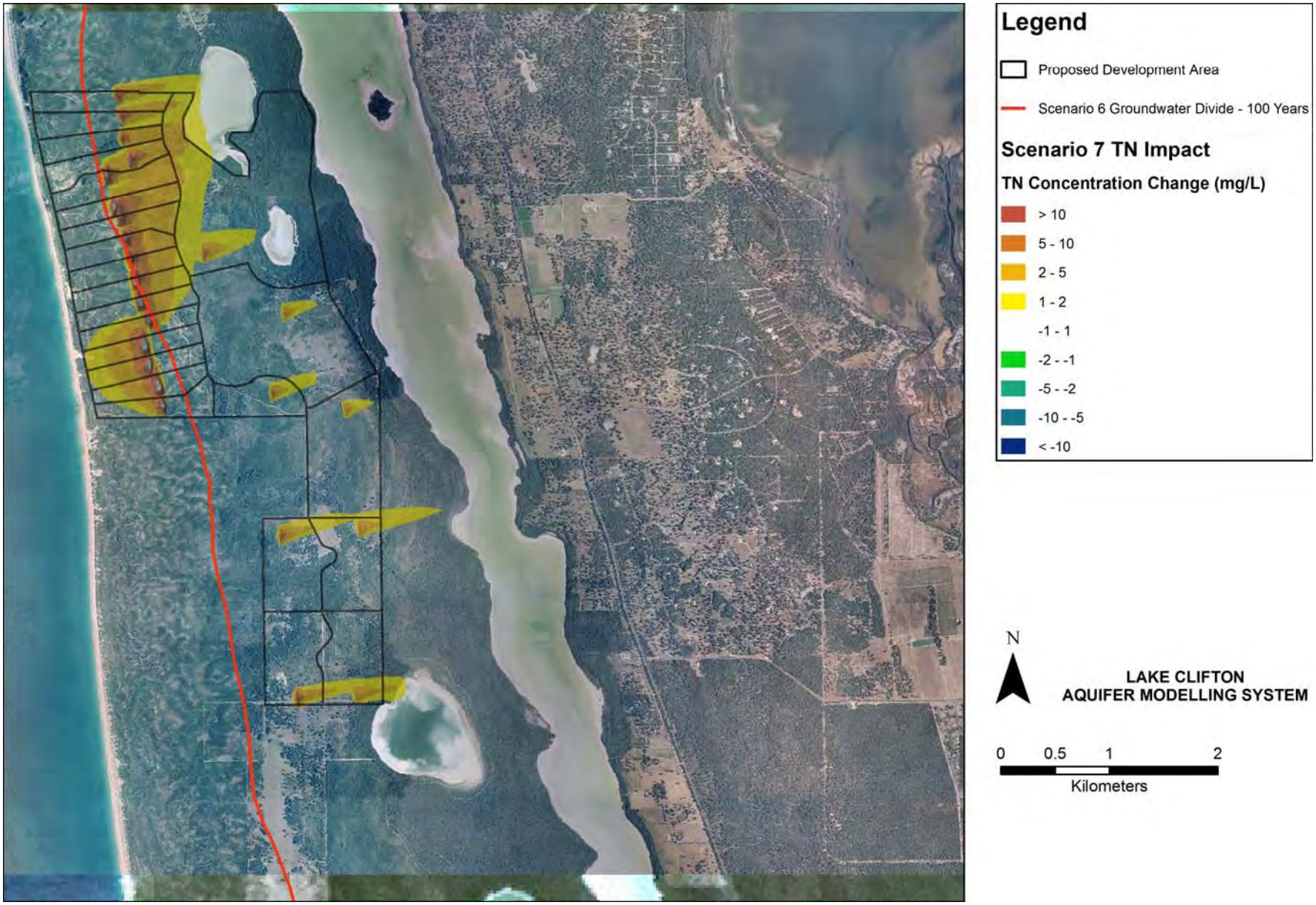

Figure 24: Scenario 7 Total Nitrogen Impact

4.9 Scenario 8 – Increased Abstraction

Scenario 8 is the base case simulation with development, modified by increasing the abstraction from each lot by a factor of 3. The parameters used in the Scenario 8 simulation are shown in Table 11. Note that no change in nutrient loading, recharge, hydraulic gradient or hydraulic conductivity occurs.

Climate	Sea Level	Lake Level	Conductivity	Loading	Abstraction
Average CSIRO calculated rainfall	Mean sea level	Mean lake level	As Calibrated	As previously modelled	2008 Allocations, 4500 kL/annum unlicensed bores

Table 11: Scenario 8 Simulation Parameters

Figure 25 shows the groundwater level at the end of the 100 year simulation period and the groundwater divide. Figure 26 shows the groundwater level impact due to increased abstraction after 100 years of simulation. The only notable feature is the cone of depression associated with the 4500 kL/annum abstraction from each lot. The drawdown due to this abstraction is a maximum of 0.03 m.

The solute transport simulation shows that TN increases in the areas of the mass loading, and compared to the original loadings, the plumes are more extensive and of higher concentration. Solute entering the water table from most of 16 conservation lots moves eastward, where it discharges to the lakes. Solute from the 8 lots east of the groundwater divide also flows into Lake Clifton and to a lesser extent Lake Pollard and Boundary Lake. T

Figure 26 shows the difference in TN concentration between the base case and Scenario 8, and represents the impact that increased abstraction will have on the area. As indicated, plumes of elevated TN concentration are associated with the 24 conservation lots; with increases in TN is 5-10 mg/L in the immediate vicinity of the development. The actual increase in TN concentrations in the lakes will depend on the mixing of groundwater and surface water, the volume of water in the lake, and how well the lake is connected to the aquifer. The results suggest TN concentrations in the lake change by less than 1 mg/L at the end of 100 years.

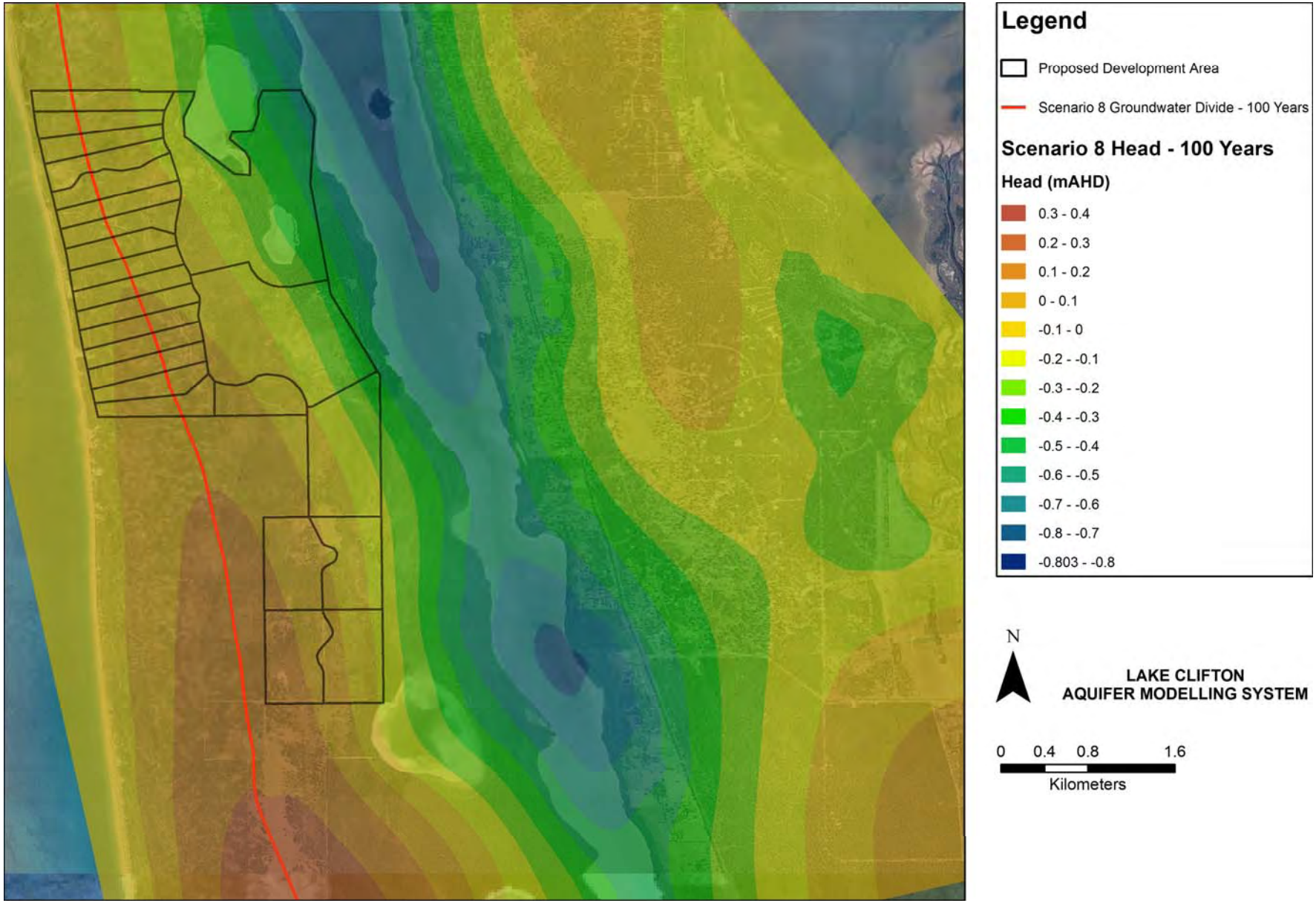

Figure 25: Scenario 8 Groundwater Level and Mean Groundwater Divide

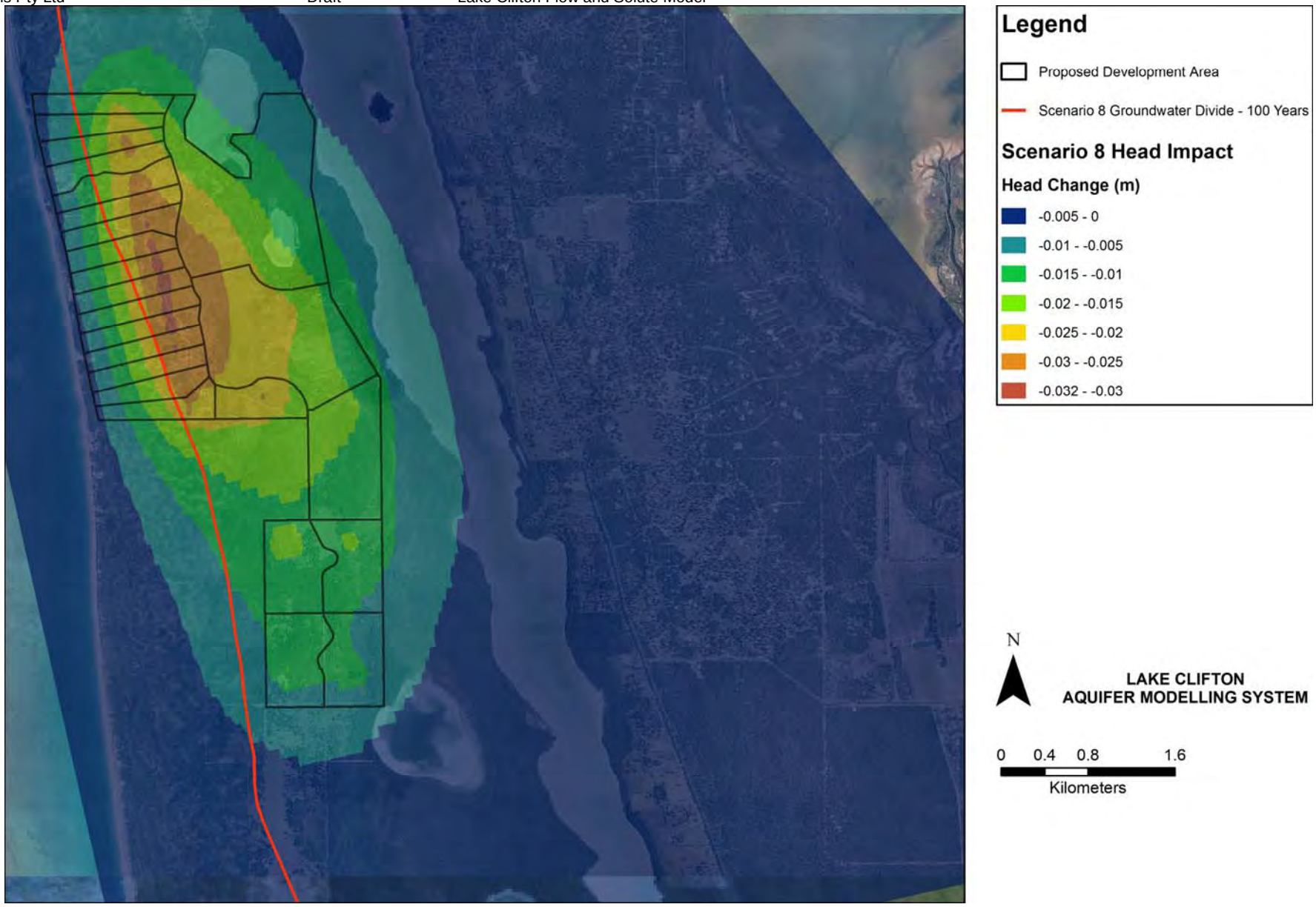

Figure 26: Scenario 8 Groundwater Impact

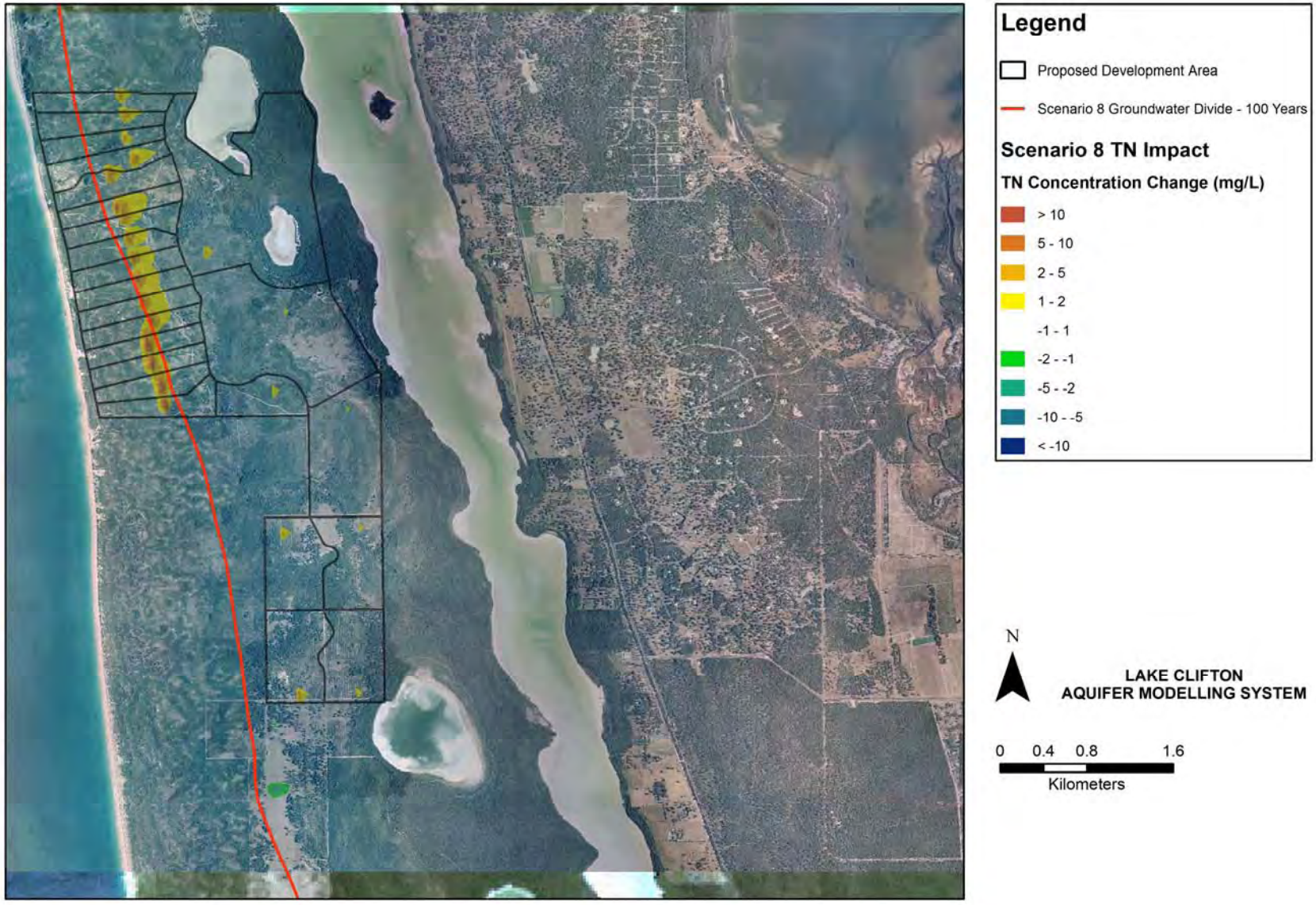

Figure 27: Scenario 8 Total Nitrogen Impact

5 CONCLUSIONS

A flow and solute model of the Lake Clifton area has been constructed and calibrated. The calibration of the flow model indicates that the groundwater model is a reasonable analogue to the aquifer system in the area.

Water level and water quality data collected from the beginning of November 2007 to the beginning of May 2010 indicated that the groundwater system is strongly dependent on rainfall recharge.

The solute transport simulation shows that TN increases in the areas of the mass loading. Solute entering the water table from the 24 conservation lots moves westward, where it discharges to the ocean. In the case of the grazing areas, concentrations of TN increase over a large area and form a plume that moves eastward where it discharges into Lake Clifton and Lake Pollard.

The simulations showed that the model is relatively insensitive to changes in rainfall and abstraction, but sensitive to changes in sea level, nutrient loading and the hydraulic conductivity of aquifers. However, in all cases, the impacts on Lake Clifton are consistent with previous scenarios and support the conclusion that there is a low probability that the development as presented will have a measureable impact on Lake Clifton.

The lack of sufficient time series water quality and water level data prevents verification of the constant density flow model, as well as the solute transport model. It is recommended that monitoring at the site be continued for both groundwater level and water quality to obtain sufficient data with which to verify the model in the future.

It is recommended that monitoring at the site be continued for both groundwater level and water quality to obtain sufficient data with which to verify the model in the future. In addition, the sensitivity of the model to aquifer hydraulic conductivity suggests that pumping tests of the aquifer should be undertaken to confirm the range of hydraulic conductivity of the aquifer, as used in the model.

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GLOSSARY

ADVECTION. The process by which solutes are transported by the motion of flowing groundwater.

ANALYTICAL MODEL. Equations that represent exact solutions to the hydraulic equation for one- or two-dimensional flow problems under broad simplifying assumptions, usually including aquifer homogeneity. They can be solved by hand, or by simple computer programs (e.g. WinFlow, TwoDan), but do not allow for spatial or temporal variability. They are useful to provide rough approximations for many applications with little effort, as they usually do not involve calibration (site-specific monitoring data is often not available for these simple problems). This approach can suit most simple, low-complexity modelling studies.

ANISOTROPY. The condition under which one or more of the hydraulic properties of an aquifer vary according to the direction of flow.

AQUICLUDE. A low-permeability unit that forms either the upper or lower boundary of a groundwater flow system. Aquitards retard but do not prevent the movement of water to or from an adjacent aquifer. Aquitards usually comprise materials such as siltstone, mudstone, marl, or clay

AQUIFER. Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit significant quantities of water to wells and springs. Aquifers generally occur in formations, which can also store large volumes of water such as sands, gravels, limestone, sandstone, or highly fractured rocks.

AQUIFER, CONFINED. An aquifer that is overlain by a confining bed. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.

AQUIFER, SEMICONFINED. An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

AQUIFER, UNCONFINED. Also known as water-table and phreatic aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of unconfined aquifers.

AQUITARD. A low-permeability unit that can store groundwater and also transmit it slowly from one aquifer to another.

ARTESIAN. Groundwater which rises above the surface of the ground under its own pressure by way of a spring or when accessed by a bore.

ARTESIAN BORES. Bores having a static water level (head) above the top of the aquifer being tapped. If the head is above ground level, the bore is free-flowing unless capped.

AUSTRALIAN HEIGHT DATUM (AHD). The reference point (very dose to mean sea level) for all elevation measurements, used for depths of aquifers and water levels in bores.

BORE (WELL). a structure drilled or dug below the surface to obtain water from an aquifer system.

BOUNDARY CONDITIONS. ***Specified Head (or Fixed or Constant Head).*** Refer to Dirichlet Condition (also known as First Type Boundary). ***Specified Flow.*** Refer to Neumann Condition (also known as Second Type Boundary). ***Head-dependent Flow.*** Refer to Cauchy Condition (also known as Third Type Boundary).

CALIBRATION. The process by which the independent variables (parameters) of a numerical model are adjusted, within realistic limits, to produce the best match between simulated and observed data (usually water-level values). This process involves refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to achieve the desired degree of correspondence between the model simulations and observations of the groundwater flow system.

CALIBRATION, INITIAL CONDITIONS. The initial hydrologic conditions for a flow system that are represented by its aquifer head distribution at some particular time corresponding to the antecedent hydrologic conditions in that system. Initial conditions provide a starting point for transient simulations.

CALIBRATION, STEADY STATE. The calibration of a model to a set of hydrologic conditions that represent (approximately) an equilibrium condition, with no accounting for aquifer storage changes.

CALIBRATION, TRANSIENT or DYNAMIC. The calibration of a model to hydrologic conditions that vary dynamically with time, including consideration of aquifer storage changes in the mathematical model.

CONCEPTUAL MODEL. A simplified and idealised representation (usually graphical) of the physical hydrogeologic setting and our hydrogeological understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.

CONFINING LAYER. A body of relatively impermeable material that is stratigraphically adjacent to one or more aquifers. It may lie above or below the aquifer.

CONJUNCTIVE USE. The combined use of surface water and groundwater storage to optimise total available water resources.

DARCY'S LAW. An empirical equation developed to compute the quantity of water flowing through an aquifer. Usually expressed as Q=kiA or Q=Tiw, where Q=flow, k=hydraulic conductivity, I=hydraulic gradient, A=aquifer cross-sectional area, T=transmissivity, w=width of aquifer transverse to flow path.

DENSITY. The mass or quantity of a substance per unit volume. Units are kilograms per cubic metre or grams per cubic centimetre.

DETERMINISTIC. A description of a parameter or a process with uniquely defined qualities. A deterministic parameter has, or is assumed to have, a unique value or a unique spatial distribution. The outcome of a deterministic process is known with certainty. There is, or is assumed to be, a clear cause-and-effect relation between independent and dependent variables.

DIFFUSIVITY. The ratio of transmissivity to storage coefficient in an aquifer.

DRAWDOWN. A lowering of the water table of an unconfined aquifer, or of the potentiometric surface of a confined aquifer. Drawdown is the result of pumping of groundwater from wells.

EVAPOTRANSPIRATION. The sum of evaporation and transpiration.

FIDELITY. The degree to which a model application resembles, or is designed to resemble, the physical hydrogeological system (Ritchey and Rumbaugh, 1996). The ASTM guides apply a hierarchical classification of three main fidelities in order of increasing fidelity: Screening, Engineering Calculation and Aquifer Simulator. Higher fidelity models have a capability to provide for more complex simulations of hydrogeological process and/or address resource management issues more comprehensively. In this guide, the term complexity is used in preference to fidelity.

FINITE-DIFFERENCE MODEL. A particular kind of numerical model based upon a rectangular grid that sets the boundaries of the model and the nodes where the model will be solved.

FLOW NET. The set of intersecting equipotential lines and flowlines representing two-dimensional steady flow through an aquifer.

GROUNDWATER. The water contained in interconnected pores located below the water table.

GROUNDWATER DIVIDE. The boundary between two adjacent groundwater basins. The divide is represented by a high in the water table surface.

GROUNDWATER FLOW MODEL. An application of a mathematical model to represent a site-specific groundwater flow system.

GROUNDWATER-DEPENDENT ECOSYSTEMS (GDEs). For the purposes of defining ecosystem dependence, groundwater may be defined as that water in the system that would be unavailable to plants and animals were it to be extracted by pumping (Hatton and Evans, 1998).

HETEROGENEOUS. A medium which consists of different (non-uniform) characteristics in different locations.

HOMOGENEOUS. A medium with identical (uniform) characteristics regardless of location.

HYDRAULIC CONDUCTANCE. A term which incorporates model geometry and hydraulic conductivity into a single value for simplification purposes. Controls rate of flow to or from a given model cell, river reach, etc.

HYDRAULIC CONDUCTIVITY. The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).

HYDRAULIC DIFFUSIVITY. A property of an aquifer or confining bed defined as the ratio of the transmissivity to the storativity.

HYDRAULIC GRADIENT. The change in total head with a change in distance in a given direction that yields a maximum rate of decrease in head.

IMPERMEABLE LAYERS. Layers of rock that do not allow water to pass through them.

ISOTROPY. The condition in which hydraulic properties of the aquifer are equal in all directions.

KARST. The types of geologic terrain underlain by carbonate rocks where significant solution of the rock has occurred due to the flowing groundwater. Karst topography is frequently characterised by sinkholes, caves, and underground drainage.

LEAKANCE. Controls vertical flow in a model between cells in adjacent layers. Equivalent to effective vertical hydraulic conductivity divided by the vertical distance between layer midpoints.

MONTE CARLO ANALYSIS. A set of model simulations for alternative model realisations, on the assumption that aspects of the model are stochastic. A *realisation* is one of many possible valid descriptions of a model in terms of its aquifer parameters, boundary conditions or stresses.

NON-UNIQUENESS. The principle that many different possible sets of model inputs can produce nearly identical computed aquifer head distributions for any given model (see heuristic representation given in Appendix A and Section 3 -Ritchey and Rumbaugh, 1996).

NUMERICAL MODEL. A model of groundwater flow in which the aquifer is described by numerical equations, with specified values for boundary conditions that are usually solved on a digital computer. In this approach, the continuous differential terms in the governing hydraulic flow equation are replaced by finite quantities. The computational power of the computer is used to solve the resulting algebraic equations by matrix arithmetic. In this way, problems with complex geometry, dynamic response effects and spatial and temporal variability may be solved accurately. This approach must be used in cases where the essential aquifer features form a complex system, and where surface-groundwater interaction is an important component (i.e. high complexity models).

OBSERVATION WELL. A non-pumping well used to observe the elevation of the water table or the potentiometric surface. An observation well is generally of larger diameter than a piezometer and typically is screened or slotted throughout the thickness of the aquifer.

PARSIMONY. The parsimony principle implies that a conceptual model has been simplified as much as possible, yet it retains enough complexity so that it adequately represents the physical system and its behaviour.

PIEZOMETER. A non-pumping well, generally of small diameter that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

POROSITY. The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

POROSITY, EFFECTIVE. The volume of the inter-connected void spaces through which water or other fluids can travel in a rock or sediment divided by the total volume of the rock or sediment.

POST-AUDIT. Comparison of model predictions with what actually happened.

POTENTIOMETRIC SURFACE. A surface that represents the level to which water will rise in tightly cased wells. The water table is a particular potentiometric surface of an unconfined aquifer (see SATURATED ZONE).

PUMPING TEST. Also known as an aquifer test. A test made by pumping a well for a period of time at a measured rate and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer.

RECHARGE. The process that replenishes groundwater, usually by rainfall infiltrating from the ground surface to the watertable and by river water entering the watertable or exposed aquifers. The addition of water to an aquifer.

SALINITY. The concentration of sodium chloride or dissolved salts in water, usually expressed in EC units or milligrams of total dissolved solids per litre (mg/L TDS). The conversion factor of 0.6 mg/L TDS = 1 EC unit is commonly used as an approximation.

SENSITIVITY ANALYSIS. The measurement of the uncertainty in a calibrated model as a function of uncertainty in estimates of aquifer parameters and boundary conditions.

SIMULATION. One complete execution of a groundwater modelling program, including input and output.

SPECIFIC STORAGE. The amount of water per unit volume of a saturated formation that is expelled from storage due to compression of the mineral skeleton and the pore water.

SPECIFIC YIELD. The ratio of the volume of water that a given mass of saturated soil or rock will yield by gravity to the volume of that mass.

STOCHASTIC. A description of a parameter or a process with random qualities. A stochastic parameter has a range of possible values, each with a defined probability. The outcome of a stochastic process is not known with certainty.

STORAGE COEFFICIENT (STORATIVITY). The volume of water that a conductive unit will expel from storage per unit surface area per unit change in head. In a confined aquifer, it is computed as the product of specific storage and aquifer thickness. In an unconfined aquifer, it is equal to specific yield.

STREAMLINE. A line (commonly transverse to groundwater level contours) that represents the flow path for a particle of water.

TOTAL DISSOLVED SOLIDS (TDS). A measure of the salinity of water, usually expressed in milligrams per litre (mg/L).

Sometimes TDS is referred to as total dissolved salts, or as TSS, total soluble salts. See also EC.

TRANSMISSIVITY. The rate at which water is transmitted through a unit width of aquifer of confining bed under a unit hydraulic gradient. The product of saturated thickness and hydraulic conductivity.

UNCERTAINTY ANALYSIS. The quantification of uncertainty in model results due to incomplete knowledge of model aquifer parameters, boundary conditions or stresses.

UNCONFINED AQUIFER. An aquifer that contains the watertable and is normally exposed to the surface. Occasionally there may be a layer overlying this type of aquifer protecting it from the surface.

UNSATURATED ZONE. Also known as the zone of aeration and the vadose zone. The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched groundwater, may exist in the unsaturated zone.

VADOSE ZONE. See UNSATURATED ZONE.

VALIDATION. See VERIFICATION.

VERIFICATION. A test of the integrity of a model by checking if its predictions reasonably match the observations of a reserved data set, deliberately excluded from consideration during calibration.

VISCOSITY. The property of fluid describing its resistance to flow. Units of viscosity are Newton-seconds per metre squared or Pascal-seconds. Viscosity is also known as dynamic viscosity.

WATER BUDGET. An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

WATER TABLE. The upper level of the unconfined groundwater, where the water pressure is equal to that of the atmosphere and below which the soils or rocks are saturated. It is the location where the sub-surface becomes fully saturated with groundwater, the level at which water stands in wells that penetrate the water body. Above the water table, the sub-surface is only partially saturated (often called the unsaturated zone). The water table can be measured by installing shallow wells extending just into the zone of saturation and then measuring the water level in those wells.

APPENDICES

APPENDIX D

CLIFTON BEACH
GRACEFUL SUNMOTH SURVEY

CLIFTON BEACH

GRACEFUL SUN MOTH SURVEY

CLIFTON BEACH

GRACEFUL SUN MOTH SURVEY

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STATEMENT OF LIMITATIONS

Scope of Services

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

Reliance on Data

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

Environmental Conclusions

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

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

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

Report for Benefit of Client

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

Other Limitations

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

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

EXECUTIVE SUMMARY

ENV. Australia Pty Ltd was commissioned by Cape Bouvard Investments in March 2010 to undertake a survey for the Graceful Sun Moth (*Synemon gratiosa*) for the Clifton Beach project area. The survey was carried out in accordance with the criteria set by the Department of Environment and Conservation in relation to Graceful Sun Moth surveys.

The surveys were conducted on four separate dates with a minimum of four days between each survey. All of the surveys were conducted in March, during warm days (25.6°C -33.2°C), between 10:00 am to 3:00 pm and had wind speeds well under the maximum of 5 metres/second (1.32 – 2.54 metres/second).

Six hundred and nineteen quadrats were established within the Graceful Sun Moth survey area to document the presence of the mat-rushes *Lomandra*, which is inline with the number specified by the Department of Environment and Conservation for this site. *Lomandra maritima* was found throughout the Graceful Sun Moth survey area in varied densities, ranging from 0% - 90%. The Graceful Sun Moth transects measured approximately 15 km of transects walked each survey date. These transects were focused on the areas most likely to contain Graceful Sun Moths including paths and vegetation containing *Lomandra*. This survey has met the criteria set by the Department of Environment and Conservation in regards to Graceful Sun Moth surveys.

A total of 116 Graceful Sun Moths were recorded (captured or observed) during the survey.

1 INTRODUCTION

ENV. Australia Pty Ltd (ENV) was commissioned by Cape Bouvard Investments in March 2010 to undertake a Graceful Sun Moth (GSM) survey for the Clifton Beach project area (herein referred to as the project area). The survey was carried out in accordance with the criteria set by the Department of Environment and Conservation (DEC) in relation to GSM surveys.

1.1 OBJECTIVES

The objectives of the GSM survey were to:

- Document the presence of the GSM within the project area; and
- Conduct a *Lomandra* species density assessment of the project area.

1.2 BACKGROUND INFORMATION

The GSM (*Synemon gratiosa*) is a small day-flying moth endemic to south-west Western Australia and has a limited distribution. Little is known about this species and the following information comes from the *DEC Graceful Sun Moth Information Kit and Survey Methods* (Bishop, Williams and Gamblin 2009). The species is currently only known from the Swan Coastal Plain between Quinns Rocks and south to Mandurah. Within this distribution it is known from a handful of sites, most of which are isolated pockets of bushland in developed areas.

The GSM is listed as Endangered under the Federal *Environment Protection and Biodiversity Conservation Act 1999.* It is declared specially protected fauna under the WA *Wildlife Conservation Act 1950*, as rare or likely to become extinct.

The GSM is relatively small with a wingspan of 25-30 millimetres (mm). They are sexually dimorphic with the female being slightly larger than the males. Both sexes have dark grey upper surface of the forewings and bright orange on the upper surface of the hind wings and the entire underside of all the wings. See Plate 1.

Plate 1: Male and Female Graceful Sun Moths

The Male specimen is the top row and the Larger Female is the Bottom row (Bishop, Williams and Gamblin 2009).

Adult GSM are active in late February to early April each year. The time when the adults are active seems to be different each year, possibly as a result of weather conditions. In March, especially the first half seems to be when the species is most active and abundant.

There is a limited amount of information known about this species. The larvae are only known to feed on two closely related species of *Lomandra* mat-rushes – *Lomandra maritima* and *Lomandra hermaphrodita*. The adults lay their eggs on the base of the plants and when the larvae hatch they burrow into the leaf bases, growing tip and rhizomes where they grow for the next eleven months.

The GSM has a restricted distribution much of which is found on the Swan Coastal Plain in the Perth metropolitan area. The greatest threat to this species is through habitat loss as this region is experiencing rapid urban development. The GSM has limited dispersal ability and so each population is essentially genetically isolated. Other factors that make the GSMs future uncertain are the ongoing threats of track use and maintenance, inappropriate fire regimes and damage to habitat from the recreational use of four-wheel drive vehicles (Threatened Species Scientific Committee 2008).

DEC guidelines indicate that for proposals that occur in the known distribution of both the GSM and the two species of *Lomandra*, a GSM survey is required prior to development.

1.3 LOCATION

Cape Bouvard Investments owns Lots 2240, 2275, 2657, 3045 and 1000 located adjacent to the western side of Lake Clifton. These landholdings constitute the project area, which is located

partly in the south western extremity of the City of Mandurah and partly in the north western extremity of the Shire of Waroona. The site is 22 km south of the Mandurah townsite (Figure 1).

The total area of the project area is 975.2 ha, although only 322.5 ha has been surveyed for GSM (herein referred to as the GSM survey area). The site is bound to the north, east (Lake Clifton) and south (partial) by the Yalgorup National Park. Part of the project area is also bound by a rural landholding to the south and the coastline to the west (Figure 2).

The land is currently zoned by State and Local Government planning instruments as Rural. The site has been used historically for rural purposes, principally extensive cattle grazing.

1.4 CLIMATE

The climate of this region is warm Mediterranean, with an average maximum summer temperature of 28.8°C and an average minimum winter temperature of 5.8°C (Bureau of Meteorology (BOM) 2010). The region receives an average annual rainfall of 1244.7 mm, with the majority of precipitation occurring in winter (BOM 2010) (Figure 3).

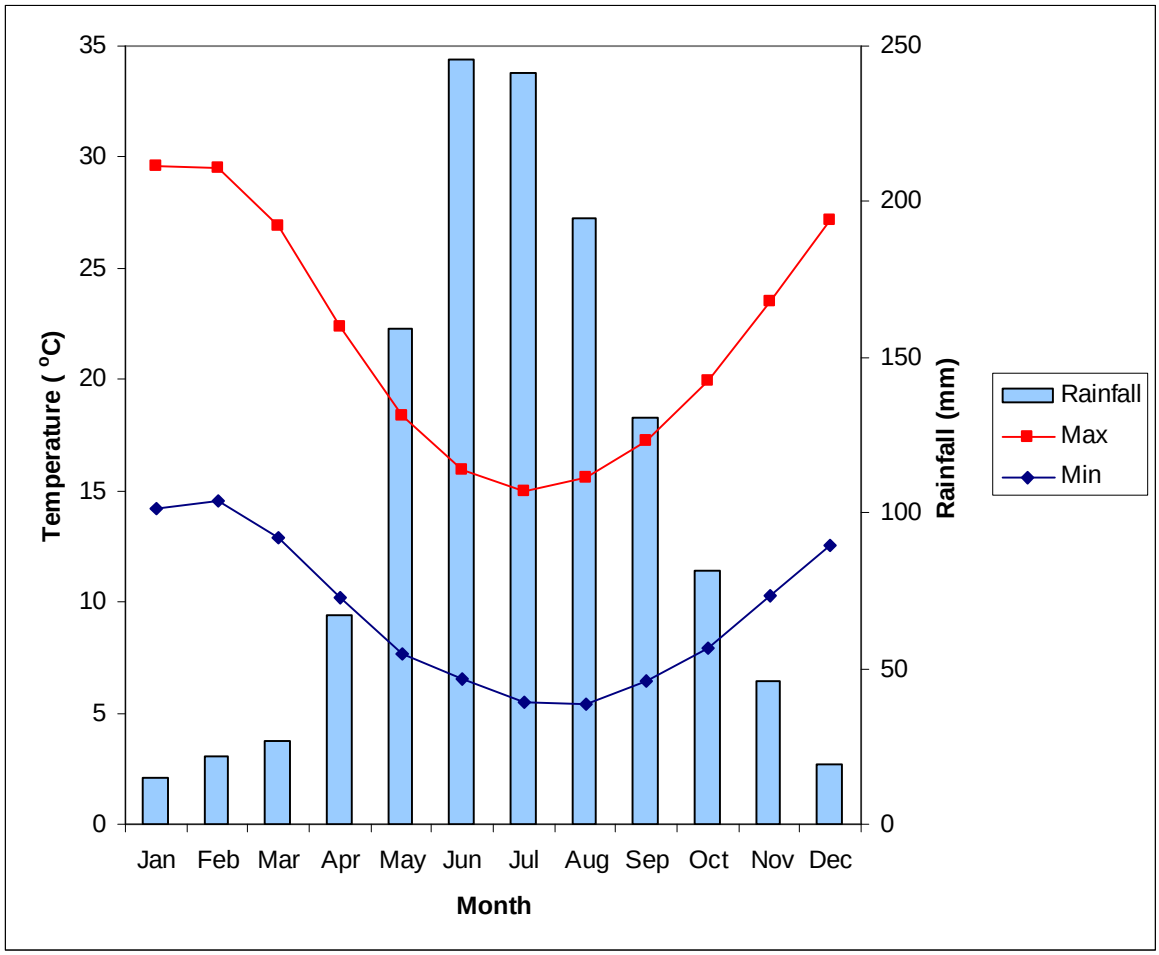

Figure 3: Average Monthly Rainfall and Maximum and Minimum Temperatures at Dwellingup (1935-2010) (BoM 2010)

1.5 VEGETATION

The Graceful Sun Moth is known only to inhabit areas with two general vegetation types:

- ***Banksia* / Woolly Bush Woodland:** Is the vegetation type associated with *Lomandra hermaphrodita* and occurs in the deep sands around the northern suburbs of Perth. *Lomandra hermaphrodita* tends to be found in low concentrations in this vegetation type (Bishop, Williams and Gamblin 2009).
- **Open areas of herbland, heathland and shrubland:** Are the vegetation types associated with *Lomandra maritima* and they occur on Quindalup soils (sand and limestone) close to the coast. *Lomandra maritima* is often present in reasonable numbers and may even be a dominant understory herb (Bishop, Williams and Gamblin 2009).

ENV has previously completed a Level 2 flora and vegetation survey (ENV 2009) of the project area. As part of the flora survey, it was found that *Lomandra maritima* was present only in certain sections of the project area. The *Lomandra* was limited to the large area of coastal heath located in the north and west of the project area (Figure 2). Areas mapped as containing *Lomandra* were targeted for the purpose of the GSM survey. Following discussion with DEC it was determined that these areas were most prospective for GSM and agreed that vegetation types not recording *Lomandra* were not required to be surveyed.

2 METHODOLOGY

2.1 STATE LEGISLATION

2.1.1 Protection of Fauna and Fauna Habitat

Fauna species and their habitat are protected formally and informally by various legislative and non-legislative measures, which are outlined below.

Legislative Protection

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act): a Federal Act;
- *Wildlife Conservation Act 1950* (WC Act): a State Act; and
- *Environmental Protection Act 1986* (EP Act): a State Act.

EPBC Act

The EPBC Act aims to protect matters of national environmental significance, which are detailed in Appendix A. Under the EPBC Act, the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) lists protected species and Threatened Ecological Communities (TEC's) by criteria set out in the act (Commonwealth of Australia 2007). The GSM is classified as Endangered under the EPBC Act.

WC Act

The DEC lists taxa under the provisions of the WC Act as protected and are classified as Schedule 1 to Schedule 4 according to their need for protection (see Appendix A). The Act makes it an offence to 'take' threatened species without an appropriate licence. There are financial penalties for contravening the WC Act. The GSM is Schedule 1 under the WC Act.

EP Act

Significant habitat necessary for the maintenance of indigenous fauna species to Western Australia is a 'clearing principle' for assessing applications for permits to clear native vegetation, where exemptions for a clearing permit under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* do not apply.

2.2 SURVEY METHODOLOGY

As the GSM is only present in certain circumstances the DEC has set criteria for how surveys are to be conducted (Bishop, Williams and Gamblin 2009).

Time of year: The DEC has specified that all GSM surveys are to be conducted in Late February and all of March. Although GSMs have been previously recorded from late February to early April, the first half of March is the peak flight period. Only surveys conducted in late February and all of March can provide sufficient information to determine that the GSM is not present at a particular site.

Replication of surveys: Due to the nature of the GSM it can be difficult to detect, therefore multiple surveys on a single site during the flight period are necessary. The DEC has specified that at least four surveys are required to ensure that the GSM is not present at a particular site. Surveys of a site must be undertaken with no less than four days in between each (M. Williams *pers. com.* DEC). As the GSM only has a life span of a few days it is important to obtain a sample of as many cohorts throughout the breeding period as possible. This is required to access the variability in the cohorts as they may differ between sites.

Time of day: As the name suggests the GSM are active in warm sunny weather and prefer bright sunshine. Surveys must be conducted between 10 am and 3 pm as this is the time when they are most active.

Wind speed: The GSM may become inactive if the wind is too strong, above 18 kilometres per hour (km/h) or 5 metres per second (m/s). In March each afternoon, surveys should be conducted prior to the sea breeze arriving.

2.2.1 Sun Moth Transects

Locations to search: GSMs do not disperse far in their life time so they are usually found close to their breeding areas or areas containing *Lomandra* species. During each survey these were identified and targeted to increase the likelihood of observation. Male GSMs are territorial creating small territories called leks that are about 20 square metres and usually occur in cleared areas such as tracks and fire breaks. GSM males also seek out hilltops, crests and dunes. Therefore search techniques focus on areas containing higher densities of *Lomandra*, tracks, fire breaks and hillcrests (Bishop, Williams and Gamblin 2009).

Transect procedure: The DEC has specified a set way to conduct GSM surveys based on the standard butterfly walk transect method. This is seen as the most effective way to survey for the presence of GSMs. The transect route is to be established using aerial photos of the site following areas that are likely to contain GSM such as tracks, firebreaks or hill crests. The transect is walked at a steady pace by one or more individuals and any GSM observed or caught five metres (m) either side of the track is recorded. Each transect was split into smaller sections of 100 m to make the details easier to record.

The length of transect required to sufficiently sample each site was able to be calculated by the following formula specified by the DEC:

Transect length in km = 0.7 x square root (ha).

2.2.2 *Lomandra* Species Density

The aim of the *Lomandra* surveys was to determine the density of *Lomandra* at each site and the conditions that may give an indication to *Lomandra* site preference (and hence GSM habitat). Each site is surveyed using 2x2 m quadrats (area of 4 metres square) that are spaced 50 m apart. A summary of the total number of quadrats required according to the size of the site or habitat area is in Table 1 (Bishop, Williams and Gamblin 2009). These quadrats are conducted along a minimum of three transects across the project area. Each transect starts at a corner of the project area and radiates out at equal angles. For larger or irregularly shaped areas more than one corner may be used to ensure adequate coverage of each site.

Table 1: Quadrat to Area Ratio

Site Area	Approximate Number of Quadrats
< 10 ha	30
11 to 20 ha	60
21 to 50 ha	120
51 to 100 ha	300

The two species of *Lomandra* the GSM utilises can be similar in appearance. Table 2 shows the defining features of each. *Lomandra hermaphrodita* tends to be associated with areas containing *Banksia* / Woolly bush Woodlands and is found in low densities. *Lomandra maritima* is found in coastal areas and grows in clumps, usually in higher densities (Bishop, Williams and Gamblin 2009).

Table 2: Differences Between *Lomandra maritima* and *Lomandra hermaphrodita.*

	Lomandra maritima	*Lomandra hermaphrodita*
Shape and Form	Plants consist of several plantlets forming small tufts – generally uniform in size	Spreading clumps of variable size
Old leaves	Spiralled and red-brown in colour	Spiralled and straw coloured
Leaf length	150 - 450 mm	300 - 600 mm
Leaf width	1 - 2 mm	1 - 2 mm
Leaf base margin	Pale brown, pink or purple, splitting into fibres	White or pale grey, splitting into fibres

	Lomandra maritima	*Lomandra hermaphrodita*
Location	Sandy soil on coastal plain and lateritic soil on the Darling Range, growing throughout the Perth region	Sandy soils near the coast. Geraldton to Bunbury
Density	Often present in reasonable numbers and may even be a dominant understory herb	Tends to be found in low concentrations

3 SURVEY VARIABLES

As per *Guidance Statement 56* (EPA 2004), the limitations and constraints associated with a survey need to be documented. These variables are detailed in Table 3.

Table 3: Constraints Associated with the Graceful Sun Moth Survey

Variable	Impact on Survey Outcomes
Experience levels/ Resources	The environmental scientists who executed the surveys are practitioners suitably qualified in their field. Environmental scientists that completed the DEC GSM training course are marked with an asterisk (*). • * Mike Brown -GSM survey • * Matthew Love - GSM survey • * Peter Jobson - GSM survey • * Glen Murray – GSM survey • Filamena Black - GSM survey • Emmanuelle Svartz - GSM survey • * John Trainer- GSM and *Lomandra* surveys • * Paula Arthur - GSM and *Lomandra* surveys • * Georgia Scott- GSM and *Lomandra* surveys • * Kim Dennison - GSM and *Lomandra* surveys • Stuart McKinnon - *Lomandra* surveys • David Harrison - *Lomandra* surveys
Scope: sampling methods and completeness	All parts of the survey have been completed in full and have been done to the standards required by the DEC.
Timing, weather, season.	The GSM transect surveys and *Lomandra* density surveys were all conducted in the month of March. All survey conditions were within the required standards set by the DEC.
Disturbances.	There were no disturbances that impacted the survey.

4 RESULTS

4.1.1 Timing of Survey

The GSM transect surveys were conducted on the 4, 10, 19 and 24 March, 2010 and the *Lomandra* density survey was conducted between the 13 - 15 April, 2010. The GSM survey meets the DEC requirements for the GSM transects to be conducted during late February and March. Lomandra density surveys do not have a restricted timeframe.

4.1.2 GSM Observations

Due to the large size of the project area (975.2 ha) the DEC was consulted as to the most effective way to survey for GSM. A section of 322.5 ha was selected (Figure 2) to be the GSM survey area as this was found to contain *Lomandra maritima* during a previous flora survey (ENV 2009). Using the formula specified in Section 2.2, a survey site of 322.5 ha equates to roughly 12.5 km of transects required to accurately inspect the GSM survey area. The required length was exceeded with approximately 15 km of transects walked each survey date. The location of the transects follow existing tracks, areas containing high concentrations of *Lomandra maritima* and areas deemed likely to contain GSM (Figure 4).

The weather conditions for each of the survey dates are recorded in Table 4. All of the conditions are within the criteria set by the DEC, explained in Section 1.3. Surveys needed to be conducted in March between 10 am and 3 pm, have wind speeds under 5 m/s and have a warm sunny climatic condition. All of these criteria were met on each of the survey dates apart from the 19 March which did not have sunny weather conditions. Note that although the conditions were not ideal GSM were recorded on this date. The requirement of a minimum of four days break between survey dates was adhered to.

Table 4: Weather Conditions during the Graceful Sun Moth Surveys.

Date	Time	%Cloud Cover	Average Temperature	Average Wind Speed (m/s)	Wind Direction
4/3/2010	10:00am -3:00 pm	0-30%	26.3˚C	2.54	SW
10/3/2010	10:00am -3:00 pm	clear	33.2˚C	1.75	SE
19/3/2010	10:00am -3:00 pm	80-100%	25.6˚C	2.46	SW
24/3/2010	10:00am -3:00 pm	2-30%	28.4˚C	1.32	SW

During the four days of surveys there were 116 GSM recorded in the GSM survey area. Forty eight GSM were recorded on the 4 March, 10 GSM were recorded on the 10 March, 6 GSM were

recorded on the 19 March and 52 GSM were recorded on the 24 March. The GSM recorded were observed along the existing tracks of the GSM survey area and the surrounding dune slopes and dune crests that contained *Lomandra maritima*. The locations of recorded GSMs are illustrated in Figure 5. The details of the recorded GSM are displayed in Appendix B and photographs of some of the GSM are located in Appendix C.

4.1.3 *Lomandra* Density

Due to the large size of the project area (975.2 ha) the DEC was consulted as to the most effective way to conduct *Lomandra* density surveys. Using the information obtained from a previous flora survey (ENV 2009), areas were selected as potential *Lomandra* sites (Figure 2). The GSM survey area was selected as the main focus of the *Lomandra* survey effort due to the high densities of *Lomandra maritima* identified in the previous flora survey (ENV 2009). The other sites of interest were *Banksia* Woodlands that were scattered across the project area. These sites were thoroughly examined and all bar one of the sites were found to contain no *Lomandra*. The south west site was found to contain only two specimens of *Lomandra hermaphrodita* in the whole site. Peter Jobson (Senior Taxonomist) inspected the area and stated that the site was a transition between two vegetation communities, meaning the conditions suited to *Lomandra hermaphrodita* is limited to a very small area and will only occur in negligible densities.

Six hundred and nineteen quadrats were conducted within the GSM survey which is inline with the number specified by the DEC for this specific site (Figures 6 and 7). The *Lomandra* density surveys were completed in the manner specified by the DEC. Quadrats were located 50 m apart along multiple transects radiating out from the corner sections of vegetation.

The species of *Lomandra* present at this site is *Lomandra maritima* which occurs along the coast and often in reasonable numbers (Bishop, Williams and Gamblin 2009). During the survey the vegetation of the GSM survey area was classified as ranging between completely degraded and very good condition with some disturbances in the form of paths, rubbish, grazing by rabbits and weeds. Photos of the site are located in Appendix D.

As shown in Figure 6 and Figure 7 the *Lomandra* is widely distributed across the GSM survey area, with higher concentrations occurring along the hill slopes and hill crests. Approximately 50% of the quadrats contained *Lomandra maritima* and the density ranged between 0%- 90%. The data for each quadrat is in Appendix E.

5 DISCUSSION

There is currently little known about the GSM and the DEC are undertaking a project that is anticipated to shed some light on the life cycle and habitat requirements of the GSM. At the moment there is limited knowledge as to the density of *Lomandra* required to constitute GSM habitat or required buffer zones around recorded GSM. Further information is required until it is possible to define with any accuracy the extent of suitable habitat around a recorded GSM.

In the interim habitat contiguous with that where GSM have been recorded and/or areas surrounding recorded GSM should be treated as potential habitat. Disturbance to these areas is likely to require a referral to DEWHA under the EPBC act.

6 CONCLUSION

The surveys were conducted on four separate dates with a minimum of four days between each survey. All of the GSM transect surveys were conducted in March 2010, on warm days (25.6°C-33.2°C), between 10:00 am to 3:00 pm and had wind speeds well under the maximum of 5 m/s (1.32-2.54 m/s). Six hundred and nineteen quadrats were conducted for the *Lomandra* density survey, this was deemed sufficient to accurately measure the site. *Lomandra maritima* was found in varied densities (0%-90%) across the GSM survey area. The GSM transects exceeded the DEC required length with 15 km of transects walked each survey date. The transects focused on the area most likely to contain GSM, including paths and vegetation containing *Lomandra*. This survey has met the criteria set by DEC in regards to GSM surveys.

A total of 116 GSM were recorded in the GSM survey area indicating that the species occurs throughout the coastal beach portions of the Clifton Beach Property.

7 REFERENCES

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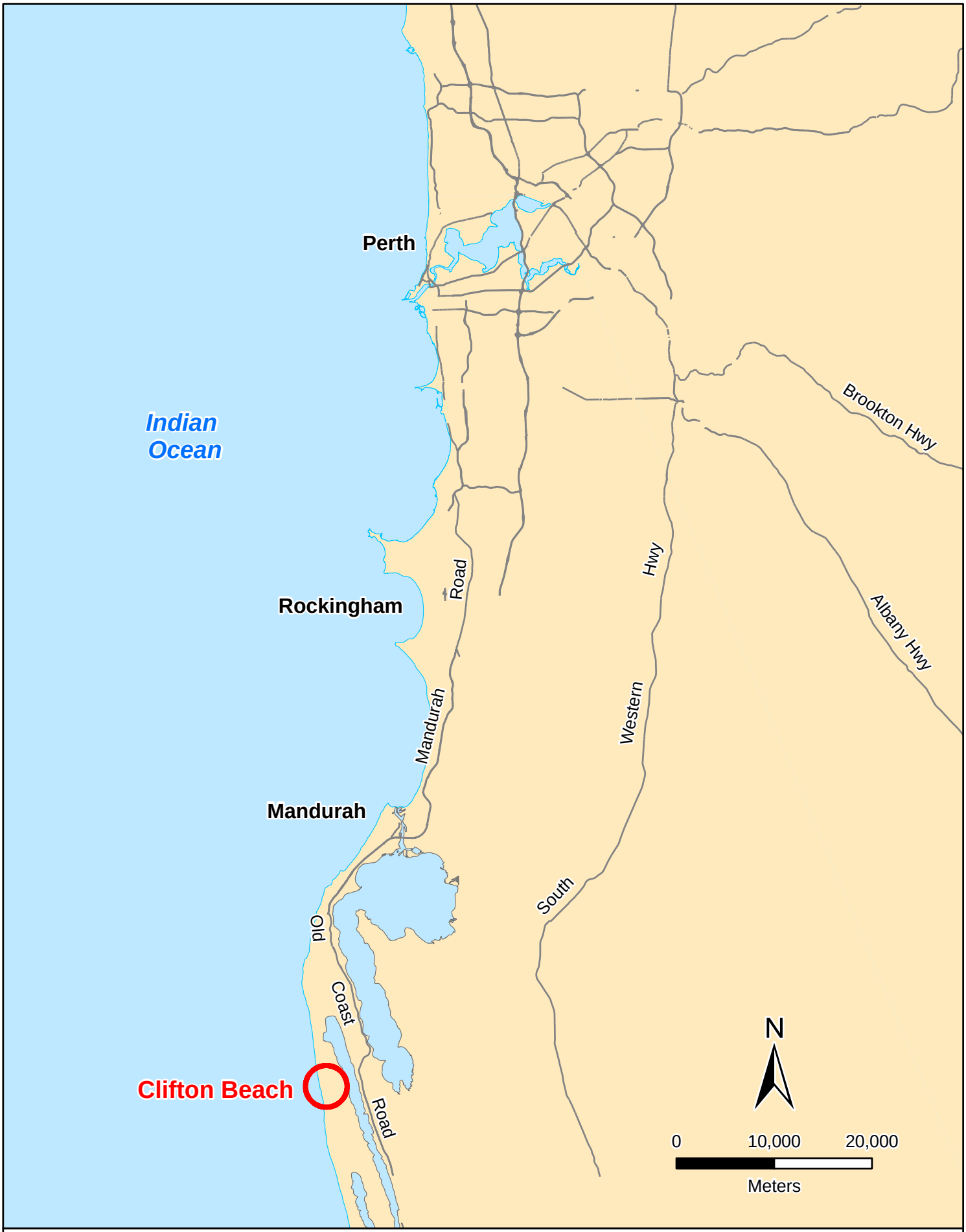
FIGURES



Regional Location

Clifton Beach Graceful Sun Moth Survey

CLIENT	JOB NO.
Cape Bouvard Investments	10.046
AUTHOR:	**DRAWN** / **DATE**
J. Trainer	S. Rho / 07-05-2010
SCALE	**PROJECTION** / **FIGURE**
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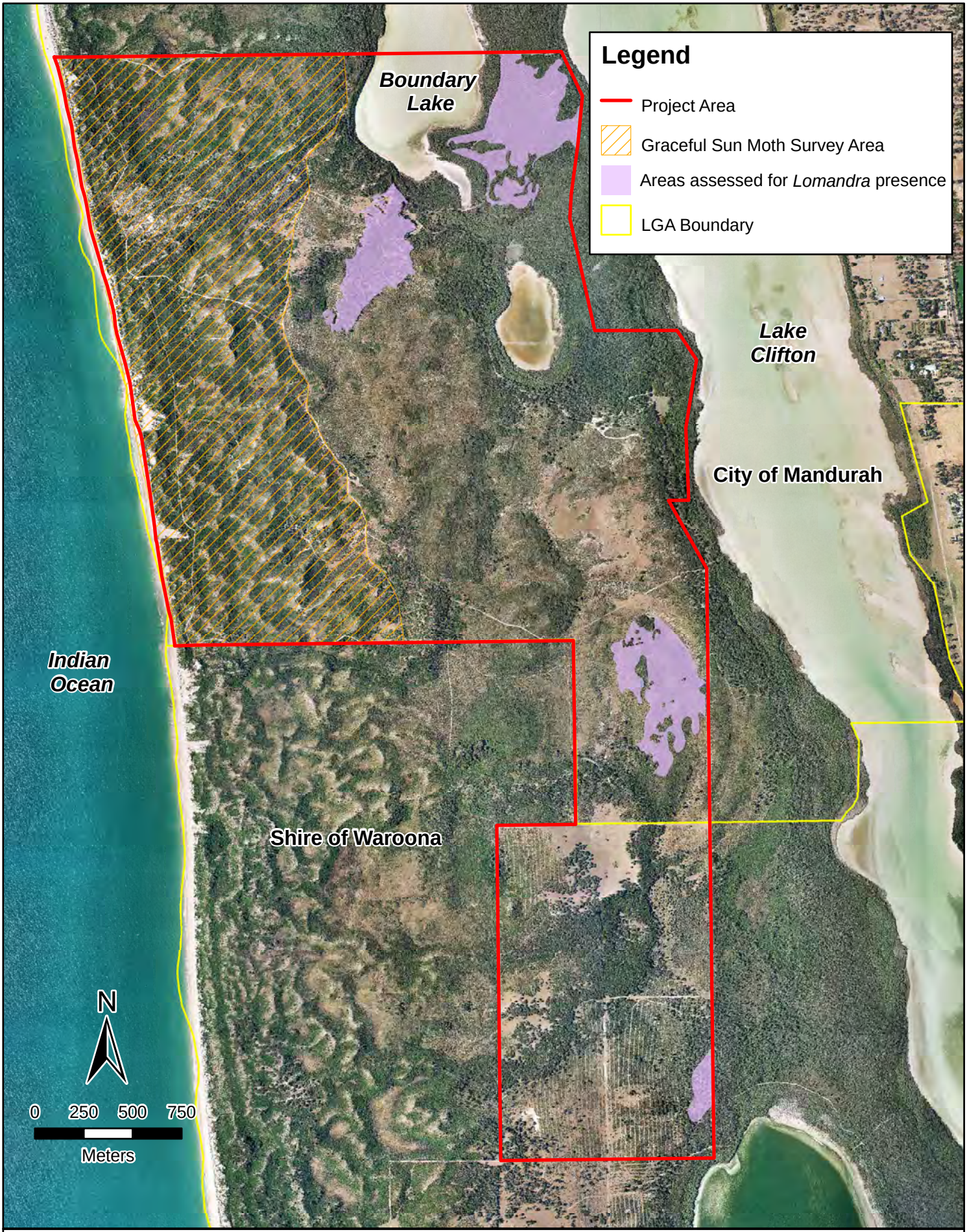
env Australia



Project Area

Clifton Beach Graceful Sun Moth Survey

CLIENT		JOB NO.
Cape Bouvard Investments		10.046
AUTHOR:	DRAWN	DATE
J. Trainer	S. Rho	06-05-2010
SCALE	PROJECTION	FIGURE
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env Australia

Graceful Sun Moth Transects

Clifton Beach Graceful Sun Moth Survey

CLIENT		JOB NO.
Cape Bouvard Investments		10.046
AUTHOR:	DRAWN	DATE
J. Trainer	S. Rho	06-05-2010
SCALE	PROJECTION	FIGURE
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env Australia

Graceful Sun Moth Locations

Clifton Beach Graceful Sun Moth Survey

CLIENT		JOB NO.
Cape Bouvard Investments		10.046
AUTHOR:	DRAWN	DATE
J. Trainer	S. Rho	06-05-2010
SCALE	PROJECTION	FIGURE
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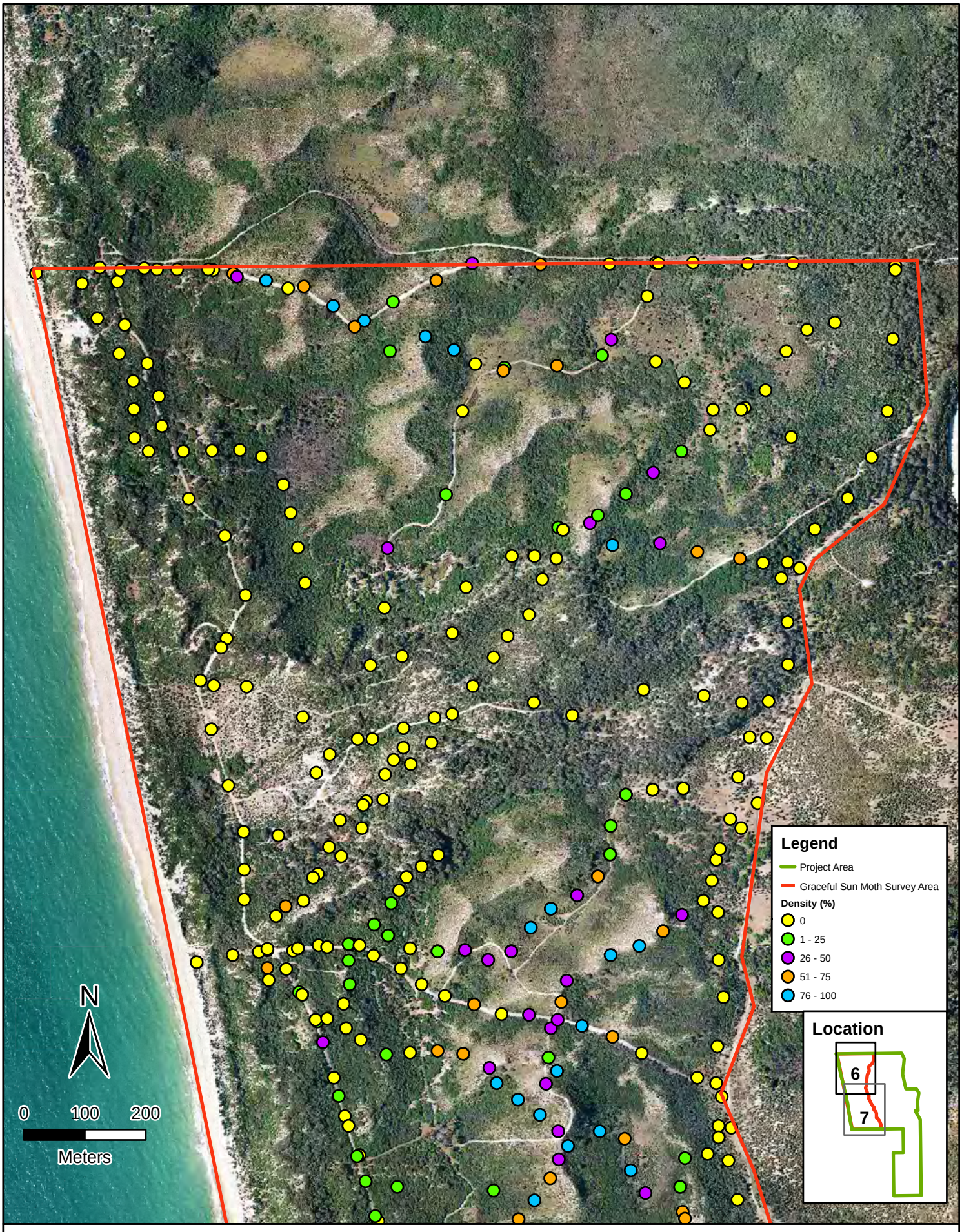
env Australia



Lomandra maritima Quadrats and Density

Clifton Beach Graceful Sun Moth Survey

CLIENT	JOB NO.
Cape Bouvard Investments	10.046
AUTHOR:	**DRAWN** / **DATE**
J. Trainer	S. Rho / 06-05-2010
SCALE	**PROJECTION** / **FIGURE**
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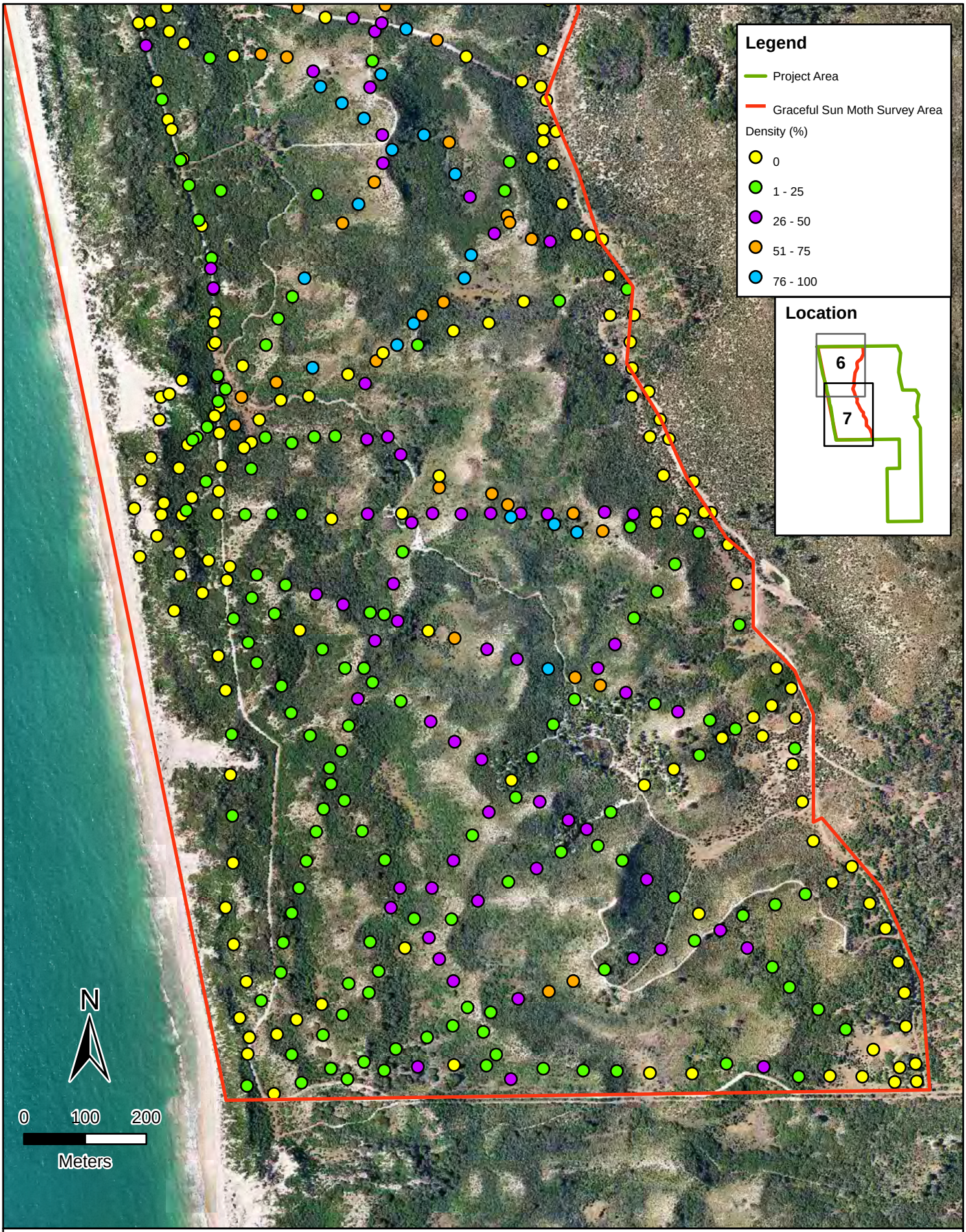
env Australia



Lomandra maritima
Quadrats and Density

Clifton Beach Graceful Sun Moth Survey

CLIENT		JOB NO.
Cape Bouvard Investments		10.046
AUTHOR:	DRAWN	DATE
J. Trainer	S. Rho	06-05-2010
SCALE	PROJECTION	FIGURE
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env Australia

APPENDIX A

DEFINITIONS OF CONSERVATION CODES FOR FAUNA OF CONSERVATION SIGNIFICANCE

LAKE CLIFTON GRACEFUL SUN MOTH SURVEY

APPENDIX A

DEFINITIONS OF CONSERVATION CODES FOR FAUNA OF CONSERVATION SIGNIFICANCE

***Environment Protection and Biodiversity Conservation Act 1999* (*Cth*): Threatened Species and Threatened Ecological Communities Codes**

The EPBC Act prescribes seven matters of national environmental significance:-

- World Heritage properties;
- National Heritage places;
- Wetlands of international importance;
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

Species in the categories ExW, CE, E, V and M (see below), and *Threatened Ecological Communities* in the CE and E categories are protected as matters of national environmental significance under the EPBC Act.

Category	Code	Category
Extinct	**Ex**	Taxa for which there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	**ExW**	Taxa known to survive only in cultivation, in captivity or as a naturalised population well outside its past range; or not recorded in its known and/or expected habitat at appropriate seasons anywhere in its past range despite exhaustive surveys over a timeframe appropriate to its life cycle and form.
Critically Endangered	**CE**	Taxa facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	**E**	Taxa not critically endangered and facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Vulnerable	**V**	Taxa not critically endangered or endangered and facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria**.**

Category	Code	Category
Conservation Dependent	**CD**	Taxa which are the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within five years.
Migratory	**Mi**	Taxa that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations, that are included in an international agreement approved by the Minister for the Environment, Heritage and the Arts and that have been placed on the national List of Migratory Species under the provisions of the EPBC Act. At present there are four such agreements: • the Bonn Convention • the China-Australia Migratory Bird Agreement (CAMBA) • the Japan-Australia Migratory Bird Agreement (JAMBA) • the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
Marine	**Ma**	Taxa protected in a Commonwealth Marine Protected Area by virtue of section 248 of the EPBC Act. These taxa include certain seals, crocodiles, turtles and birds, as well as various marine fish. Commonwealth marine areas are matters of national environmental significance under the EPBC Act. An action will require approval if the: • action is taken in a Commonwealth marine area and the action has, will have, or is likely to have a significant impact on the environment, or • action is taken outside a Commonwealth marine area and the action has, will have, or is likely to have a significant impact on the environment in a Commonwealth marine area[1] The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters. The Commonwealth marine area stretches from 3 to 200 nautical miles (approximately 5-370 km) from the coast. Marine protected areas are marine areas which are recognised to have high conservation value.

Western Australian Threatened Fauna Categories

Wildlife Conservation Act 1950 (WA)

Category	Code	Description
Schedule 1	S1	Rare or likely to become extinct.
Schedule 2	S2	Presumed extinct.
Schedule 3	S3	Birds subject to an agreement between the governments of Australia and Japan, the People's Republic of China & the Republic of Korea relating to the protection of migratory birds and birds in danger of extinction.
Schedule 4	S4	Other specially protected fauna.

Department of Environment and Conservation Fauna Priority Codes

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring: not currently threatened or in need of special protection, but could become so. Usually represented on conservation lands.
Priority 5	P5	Taxa in need of monitoring: not considered threatened, but the subject of a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

APPENDIX B

DETAILS OF THE RECORDED GRACEFUL SUN MOTHS

LAKE CLIFTON GRACEFUL SUN MOTH SURVEY

APPENDIX B
DETAILS OF THE RECORDED GRACEFUL SUN MOTHS

Name	Date	Sex	Easting	Northing
GSM1	4/03/2010	unknown	371941	6372780
GSM2	4/03/2010	unknown	371812	6372629
GSM3	4/03/2010	unknown	371819	6372605
GSM4	4/03/2010	unknown	371820	6372586
GSM5	4/03/2010	unknown	371852	6372578
GSM6	4/03/2010	unknown	371755	6372347
GSM7	4/03/2010	unknown	371709	6372234
GSM8	4/03/2010	unknown	371716	6372210
GSM9	4/03/2010	unknown	371716	6372210
GSM10	4/03/2010	unknown	371717	6372229
GSM11	4/03/2010	unknown	371717	6372229
GSM12	4/03/2010	unknown	371717	6372229
GSM13	4/03/2010	unknown	371717	6372229
GSM14	4/03/2010	unknown	371668	6372071
GSM15	4/03/2010	unknown	371668	6372071
GSM16	4/03/2010	unknown	371668	6372071
GSM17	4/03/2010	unknown	371637	6372054
GSM18	4/03/2010	unknown	371637	6372054
GSM19	4/03/2010	unknown	371773	6371926
GSM20	4/03/2010	unknown	371851	6371883
GSM21	4/03/2010	unknown	371851	6371883
GSM22	4/03/2010	unknown	371942	6372781
GSM23	4/03/2010	unknown	371812	6372630
GSM24	4/03/2010	unknown	371812	6372630
GSM25	4/03/2010	unknown	371812	6372630
GSM26	4/03/2010	unknown	371812	6372630
GSM27	4/03/2010	unknown	371819	6372605
GSM28	4/03/2010	unknown	371821	6372587
GSM29	4/03/2010	unknown	371852	6372578
GSM30	4/03/2010	unknown	371717	6372230
GSM31	4/03/2010	unknown	371717	6372230
GSM32	4/03/2010	unknown	371717	6372230
GSM33	4/03/2010	unknown	371717	6372230
GSM34	4/03/2010	unknown	371755	6372347
GSM35	4/03/2010	unknown	371710	6372235
GSM36	4/03/2010	unknown	371716	6372210
GSM37	4/03/2010	unknown	371716	6372210
GSM38	4/03/2010	unknown	371668	6372071
GSM39	4/03/2010	unknown	371668	6372071
GSM40	4/03/2010	unknown	371668	6372071
GSM41	4/03/2010	unknown	371637	6372054
GSM42	4/03/2010	unknown	371637	6372054
GSM43	4/03/2010	unknown	371774	6371926
GSM44	4/03/2010	unknown	371852	6371884
GSM45	4/03/2010	unknown	371852	6371884
GSM46	4/03/2010	unknown	371643	6371437
GSM47	4/03/2010	unknown	371612	6371614

Name	Date	Sex	Easting	Northing
GSM48	4/03/2010	unknown	371523	6372357
GSM49	10/03/2010	female	372323	6371257
GSM50	10/03/2010	male	372178	6371464
GSM51	10/03/2010	female	372023	6371680
GSM52	10/03/2010	male	371906	6371782
GSM53	10/03/2010	male	371733	6372567
GSM54	10/03/2010	male	371733	6372567
GSM55	10/03/2010	male	371733	6372567
GSM56	10/03/2010	male	371839	6372572
GSM57	10/03/2010	unknown	371599	637868
GSM58	10/03/2010	unknown	371533	6372325
GSM59	19/03/2010	male	371860	6371940
GSM60	19/03/2010	unknown	371863	6371938
GSM61	19/03/2010	unknown	371598	6371671
GSM62	19/03/2010	unknown	371863	6371938
GSM63	19/03/2010	unknown	372182	6370795
GSM64	19/03/2010	unknown	371598	6371671
GSM65	24/03/2010	male	371472	6373728
GSM66	24/03/2010	female	371472	6373728
GSM67	24/03/2010	male	371457	6372562
GSM68	24/03/2010	male	372752	6370812
GSM69	24/03/2010	male	372020	6370794
GSM70	24/03/2010	male	371771	6370796
GSM71	24/03/2010	female	371640	6371431
GSM72	24/03/2010	female	371640	6371431
GSM73	24/03/2010	male	371640	6371431
GSM74	24/03/2010	male	371628	6371492
GSM75	24/03/2010	male	371514	6372394
GSM76	24/03/2010	male	371514	6372394
GSM77	24/03/2010	male	372091	6372448
GSM78	24/03/2010	unknown	372020	6370795
GSM79	24/03/2010	unknown	371962	6370794
GSM80	24/03/2010	unknown	371876	6370796
GSM81	24/03/2010	unknown	371640	6371431
GSM82	24/03/2010	unknown	371635	6371448
GSM83	24/03/2010	unknown	371627	6371492
GSM84	24/03/2010	unknown	371514	6372392
GSM85	24/03/2010	unknown	371511	6372400
GSM86	24/03/2010	unknown	372091	6372448
GSM87	24/03/2010	male	371550	6373696
GSM88	24/03/2010	male	371391	6373757
GSM89	24/03/2010	male	371849	6372543
GSM90	24/03/2010	unknown	371813	6372352
GSM91	24/03/2010	unknown	371749	6372350
GSM92	24/03/2010	unknown	371749	6372350
GSM93	24/03/2010	unknown	371749	6372350
GSM94	24/03/2010	unknown	371666	6372069
GSM95	24/03/2010	unknown	371648	6372071
GSM96	24/03/2010	unknown	371648	6372071
GSM97	24/03/2010	unknown	371648	6372071
GSM98	24/03/2010	unknown	371876	6371874
GSM99	24/03/2010	unknown	371964	6371677
GSM100	24/03/2010	unknown	372164	6371485
GSM101	24/03/2010	unknown	372164	6371485

Name	Date	Sex	Easting	Northing
GSM102	24/03/2010	unknown	372164	6371485
GSM103	24/03/2010	unknown	372164	6371485
GSM104	24/03/2010	unknown	372164	6371485
GSM105	24/03/2010	unknown	372164	6371485
GSM106	24/03/2010	unknown	372164	6371485
GSM107	24/03/2010	unknown	372164	6371485
GSM108	24/03/2010	unknown	372164	6371485
GSM109	24/03/2010	unknown	372164	6371485
GSM110	24/03/2010	unknown	372164	6371485
GSM111	24/03/2010	unknown	372164	6371485
GSM112	24/03/2010	unknown	372351	6371222
GSM113	24/03/2010	unknown	372351	6371222
GSM114	24/03/2010	unknown	372351	6371222
GSM115	24/03/2010	unknown	372330	6371060
GSM116	24/03/2010	unknown	372330	6371060

APPENDIX C

GRACEFUL SUN MOTH PHOTOGRAPHS

LAKE CLIFTON GRACEFUL SUN MOTH SURVEY

APPENDIX C

GRACEFUL SUN MOTH PHOTOGRAPHS
Graceful Sun Moth

APPENDIX D

SITE PHOTOGRAPHS

LAKE CLIFTON GRACEFUL SUN MOTH SURVEY

APPENDIX D

SITE PHOTOGRAPHS

APPENDIX E

SUMMARY OF *LOMANDRA MARITIMA* IN THE PROJECT AREA

LAKE CLIFTON GRACEFUL SUN MOTH SURVEY

APPENDIX E
SUMMARY OF *LOMANDRA MARITIMA* IN THE PROJECT AREA

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q1	372400	6371748	0
Q2	372356	6371747	0
Q3	372311	6371748	0
Q4	372273	6371746	40
Q5	372226	6371749	30
Q6	372175	6371747	60
Q7	372133	6371746	40
Q8	372089	6371747	50
Q9	372040	6371747	50
Q10	371992	6371746	50
Q11	371945	6371747	30
Q12	371895	6371747	0
Q13	371839	6371746	40
Q14	371780	6371738	0
Q15	371731	6371746	20
Q16	371683	6371746	15
Q17	371639	6371745	10
Q18	371594	6371746	0
Q19	371536	6371744	0
Q20	371502	6371745	0
Q21	371495	6371710	0
Q22	371532	6371683	0
Q23	371579	6371670	0
Q24	371614	6371660	0
Q25	371658	6371647	10
Q26	371705	6371630	5
Q27	371755	6371615	50
Q28	371799	6371598	40
Q29	371843	6371585	5
Q30	371888	6371571	40
Q31	371938	6371555	0
Q32	371981	6371543	60
Q33	372034	6371525	50
Q34	372083	6371509	40
Q35	372134	6371493	80
Q36	372178	6371479	70
Q37	372219	6371466	70
Q38	372261	6371454	50
Q39	372308	6371436	10
Q40	372346	6371423	40
Q41	372398	6371409	10
Q42	372440	6371395	10
Q43	372484	6371383	0
Q44	372537	6371363	10
Q45	372736	6370819	0
Q46	372708	6370842	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q47	372665	6370871	0
Q48	372620	6370904	5
Q49	372575	6370937	5
Q50	372528	6370973	5
Q51	372500	6371006	5
Q52	372459	6371037	40
Q53	372415	6371066	50
Q54	372380	6371093	0
Q55	372340	6371120	10
Q56	372295	6371149	30
Q57	372255	6371180	20
Q58	372215	6371204	10
Q59	372167	6371246	30
Q60	372120	6371276	30
Q61	372074	6371311	0
Q62	372025	6371345	40
Q63	371981	6371374	30
Q64	371942	6371407	30
Q65	371893	6371440	20
Q66	371847	6371471	20
Q67	371802	6371494	20
Q68	371765	6371525	10
Q69	371728	6371556	0
Q70	371687	6371583	10
Q71	371650	6371609	10
Q72	371609	6371638	0
Q73	371533	6371646	0
Q74	371569	6371617	0
Q75	371620	6371575	10
Q76	371644	6371536	10
Q77	371658	6371503	10
Q78	371698	6371465	5
Q79	371714	6371421	20
Q80	371745	6371384	20
Q81	371777	6371331	5
Q82	371801	6371278	10
Q83	371830	6371228	20
Q84	371867	6371181	20
Q85	371892	6371135	30
Q86	371915	6371085	10
Q87	371939	6371054	40
Q88	371956	6371019	30
Q89	371979	6370983	40
Q90	372002	6370940	10
Q91	372028	6370900	20
Q92	372049	6370863	10
Q93	372073	6370823	50
Q94	371642	6370812	10
Q95	371643	6370864	0
Q96	371630	6370923	0
Q97	371641	6370982	0
Q98	371620	6371043	0
Q99	371607	6371103	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q100	371619	6371176	0
Q101	371618	6371253	10
Q102	371615	6371320	0
Q103	371617	6371386	10
Q104	371607	6371458	0
Q105	371595	6371514	0
Q106	371523	6371588	0
Q107	371467	6371676	0
Q108	371911	6371732	30
Q109	371896	6371684	20
Q110	371881	6371632	30
Q111	371866	6371582	5
Q112	371851	6371539	30
Q113	371833	6371494	20
Q114	371823	6371444	40
Q115	371808	6371400	10
Q116	371796	6371359	20
Q117	371779	6371305	10
Q118	371767	6371264	10
Q119	371755	6371227	10
Q120	371739	6371179	10
Q121	371727	6371135	10
Q122	371715	6371094	10
Q123	371701	6371046	5
Q124	371697	6370997	10
Q125	371665	6370951	5
Q126	371646	6370891	0
Q127	371686	6370799	0
Q128	371731	6370817	5
Q129	371779	6370840	5
Q130	371833	6370851	10
Q131	371885	6370872	20
Q132	371936	6370891	10
Q133	371978	6370910	20
Q134	372040	6370932	20
Q135	372085	6370954	40
Q136	372135	6370966	60
Q137	372175	6370983	60
Q138	372226	6371002	20
Q139	372273	6371020	30
Q140	372318	6371035	40
Q141	372373	6371049	20
Q142	372452	6371090	10
Q143	372505	6371108	10
Q144	372554	6371125	10
Q145	372598	6371144	0
Q146	372531	6371461	0
Q147	372499	6371433	0
Q148	372469	6371414	0
Q149	372418	6371380	0
Q150	372381	6371352	5
Q151	372339	6371329	0
Q152	372291	6371303	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q153	372236	6371259	10
Q154	372197	6371231	30
Q155	372155	6371194	10
Q156	372115	6371167	30
Q157	372069	6371145	20
Q158	372019	6371114	30
Q159	371976	6371084	20
Q160	371900	6371037	0
Q161	371857	6370999	10
Q162	371808	6370979	10
Q163	371764	6370945	0
Q164	371723	6370920	0
Q165	371691	6370896	0
Q166	372700	6370818	0
Q167	372647	6370827	0
Q168	372594	6370828	0
Q169	372543	6370827	10
Q170	372486	6370843	30
Q171	372425	6370848	10
Q172	372369	6370832	0
Q173	372300	6370833	0
Q174	372246	6370836	10
Q175	372191	6370837	20
Q176	372126	6370840	20
Q177	372033	6370845	10
Q178	371980	6370846	0
Q179	371921	6370843	30
Q180	371866	6370837	20
Q181	371806	6370823	10
Q182	371715	6370863	10
Q183	371766	6370895	10
Q184	371798	6370928	10
Q185	371841	6370964	20
Q186	371843	6371047	20
Q187	371877	6371103	30
Q188	371944	6371135	30
Q189	371979	6371180	30
Q190	372010	6371221	20
Q191	372037	6371259	30
Q192	372081	6371283	20
Q193	372108	6371348	10
Q194	372142	6371402	10
Q195	372177	6371443	20
Q196	372215	6371494	30
Q197	372243	6371533	30
Q198	372274	6371576	20
Q199	372312	6371619	20
Q200	372341	6371664	10
Q201	372380	6371716	10
Q202	372734	6370848	0
Q203	372718	6370909	0
Q204	372716	6370964	0
Q205	372706	6371014	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q206	372685	6371069	0
Q207	372659	6371110	0
Q208	372630	6371170	0
Q209	372567	6371212	0
Q210	372549	6371276	0
Q211	372533	6371337	0
Q212	372538	6371413	0
Q213	372507	6371494	0
Q214	372446	6371565	10
Q215	372442	6371632	0
Q216	372428	6371696	0
Q217	372322	6371809	0
Q218	372300	6371872	0
Q219	372271	6371938	0
Q220	372235	6371999	0
Q221	372235	6372071	0
Q222	372234	6372135	0
Q223	372203	6372200	0
Q224	372157	6372253	0
Q225	372142	6372317	0
Q226	372126	6372374	0
Q227	372122	6372444	0
Q228	372124	6372504	0
Q229	372134	6372585	0
Q230	372126	6372646	0
Q231	372125	6372724	0
Q232	372122	6372810	0
Q233	372145	6372877	0
Q234	372158	6372946	0
Q235	372177	6373011	0
Q236	372208	6373070	0
Q237	372240	6373130	0
Q238	372239	6373200	0
Q239	372239	6373298	0
Q240	372284	6373352	0
Q241	372338	6373403	0
Q242	372377	6373470	0
Q243	372403	6373546	0
Q244	372412	6373664	0
Q245	372163	6372862	0
Q246	372128	6372828	0
Q247	372115	6372776	0
Q248	372101	6372743	0
Q249	372066	6372720	30
Q250	372035	6372693	70
Q251	371996	6372669	80
Q252	371949	6372654	85
Q253	371877	6372612	50
Q254	371868	6372577	70
Q255	371851	6372534	30
Q256	371847	6372486	25
Q257	371843	6372443	40
Q258	371857	6372405	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q259	371861	6372464	90
Q260	371864	6372319	30
Q261	371850	6372288	70
Q262	371824	6372252	80
Q263	371798	6372221	70
Q264	371757	6372268	20
Q265	371736	6372131	90
Q266	371716	6372101	20
Q267	371693	6372065	15
Q268	371673	6372022	20
Q269	371635	6371988	0
Q270	371607	6371950	6
Q271	371598	6371921	0
Q272	371589	6371906	0
Q273	371577	6371888	10
Q274	371560	6371871	6
Q275	371545	6371859	0
Q276	371469	6371801	0
Q277	371485	6371838	0
Q278	371499	6371900	0
Q279	371501	6371937	0
Q280	371515	6371942	0
Q281	371536	6371965	0
Q282	371593	6371969	0
Q283	371586	6372022	0
Q284	371590	6372074	0
Q285	371587	6372113	6
Q286	371584	6372164	6
Q287	371568	6372217	0
Q288	371599	6372274	6
Q289	371537	6372326	0
Q290	371513	6372390	0
Q291	371495	6372453	0
Q292	371468	6372545	6
Q293	371511	6372574	0
Q294	371521	6372606	15
Q295	371519	6372645	6
Q296	371523	6372672	6
Q297	371561	6372704	10
Q298	371589	6372739	6
Q299	371602	6372760	0
Q300	371614	6372782	0
Q301	371639	6372799	0
Q302	371666	6372818	0
Q303	371506	6371764	0
Q304	371552	6371773	0
Q305	371596	6371783	0
Q306	371649	6371820	6
Q307	371649	6371863	0
Q308	371662	6371900	0
Q309	371697	6371932	0
Q310	371743	6371938	0
Q311	371835	6371959	30

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q312	371853	6371996	70
Q313	371887	6372022	90
Q314	371914	6372057	80
Q315	371928	6372071	70
Q316	371963	6372092	70
Q317	371997	6372131	90
Q318	372008	6372169	80
Q319	372046	6372204	30
Q320	372067	6372233	60
Q321	372063	6372274	10
Q322	372071	6372321	20
Q323	372108	6372328	0
Q324	372126	6372355	0
Q325	372147	6372371	0
Q326	372131	6372422	0
Q327	371386	6372663	0
Q328	371386	6372662	0
Q329	371436	6372665	0
Q330	371484	6372667	0
Q331	371537	6372670	0
Q332	371584	6372686	6
Q333	371620	6372665	0
Q334	371665	6372660	15
Q335	371710	6372662	50
Q336	371748	6372646	35
Q337	371786	6372660	30
Q338	371818	6372699	80
Q339	371851	6372730	80
Q340	371894	6372752	40
Q341	371928	6372783	70
Q342	371948	6372819	20
Q343	371949	6372866	15
Q344	371974	6372917	6
Q345	372018	6372925	0
Q346	372068	6372927	0
Q347	372190	6372903	0
Q348	372259	6373288	0
Q349	372229	6373272	0
Q350	372199	6373297	0
Q351	372161	6373304	60
Q352	372091	6373315	75
Q353	372030	6373329	30
Q354	371952	6373326	80
Q355	371915	6373362	30
Q356	371863	6373355	20
Q357	371824	6373308	0
Q358	371787	6373308	0
Q359	371712	6373257	0
Q360	371689	6373182	0
Q361	371607	6373144	0
Q362	371609	6372994	0
Q363	371579	6372950	0
Q364	371548	6372906	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q365	371543	6372900	0
Q366	371505	6372875	0
Q367	371487	6372831	0
Q368	371469	6372787	0
Q369	371445	6372743	0
Q370	371400	6372718	0
Q371	371348	6372745	0
Q372	371348	6372794	0
Q373	371347	6372856	0
Q374	371322	6372932	0
Q375	371294	6373024	0
Q376	371276	6373104	0
Q377	371319	6373173	0
Q378	371350	6373244	0
Q379	371316	6373341	0
Q380	371257	6373402	0
Q381	371213	6373521	0
Q382	371208	6373570	0
Q383	371189	6373624	0
Q384	371152	6373687	0
Q385	371140	6373758	0
Q386	371111	6373781	0
Q387	371145	6373777	0
Q388	371184	6373780	0
Q389	371238	6373778	0
Q390	371297	6373777	0
Q391	371330	6373771	70
Q392	371384	6373760	90
Q393	371446	6373750	75
Q394	371494	6373718	80
Q395	371545	6373694	80
Q396	371592	6373725	20
Q397	371663	6373760	60
Q398	371722	6373788	50
Q399	371834	6373786	70
Q400	371947	6373787	5
Q401	372023	6373789	0
Q402	372026	6373833	0
Q403	372083	6373834	0
Q404	372176	6373812	0
Q405	372246	6373859	0
Q406	372416	6373784	0
Q407	372009	6373734	0
Q408	371950	6373663	50
Q409	371861	6373620	70
Q410	371775	6373617	15
Q411	371706	6373546	0
Q412	371679	6373409	25
Q413	371583	6373321	30
Q414	371578	6373223	0
Q415	371555	6373129	0
Q416	371558	6373008	0
Q417	371609	6373026	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q418	371593	6372974	0
Q419	371488	6372983	0
Q420	371404	6372850	0
Q421	372416	6373777	0
Q422	372317	6373691	0
Q423	372271	6373679	0
Q424	372237	6373644	0
Q425	372203	6373580	0
Q426	372169	6373551	0
Q427	372112	6373515	0
Q428	372065	6373480	10
Q429	372019	6373445	30
Q430	371974	6373410	20
Q431	371928	6373375	20
Q432	371871	6373351	0
Q433	371860	6373304	0
Q434	371837	6373270	0
Q435	371815	6373212	0
Q436	371780	6373177	0
Q437	371757	6373142	0
Q438	371723	6373095	0
Q439	371689	6373049	0
Q440	371655	6373002	0
Q441	371621	6372967	0
Q442	371576	6372909	0
Q443	371541	6372862	0
Q444	371507	6372816	0
Q445	371461	6372781	0
Q446	371416	6372734	70
Q447	371386	6372633	70
Q448	372205	6373010	0
Q449	372164	6373068	0
Q450	372102	6373079	0
Q451	372003	6373089	0
Q452	371886	6373047	0
Q453	371823	6373068	0
Q454	371660	6373043	0
Q455	371534	6373008	0
Q456	371466	6372953	0
Q457	371444	6373044	0
Q458	371352	6373094	0
Q459	371298	6373096	0
Q460	371310	6373158	0
Q461	371448	6373264	0
Q462	371436	6373322	0
Q463	371424	6373379	0
Q464	371412	6373425	0
Q465	371377	6373471	0
Q466	371341	6373482	0
Q467	371295	6373481	0
Q468	371248	6373480	0
Q469	371191	6373480	0
Q470	371168	6373502	0

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q471	371167	6373549	0
Q472	371166	6373595	0
Q473	371143	6373640	0
Q474	371107	6373698	0
Q475	371082	6373755	0
Q476	370991	6373770	0
Q477	371205	6373778	0
Q478	371289	6373778	0
Q479	371336	6373766	50
Q480	371420	6373747	0
Q481	371529	6373684	60
Q482	371587	6373644	15
Q483	371645	6373668	80
Q484	371692	6373646	80
Q485	371727	6373623	0
Q486	371773	6373612	60
Q487	371935	6373637	6
Q488	372023	6373627	0
Q489	372070	6373593	0
Q490	372117	6373548	0
Q491	372163	6373548	0
Q492	372245	6373503	0
Q493	371597	6371878	0
Q494	371595	6371930	15
Q495	371594	6371972	6
Q496	371590	6372026	0
Q497	371588	6372059	0
Q498	371587	6372115	30
Q499	371583	6372147	35
Q500	371563	6372226	25
Q501	371547	6372283	25
Q502	371533	6372324	6
Q503	371519	6372374	0
Q504	371503	6372423	6
Q505	371477	6372511	30
Q506	371465	6372548	0
Q507	371438	6372593	20
Q508	371417	6372631	0
Q509	371443	6372589	6
Q510	371484	6372550	0
Q511	371515	6372534	0
Q512	371539	6372515	0
Q513	371581	6372491	6
Q514	371620	6372494	0
Q515	371665	6372497	70
Q516	371707	6372492	65
Q517	371750	6372469	40
Q518	371762	6372444	80
Q519	371797	6372417	85
Q520	371833	6372392	80
Q521	371863	6372365	50
Q522	371879	6372341	85
Q523	371931	6372365	90

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q524	371972	6372353	70
Q525	371982	6372301	85
Q526	372006	6372264	50
Q527	372071	6372222	75
Q528	372107	6372195	70
Q529	372137	6372191	50
Q530	372180	6372203	0
Q531	372222	6372194	0
Q532	372253	6372158	0
Q533	372274	6372071	0
Q534	372268	6372027	0
Q535	372271	6371984	0
Q536	372298	6371946	0
Q537	372325	6371904	0
Q538	372358	6371880	0
Q539	371443	6372589	0
Q540	372371	6371799	0
Q541	37214	6372431	0
Q542	372091	6372453	0
Q543	372000	6372493	0
Q544	371952	6372520	75
Q545	371902	6372538	80
Q546	371862	6372548	50
Q547	371815	6372556	30
Q548	371770	6372557	0
Q549	371725	6372573	75
Q550	371677	6372587	0
Q551	371639	6372606	0
Q552	371605	6372632	0
Q553	371560	6372653	0
Q554	371519	6372672	10
Q555	371470	6372670	0
Q556	371428	6372661	0
Q557	371372	6372659	0
Q558	371329	6372654	0
Q559	371270	6372642	0
Q560	371388	6372613	0
Q561	371386	6372664	0
Q562	371436	6372665	0
Q563	371484	6372667	0
Q564	371537	6372670	0
Q565	371584	6372686	6
Q566	371620	6372665	0
Q567	371665	6372660	15
Q568	371710	6372662	50
Q569	371748	6372646	35
Q570	371786	6372660	30
Q571	371818	6372699	80
Q572	371851	6372730	80
Q573	371894	6372752	40
Q574	371928	6372783	70
Q575	371948	6372819	20
Q576	371949	6372866	15

Quadrat Number	Easting	Northing	Percentage cover of *Lomandra maritima*
Q577	371974	6372917	6
Q578	372018	6372925	0
Q579	372068	6372927	0
Q580	372190	6372923	0
Q581	372263	6372113	6
Q582	372152	6372094	10
Q583	372094	6372093	0
Q584	372037	6372058	0
Q585	371979	6372045	0
Q586	371921	6372022	6
Q587	371864	6372009	0
Q588	371807	6371974	0
Q589	371633	6371937	55
Q590	371622	6371891	70
Q591	371749	6371985	80
Q592	371690	6371961	75
Q593	371553	6371867	20
Q594	371531	6371821	0
Q595	371458	6371755	0
Q596	372389	6371749	0
Q597	372351	6371737	0
Q598	372310	6371732	0
Q599	372268	6371725	6
Q600	372223	6371718	70
Q601	372181	6371716	85
Q602	372144	6371729	80
Q603	372073	6371741	85
Q604	372068	6371761	75
Q605	372042	6371779	75
Q606	371999	6371785	70
Q607	371956	6371789	65
Q608	371956	6371808	0
Q609	371893	6371843	40
Q610	371872	6371872	35
Q611	371838	6371868	30
Q612	371786	6371873	25
Q613	371752	6371872	25
Q614	371715	6371862	6
Q615	371672	6371871	6
Q616	371637	6371854	0
Q617	371600	6371824	0
Q618	371575	6371799	6
Q619	371543	6371752	20