West Culburra Mixed Use Concept Plan
Major Project 09-0088, Now SSD 3846
Supplementary
Response to Submissions

John Toon Pty Limited
July 2017

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1. Introduction

This Response to Submissions (RTS) is for the West Culburra Mixed Use Concept Plan identified as Major Project 09-0088 now State Significant Development (SSD). The purpose of the Concept Plan is to obtain consent for the expansion of Culburra Beach Township for a mixture of residential uses of various densities, some commercial uses, some industrial development and some tourist facilities. The Concept Plan is shown at Figure 1.

The RTS is prepared in response to a range of government agency submissions and consultations, consultations with Shoalhaven City Council, submissions from private individuals and community groups and comments arising from an on-going dialogue with the Department of Planning and the Peer Reviewer with respect to water quality. The 'Response to Submissions' (John Toon Pty Limited; October 2013) flowed from a consideration of matters raised following the exhibition of the Major Project on July-August 2013. Subsequent comments from OEH and DPI (see Appendices 1 and 2) are responded to in this RTS which follows on from a site inspection by the Department on 3 April 2014 at which the extent and outline of the Concept Plan was discussed and several issues were raised, followed by a letter from the Department, dated 7 April 2014, outlining key issues which must be addressed in this RTS. Following subsequent meetings with the Department these key issues were further elaborated by email dated 23 May 2014. These issues are addressed in this RTS and a number of supplementary reports. The overall Concept Plan remains very similar to that submitted to the Department on November 2013. The Schedule of Responses to Issues raised is at Appendix 3.

The RTS describes the current project and presents justifications for the proposed land uses. The layout has been simplified to the extent that all residential zones are shown as Residential 2(c) with any variations in density to be subject to detailed development applications to Council. The Concept

Plan now only includes major access roads and footpaths/cycleways; local residential roads are excluded as are detailed subdivision layouts.

The RTS includes the following supplementary reports:

1. Estuarine Process Modelling Report Proposed Mixed Use Subdivision, West Culburra. Martens November 2016.
2. Water Cycle Management Report, Martens, Mixed Use Subdivision, West Culburra. Martens, November 2016.
3. Water Quality Monitoring Plan, Mixed Use Subdivision, West Culburra, Martens November 2016.
4. A Preliminary BioBanking Assessment Report. Cumberland Ecology September 2014 (Appendix 5).
5. West Culburra Aquatic Ecology Impact Assessment. Proposed Mixed Use Subdivision. Ecological Australia, May 2017 (Appendix 8).
6. Water Cycle Management Report Addendum, Mixed Use subdivision, West Culburra (SSD3846). Martens 8 June 2017 (email) (Appendix 7).
7. Summary of Biodiversity Offset Strategy for the West Culburra Part 3A Project. Ecological Australia, 18 May 2017 (email) (Appendix 6).

2. Description of the Current Project

The area covered by the West Culburra Mixed Use Concept Plan is part of some 1100ha of land owned by the Proponent (see Figure 2) generally located west of Culburra Beach and Lake Wollumboola. At the time the plan was endorsed in 2009 as a major project the land was in the single ownership of Mr Warren Halloran, the then proponent. Since that time all the Halloran lands, including extensive holdings at Sussex Inlet, Kinghorne and north of Callala Bay, have been transferred to a Trust established to manage all the lands (The Halloran Trust). The Trust is now the Proponent. The extent of the Jervis Bay land holdings are shown on Figure 2; the figure also shows the location of the area covered by the Concept Plan.

The West Culburra Mixed Use Concept Plan has a gross area of about 116ha (see Figure 3) and a net usable area of circa 75ha, the majority of which is zoned Residential (c) 'Living Area' in SLEP 1985. It is defined on the north side by the Crookhaven River estuary, on the south side by the divide between the catchment of Lake Wollumboola and the catchment of the Crookhaven River; on the east side the site abuts Culburra Beach Business Centre and on the west by the western boundaries of Portion 61 DP755971 and Lot 7 DP1065111. The site is generally 300-400m deep (on the north-south axis) and some 2750m

long (on the east-west axis). The boundaries and areas of the lands taken up by the Concept Plan are shown in Figure 3.

The site is predominantly woodland and wraps around Culburra Sewage Treatment Plant (STP) at its eastern end where adjoining lands are zoned (SLEP 1985) industrial and local centre. A SEPP 14 wetland is located adjacent to the site; it is dominantly a mangrove forest located between the site and Billys Island (see Figure 10).

The location of the Concept Plan abuts the foreshore of the Crookhaven estuary which is here tidal and subject to potential sea water rise due to global warming. It is unlikely to be directly affected by erosion or storm action being in excess of 1km inland from the coast. The land is a mixture of regrowth woodland that was cleared circa 1920 and pasture. The land is elevated, with slopes up to 8%, offering expansive views over the Crookhaven estuary and the lower reaches of the Shoalhaven. The land is stable and well suited to urban development.

Culburra Beach is primarily a holiday and retirement township. The permanent population is about 3000 persons skewed to the older age cohorts. In recent years there has been a small increase in the number of households with young families. There is a noticeable out-migration of youth and young adults which is considered to be indicative of limited higher education and job opportunities. Culburra Beach is within easy commuting distance of Nowra (20 mins) and its coastal location is an attraction for some upper-income groups who commute to Nowra; house prices in the few advantageous locations are in excess of $1million. A significant percentage of existing housing is in the affordable range of $300 – 500,000; whilst not enjoying ocean views, proximity to the beach is a significant determinant of house prices. Generally Culburra Beach is considered an affordable location for young households, for retirees and for metropolitan residents seeking a coastal holiday home. Approximately one-third of dwellings are unoccupied at the time of the census. It is believed locally that the population approaches 10,000 in the summer holiday season.

The current project comprises five stages of development with a combined area of 74.58ha. Stages 1, 2, 3 and 4 are primarily residential uses with an estimated capacity of 650 dwellings with lot sizes ranging from 300m^2 to 800m^2 with the average being about 550m^2. Stages 2, 3 and 4 are by far the largest component of the Concept Plan in terms of both area and number of dwellings. These stages are west of the STP. These stages will incur heavy up-front infrastructure costs in terms of access, services, water supply, sewerage and drainage.

Provision is also made for sites for tourist development in Stage 2 and Stage 4. The location of tourist facilities at Cactus Point in Stage 4 of the development,

is considered to be important for the diversification of the Culburra Beach economy. This location has an ideal orientation and outlook for tourist oriented facilities. Stage 5 is the expansion of the existing industrial zone adjacent to the STP; this stage has an area of 7.24 ha (now reduced to 3.5ha to meet water quality objectives). The industrial zone is also considered essential to the diversification of the Culburra Beach economy and to promoting local employment opportunities.

The ridgeline that defines the southern boundary of the developable area was determined by survey by Allen Price and Associates, Surveyors. The need for the definition of the ridgeline arises by reference to the South Coast Regional Strategy (SCRS). Appendix 2 of the SCRS contains summarised comments of the Sensitive Lands Review Panel on various sites, one of which was Long Bow Point, Culburra Beach. The Panel determined that land within the catchment of Lake Wollumboola was not considered suitable for urban development. Consequently land south of the ridgeline is excluded from this Concept Plan. There are four minor encroachments into the catchment of Lake Wollumboola which are discussed later in this RTS (see Section 9).

3. Justification for the Current Project

The justification for the proposal rests on seven pillars.

These are:

- provision of housing for known and anticipated demand;
- promotion of new business opportunities in tourism and recreation, in health and aged care and in management of ecologies and items of heritage significance;
- promotion of local employment opportunities;
- use of land that is well suited to urban development;
- use of land consistent with relevant zoning and statutory instruments;
- efficient and economic use of existing infrastructure; and
- integrating development with local public transport services.

Growth at Culburra Beach has been constrained since circa 1970 primarily due to the absence of services. Then, circa 1980, services, particularly water supply and sewerage were upgraded with a new sewage treatment plant being

constructed; simultaneously urban growth studies were initiated by Shoalhaven City Council (SCC) resulting in some 400ha of land being zoned for new urban development at West Culburra in SLEP 1985. Detailed development plans were submitted by the proponent for a Stage 1 of the projected 400 ha development located on Long Bow Point. This proposal proved contentious and the Minister ordered a Commission of Inquiry to review the proposal. The Commissioner recommended the Long Bow Point proposal be refused consent. Following several years during which the proponent discussed numerous alternatives with the Department of Planning it was eventually agreed that this project could proceed – it being outside the catchment of Lake Wollumboola. Capacity of the water supply to Culburra was augmented and a sewage treatment plant had been installed for an additional 3000 persons in 1985; this capacity has lain unused since that time; consequently the key infrastructure is in place for this proposal.

Demand for housing for older age cohorts and down-sizers is known to be strong. Real estate advice is that there is a current demand for at least 70 dwellings suited to down-sizers. An analysis of recent sales indicated a good demand for 3-bedroom family houses in the $350-550,000 price range; these sales were of houses that were located in average positions with no particular advantage in terms of access to beaches, shops or other facilities. New dwellings, of which there were a limited number, sold quickly.

The indication is that there is a pent-up demand for houses in Culburra Beach. The proponent aims to market house and land packages in the $400-650,000 price range, house types will be both small-lot (300m^2), standard lots (500-600m^2) with some larger lots (up to 900m^2) in favoured locations (aspect and views). The larger lots are most likely to be one-off designs. The small-lot and standard lots are proposed to be developed as house and land packages. Preliminary consultations with an architect and local builders have been held with a view to commissioning the designer and builders to jointly develop packages for potential home buyers under the overall design control of the proponent. Subject to approval of this Concept Plan it is envisaged the DA's for each stage of development will be submitted to SCC for approval. Preliminary discussions have been held with architects and builders, and with Council, with respect to the Stage 1 development. (see Figure 15).

Because of the absence over some four decades of any new urban development at Culburra Beach, and to a lesser extent, Callala Bay, the proponents have opted for a provisional demand profile that is one third retirees, one third young households and one third holiday homes. Our provisional estimate of demand is 90 lots per annum. Upon approval being granted this target is not expected to be reached until at least year 2 of the construction phase.

There are several approaches adopted in the Concept Plan to the generation of employment. The main one focuses on the leisure hub at Cactus Point. This location overlooks the broad expanse of the Crookhaven River, here some 300m wide, with views to Mount Coolangatta. It has ideal north orientation and the land slopes gently down to the water's edge. There are several middens in the vicinity of Cactus Point suggesting that it was a place frequented by aboriginals who would surely have been sensitive to the micro-climate attributes of the local environment. This reinforces the view that this is an ideal location for leisure activities. The uses envisaged are motels, restaurants, cafés and tourist-orientated shops. It is recognised that the middens, which are considered to have regional significance, will need to be protected whilst also being of historical interest. Their historical importance will be demonstrated through interpretation panels and potentially exhibits of any artefacts discovered in-situ. The leisure hub is part of Stage 4 which is not estimated to be developed until at least 5 years after approval of this Concept Plan. The proponents consider the leisure hub concept will require considerable design development with consultations with local aboriginal groups, archaeologists, landscape designers as well as Council and the local community. It is the proponents' view that Cactus Point can become a very distinctive place. The staging allows ample time for the full potential to be explored and appropriate designs to be developed for this significant location.

A second approach to employment is the ongoing management of the foreshore reserve. This reserve comprises mangrove forest and swamps, saltwater marshes, extensive stands of casuarinas and zeric woodland. It is an eco-system of considerable diversity. Lookouts at key vantage points are envisaged along the foreshore reserve with interpretation panels highlighting key features of the eco-system. Adjacent to the foreshore reserve, but outside the 7(a) zone, it is proposed to embellish this reserve with children's play areas, BBQ shelters, exercise equipment etc. to enhance the leisure/recreation experience. It is anticipated the on-going maintenance of the foreshore reserve and associated facilities will generate a small and continuing number of local employment opportunities.

The active construction phase is considered likely to lead to the take-up of some of the industrial estate as works depots, suppliers of building materials and domestic fittings etc. The incoming population is expected to lead to an increase in employment in retail and community services, including health and additional community facilities, benefitting the whole Culburra Beach community through increasing diversity of available services and facilities.

The integrity of the ecology of the foreshore reserve will be maintained. Certain areas have been vandalised and other areas are extensively invaded by lantana, blackberries and other noxious weeds. The rehabilitation of the foreshore will involve ecologists and landscape designers as well as the local

community and Council in co-ordinating the program of rehabilitation and the provision of facilities for controlled access to maximise the ecological experience of the foreshore zone. This is considered to be an important public works contribution to the community.

Discussions have been held with the local bus proprietor who runs the Culburra Beach – Nowra bus services (see EA Appendix R) regarding the current service being routed through the development envisaged in the Concept Plan. The Proprietor has indicated that he would welcome the opportunity to route his service along the collector Road through Stages 2, 3 and 4 of the proposed development. He also indicated strong support for the extension of the bus service along an extended westward collector road to complete the loop back onto Culburra Road. The completed loop has been part of the proponents long term strategy for the development of this area.

The mutually beneficial support gained by both the bus service and future residents arising from the proposed Concept Plan is considered to be a positive aspect of the proposed development.

In our view there is sufficiently significant public benefit to be gained from the proposed Concept Plan to justify the project. The Concept Plan is strongly supported by the majority of residents of Culburra Beach.

4. The Structural elements of the Concept Plan

The overall site dimensions are approximately 2750m x 300-600m. The linear form of the site dictates the structure of the proposed development.

The main structural elements reflecting the linear form of the site are the collector road and associated cycle/walkway located on the divide and the foreshore cycle/walkway, both reflecting the defining topographical elements.

The primary structural element is the collector road which is conceptualised as a 3km loop road off Culburra Road. It is generally aligned along the divide and generally forms the southern edge of the proposed urban development acting in part as a bushfire protection zone. The more elevated sections will provide panoramic views towards Mount Coolangatta and the Cambewarra ranges. Only the first section of the loop road (some 1800m) is included in this Concept Plan. The Culburra Beach – Nowra bus service will be re-routed along the collector road; in the first instance it will be routed along the Collector Road and through local roads in a truncated loop off the roundabout intersection with Culburra Road.

Some 95% of all residential areas are within 400m (5 minutes) walking time of the proposed bus stop locations along the collector road (see Figure 5.1 Transport and Accessibility Impact Assessment, Appendix R, EA).

The northern edge of urban development is defined by a foreshore drive which provides access to the foreshore reserve, the leisure hub and the associated foreshore recreation facilities. The foreshore drive acts as a bushfire protection zone for the residential zones.

The existing sewer rising main from Greenwell Point to Culburra STP is located in and adjacent to the foreshore reserve. It is anticipated that this rising main will be re-engineered and integrated with the main collector sewer for the proposed development. The details of these works will be undertaken in consultation with SCC.

The collector road and foreshore drive are connected by two principal vista avenues in addition to other local roads and footpaths. The vista avenues are designed to give legibility and clarity to the urban development by providing a clear visual link between the ridge and the foreshore with additional visual emphasis being achieved through alignment with topographical elements such as Mount Coolangatta and Orient Point.

Two cycle/walkways form the supporting access network. They also reflect the linear form of the site. One is aligned with the collector road and Culburra Road to form a direct link to the town centre, linking eventually with the cycle network east of the town centre. The other is located in the foreshore reserve and is intended as a slower leisure route linking the leisure hub with the town centre. Co-located with this route are children's play areas, BBQ facilities, viewing platforms, shelters and the like, emphasising its recreational, as well as its primary access function. There will be frequent access points to the foreshore cycle/walkway from parking areas aligned along the foreshore drive.

Council have given provisional approval to the proposed foreshore cycle/walkway traversing Council owned foreshore land adjacent to the STP but not forming part of the STP site. There is a large saltmarsh in this foreshore area (see: West Culburra Aquatic Ecology Impact Assessment, ELA, 2017 (Appendix 8).

The two cycle/walkways complement the primary road network creating a ladder like effect with the vista avenues and other throughways forming the rungs of the ladder.

5. The Evolving Statutory Context of the Concept Plan

The relevant Statutory Planning Instrument at the time the West Culburra Mixed Use Concept Plan was allowed to proceed was Shoalhaven Local Environment

Plan 1985 (see Figure 4). This plan zoned most of the area identified for the Concept Plan as 2(c) Residential "C" (Living Area). The object of this zone was 'to provide new residential areas with a range of housing types with provision for urban facilities to serve the local community'. Certain uses were prohibited and those not prohibited were permissible with development consent. The major part of this zone was located some 1000m west of the existing settlement of Culburra Beach; and separated from it by the STP. The zone also included a small area of some 10ha south of Culburra Road west of the retirement village. The intervening area north of Culburra Road is divided into two approximately equal zones each of about 20ha; one is a 3(f) (Business "F" (village) zone) in which residential flat buildings and a range of other dwelling forms are prohibited; and the other is a 4(a) (Industrial "A" (General) zone) adjacent to the existing STP. The foreshore area is generally 100m wide and is zoned 7(a) (Environment Protection "A" (Ecology) Zone).

In 2012 the proponent submitted a development application for a golf course on land zoned residential 2(c) on Long Bow Point south of Culburra Road. The use is permissible in the zone. The golf course is part of a broader strategy being pursued by the proponent designed to increase the attractiveness of Culburra Beach as a retirement and tourist destination. The plan of the golf course has been amended several times to meet concerns raised with respect to the impacts on Lake Wollumboola and on certain classes of vegetation located on the site. The proponent aims to maintain the golf course in its environment as a managed ecological precinct. The Golf Course proposal is shown at Figure 5.

In the early 2000's Shoalhaven City Council resolved to prepare a new LEP using the new land use template. Generally Council adopted an 'as near as possible like-for-like' zoning for the new plan – Draft Shoalhaven LEP 2009. The 2(c) Residential zone became the R1 General Residential zone in which tourist and visitor accommodation is permitted with consent; the 3(f) business zone became the B2 Local Centre zone in which dwellings are prohibited; and the 4(a) Industrial zone became the IN 1 General Industrial zone. The 7(a) zone became an E2 Environmental Conservation zone. Draft LEP 2009 is shown at Figure 6.

Subsequent to the exhibition of Draft Shoalhaven LEP 2009 the proponent in 2013 sought Council's support for the preparation of a Planning Proposal for the entre Halloran land holdings in the vicinity of Culburra Beach/Callala Bay/Kinghorne, in all some 1650ha. Council recommended, and the Minister endorsed, the exclusion of all the proponent's land from the Draft LEP pending the submission of a Planning Proposal for all the proponents land. Essentially the Planning Proposal aims to achieve a balance between land allocated for urban purposes and land to be dedicated to the enlargement of Jervis Bay National Park.

Shoalhaven LEP 2014 commenced on 22 April 2014. In it all the proponents land in the vicinity of Culburra/Callala Bay/Kinghorne, with the exception of the B2 (Local Centre) zone at Culburra, is excluded. SLEP 2014 is shown at Figure 8; the retained local centre zoning adjacent to Culburra Beach town centre is shown at Figure 9.

The sequence of zoning changes that affect the land taken up by the Concept Plan are summarised in Appendix 4.

On 16 November 2015 a 'Gateway' determination was made to allow the Planning Proposal to proceed; subject to variations and conditions. The Planning Proposal is shown at Figure 7.

Thus the proponent has three separate but inter-locking and overlapping projects in the Culburra Beach district that are currently (2017) in the planning stage. These are:-

1. The West Culburra Mixed Use Concept Plan (Figure 1);
2. The Golf Course (Figure 5); and
3. The Planning Proposal (Figure 7).

The Statutory Context also includes the following:

1. State Environmental Planning Policy No. 71 Coastal Protection.
2. State Environmental Planning Policy No. 14 Coastal Wetlands.
3. The South Coast Regional Strategy DOP 2007.
4. The Jervis Bay Settlement Strategy, SCC and DOIPNR 2003.

SEPP 71 applies because the land is identified on the relevant maps. The land has a 3.5km frontage to Crookhaven River and Curleys Bay which are classed as an estuary and bay; these lands may be subject to changing sea levels due to climate change but are otherwise unlikely to be affected by wave action or erosion. All the land the subject of the concept plan is in excess of 100m from the coastline. Lake Wollumboola is identified as a coastal lake in SEPP 71; no land in the concept plan is within 100m of the lake.

There are SEPP 14 wetlands (see Figure 10) adjacent to the area covered by the concept plan. These wetlands are discussed in the ecology report (Appendix O in the EA); the wetlands are also a material consideration in the water quality reports accompanying this RTS (see Appendix 7).

The proponent commissioned an aquatic ecology study to determine the impact, if any, of the proposed surface water treatment train on sea-grasses, saltmarsh and Mangrove forest in the Crookhaven River estuary and SEPP14 wetlands adjacent to the proposed development (see Appendix 8 West Culburra Aquatic Ecology Impact Assessment; Proposed Mixed Use

Subdivision Ecological, Australia 2017). This study is also relevant to the SEPP14 wetlands and should be read in conjunction with the water quality reports.

The South Coast Regional Strategy (SCRS) in the principal document shaping planning policy for the land covered by the Concept Plan.

The SCRS covers the local government areas of Shoalhaven, Eurobadalla and Bega Valley. It covers some 360km of coastline ranging from the more densely populated Nowra region to the relatively remote and sparsely populated SE corner of the State.

The SCRS identifies the following three regional challenges: (1) protecting the natural environment; (2) accommodating population growth and new housing; and (3) promoting the regional economy and employment growth.

These three challenges are relevant to this Concept Plan.

In 2012 the NSW Government released the Illawarra/South Coast Regional Action Plan. This plan covers the Illawarra region and Kiama and Shoalhaven LGA's. The population projection in this document indicates an expected regional growth of 85,000 between 2011 and 2031. The significance of this document is that it identifies Nowra as the location of significant urban land releases suggesting that the northern part of Shoalhaven will become progressively more integrated with the Illawarra Region centred on Wollongong. It is the proponents' view that this regional influence will be reflected in increased demand for permanent residential accommodation at Culburra Beach.

The third thrust of SCRS and Priority Number One of the Regional Action Plan is the revitalisation of the economy by attracting new industry, supporting business and creating jobs. It is not expected that Culburra Beach will attract any industry of regional significance. It is recognised that there is a deficiency of job opportunities particularly for youth and the younger age cohorts. The Scoping Study (Scoping Study of the Culburra/Orient Point Community. Appendix E in the EA) indicated a probable increase in jobs in health and aged care. This RTS also emphasises the need to promote leisure, recreation and tourism jobs and to this end seeks to secure locations that are very well suited to recreation and tourism related businesses for leisure uses and tourism related employment. The third area of employment growth will arise from new development. The construction phase will promote additional jobs in the local building industry with consequential follow-on demands for local services and facilities as the population increase.

Appendix 2 of SCRS considers the recommendations of the South Coast Sensitive Urban Lands Review Panel relating to specific sites, one of which is

Culburra Beach. In regard to the latter, the Panel's recommendation is: 'land within the catchment of Lake Wollumboola is considered unsuitable for urban development, principally on the grounds of the potential negative impacts on the lake which is a sensitive intermittently closing and opening lake or lagoon (ICOLL)'.

This recommendation has been the primary determinant of the location of the southern boundary of the proposal which is the edge of the catchment of Lake Wollumboola. There are four situations where the catchment is encroached upon. These are discussed in detail below (see Section 9). SCRS, at p. 14, sets out actions with respect to the Natural Environment. Dot point 3 states 'Local Environmental Plans will not include further residential or rural-residential zoning in the catchments of the coastal lakes and estuaries shown on Map 2 unless it is demonstrated that a neutral or beneficial effect on water quality as measured at the boundary of the proposed new zoning can be achieved'. In each of the four situations this condition is met.

The following two non-statutory planning reports reflecting the dynamics of population growth, housing demand and the changing spatial relationships in the Illawarra/South Coast region are:

1. Illawarra/South Coast Reginal Action Plan – Dept. of Premier and Cabinet, NSW, December 2012

2. Illawarra-Shoalhaven Regional Plan – Dept. of Planning and Environment, NSW, November 2015.

These documents demonstrate the spreading metropolitan influence on the south coast by the recognition that the City of Shoalhaven, particularly the northern part focused on Nowra, is projected to become more urbanised and integrated with the Illawarra region focused on metro-Wollongong. There is an explicit re-ordering of priorities between the SCRS (2007) and the Illawarra-Shoalhaven Regional Plan (2015) (ISRP). The latter gives greater emphasis to identifying and facilitating growth sectors of the regional economy and to providing a wider range of dwelling types across the region including Nowra-Bomaderry.

The progressive implementation of these policies is expected to be reflected in development in the Culburra Beach/Callala Bay district, both settlements being within the Nowra catchment for higher level urban services.

The West Culburra Concept Plan is based on the zonings of Shoalhaven LEP 1985 (see Figure 4) which was the relevant instrument when the Concept Plan was being prepared and when it was submitted. Since a Part 3A (and now SSP) application cannot be used to change prescribed zonings, the Concept Plan is somewhat incomplete. Certain intended forms of development are not

permissible and are excluded from the Concept Plan. For example, it is common ground amongst Department, Council and consultant planners that the 3(f) zone at Culburra Beach town centre is far too large. There is common agreement that future commercial uses should be concentrated in and adjacent to the existing town centre of Culburra Beach. It is the proponents opinion that part of the existing 3(f) zone west of Canal Street East should be allocated to medium density residential uses but this cannot be shown on the Concept Plan because residential uses are not permissible in the 3(f) zone. Consequently the Concept Plan as presented appears to be incomplete.

6. The changes made to the Concept Plan following consideration of the submissions.

The significant changes to the physical arrangement of the Concept Plan have been outlined in the 'Response to Submission' (John Toon Pty Ltd, October 2013), Subsequent to that report, the following additional changes have been made in response to matters raised by the Department.

6.1 The Department advised that any amendment to the Concept Plan would require a resubmission to the Department. The Department is concerned to avoid any unnecessary re-submissions. Since detailed subdivision design may well be changed as the project develops it was decided to delete unnecessary detail.

All the local roads and indicative lot subdivision have been deleted from Stages 1, 2, 3, 4 and 5; stages 1, 2, 3 and 4 are primarily residential uses; stage 5 is the Industrial zone.

It is proposed that each stage of development will now be the subject of a separate development application to Council which may include variations in lot size, density of development, range of dwelling types and such non-residential uses as are considered appropriate and compatible with the intended residential environment. See, for example, Figure 15 which shows the layout proposal for Stage 1 (part) with different lot sizes. In selected locations detailed development control guidelines will be submitted to Council for approval. It is anticipated that these controls will embody 'green' objectives with respect to both the individual dwellings and the public domain (streets, pathways and open space where relevant). In certain locations where larger lots are proposed in anticipation of one-off dwelling designs being built standard Council controls will apply.

It is envisaged that each stage of the development will have regard to Council's subdivision code (DCP 100) with respect to the shape and

orientation of lots, solar access and road layout. The major open space located south of the collector road is considered to satisfy the requirements for active playing fields generated by the proposal. The foreshore zone and associated open space is considered to satisfy the requirements for passive and recreational open space generated by the proposal.

Consequently the mixed use development indicated on earlier plans (eg the Circus) has been deleted from the Concept Plan. If such uses are to be proposed they will be incorporated in detailed development control plans that will be submitted to Council for approval as part of the normal development control process.

6.2 Following the further review of the Water Cycle Management Report in June 2017 (see Addendum to Water Cycle Management Report, Martens, June 2017) (Appendix 7), further amendments were made to the Concept Plan as follows:

1. The area of the industrial zone (Stage 5) was reduced by half, with the deleted area being retained as woodland;

2. All the wetlands aligned alongside, but outside, the 7(a) zone have been deleted because they are no longer required for the amended water cycle treatment train (that is there is no longer a reliance on infiltration) with the wetland area now being retained woodland; and

3. The size of the pondage on the east side of the proposed oval being increased to 3200m^2 to satisfy the amended Water Cycle Management requirements.

No other changes are proposed. These changes are incorporated in the submitted Concept Plan (see Figure 1).

7. The key Issues to be considered in this RTS arising from The Response to Submissions, dated April 2014.

The key issues identified in the letter from DPI dated 7 April 2014 (Appendix 2) are as follows:-

1. Environmental offsets – an environmental offset package is required that is consistent with the requirements of the Office of Environment and Heritage;

2. Subdivision Layout – the subdivision layout should have regard for Council's subdivision code (DCP 100) including more usable public open space, standard shaped lots, improved solar access and a more logical and permeable road layout;

3. Water Quality – water quality information should demonstrate a neutral or Beneficial Effect (NorBE) on the Crookhaven Estuary, SEPP14 wetlands and Lake Wollumboola;

4. Traffic and Access – resolution is required regarding the Culburra Road intersection; appropriate access arrangements must be provided for Stages 1 and 5 including the electricity substation, and further consideration must be given to impacts on the surrounding road network (eg safety, pavements, car parking);

5. Bushfire Management – the concept plan should illustrate the extent of all relevant APZ's wholly within lot boundaries with appropriate emergency access arrangements for Stages 3 and 4 defined (south-west road connection to Culburra Road);

6. Foreshore Area and Zoning – the Cactus Point leisure hub requires further justification, including consideration of zoning/permissibility issues, landowners consent and the location of boat infrastructure and sea-wall revetment works on or adjacent to freehold land; and

7. Economic Impacts – consistency with Council's DCP67 with respect to the extent of commercial development in the Culburra Expansion Area should be demonstrated or sufficient justification provided for any inconsistencies.

These matters are dealt with in the following section:

8. Consideration of the Key Issues

8.1 Environmental Offsets

As noted in Section 5 above the statutory context of the West Culburra Mixed Use Concept Plan has changed since its inception in 2009. This is most evident in the Bio-diversity offset strategy for the West Culburra project which is now subsumed within a comprehensive offset strategy for the Planning Proposal. This comprehensive strategy is structured to allow each individual component including this West Culburra Concept Plan to be segregated, examined and if necessary, adjusted to changing circumstances. Over the period of time during which the Concept Plan

has been in preparation there has been an evolving framework of rules and regulations with respect to the assessment of offsets for major projects such as this. The offset strategy is consistent with the rules that currently apply to the West Culburra Mixed Use Concept Plan. The component of the offset strategy that applies to this Concept Plan is shown at Appendix 6.

In 2013 SLR prepared an ecological and riparian assessment report for the West Culburra Mixed Use Concept Plan (West Culburra Ecological and Riparian Issues and Assessment Report; SLR March 2013). The Office of Environment and Heritage (OEH) advised the proponent in letters dated June 2013 and May 2014 that the office was 'satisfied that the development is unlikely to have a significant impact on the threatened species and their habitats' and that 'the development should only proceed if suitable offsets can be located and secured to ensure overall biodiversity values are maintained'. OEH stated its position that an offset parcel should be located in the Lake Wollumboola catchment in accordance with the SCRS 2007.

In 2014 Cumberland Ecology prepared a preliminary draft biobanking assessment of the offsets for the West Culburra Project (Culburra West and Millalen: Preliminary Biobanking Assessment Report, Cumberland Ecology 2014, Appendix 5) in which the suitability of Millalen, a 266ha property adjacent to Conjola National Park, as an offset for the West Culburra project was assessed and determined to be appropriate.

In 2013 OEH published seven new principles for offsets for Major Projects (The West Culburra Mixed Use Concept Plan was at that time classed as a Major Project) which were formalised as the Draft Framework of Biodiversity Assessment (FBA) for Major Projects (OEH 2014). Cumberland Ecology used these rules to assess the Millalen Lands. Cumberland Ecology concluded 'we consider the offset to be adequate because of its high quality vegetation, its strategic location (adjacent to Conjola National Park)' and it being located 'within the area of the same catchment authority as the proposed development and contains similar vegetation communities'. This preliminary study was based on a desk-top survey of Millalen using a vegetation map (OEH 2010) and allotting corresponding Biobanking Vegetation Types (BVT's) to these vegetation communities and by allocating corresponding BVT's to the vegetation mapping and ecological assessment of the West Culburra development site (SLR, 2013).

In 2015 Ecological Australia were commissioned to undertake a detailed ecological survey of all 2500ha of the Halloran Trust Lands including the

West Culburra development site (see Figure 12), Sussex Inlet and Millalen as part of the Planning Proposal.

Appendix 6 outlines the process that has been agreed between Ecological Australia, acting for the proponents with respect to this Concept Plan, and OEH.

Ecological Australia further refined through extensive field survey the number of ecosystem credits required to offset the West Culburra Concept Plan. A total of 5472 credits were assessed as being required. This figure differed slightly from that assessed by Cumberland Ecology using a desktop method of assessment (See Appendix 5). Both used the FBA (Framework of Biodiversity Assessment) to determine the number of credits required as offsets. The Ecological Australia assessment of 5472 credits (see Table 1 in Appendix 6) has been inspected in the field by OEH who have indicated that they are satisfied with the vegetation mapping and credit calculations. Table 1 also indicates the source of credits, the majority being sourced in the catchment of Lake Wollumboola. Other material in Appendix 6 indicates that there is an ample supply of credits available in the 4 biobanking sites identified in the EA Summary for the West Culburra Concept Plan and other development sites currently foreshadowed in the Planning Proposal.

Subsequent to the preparation of this report the land uses have been amended to reflect the requirements of the water quality report addendum. Less woodland is to be cleared with a consequent reduction in credits required. The figures in Table 1. will be adjusted to reflect this minor change which will have no impact on the overall strategy.

Cumberland Ecology were also required to report on the need for a north-south Wildlife corridor through the West Culburra development site and on the ecological impact of the three proposed viewing corridors providing vistas to the Crookhaven Estuary, each involving the clearing of the riparian vegetation (see Sections 5.3 and 5.4, Appendix 5).

With regard to the wildlife corridor Cumberland Ecology, having considered the range of Fauna groups that are considered likely to travel between the estuarine habitat and the inland woodland/forest habitats, conclude ‘there seems to be no ecological benefit of creating a north-south fauna corridor since such a corridor would connect two entirely different habitats. We believe that there is little ecological benefit to be gained from provision of such a link’.

The opinion of Cumberland Ecology on the issue of corridors reflects that of the proponents as outlined in the original ‘Ecological and Riparian Issues and Assessment Report’ (Appendix O, EA).

A letter from OEH (OEH 21/06/2013) written in response to the Concept Plan exhibition stated "the EA required the need for a local corridor to be identified linking the site to areas both north and south of the site in the Director Generals Requirements and in the SCRS recommendation. OEH considers that 'while it is imperative to maintain a foreshore buffer for a range of environmental and cultural heritage reasons, this may not necessarily provide a functional local corridor as vegetation in the surrounding area is likely to be cleared in the future. Rather, it is critical for the potential offset options to provide enhanced connectivity at the landscape or regional scale'.

In our view there is absolutely no justification for requiring a north-south fauna corridor to be inserted into the development. The proponent strongly resists the request for the insertion of a north-south 'wildlife' corridor through the proposed development. The need for and value of such a corridor is not supported by the ecological evidence.

With respect to the clearing of riparian vegetation to open up visits to the aquatic setting of Culburra Beach, Cumberland Ecology reported as follows: 'Having considered the types and quantities (areas) of vegetation that would be cleared to create these vistas, Cumberland Ecology recommend that 'the mangrove vegetation within the viewing corridors be carefully reduced and that the lower lying areas be managed to promote the growth of shrubs and ground cover plants that are part of the Coastal Saltmarsh EEC'. The proponent concurs with and will implement this recommendation. CE continue 'The remaining vegetation within the viewing corridors could be managed as a low shrubby version of the original vegetation community which would entail removal of the canopy stratum only'. The proponent concurs with this approach and will implement the suggested action when forming the vistas.

Cumberland Ecology conclude as follows:

'These viewing corridors are unlikely to have any ecological impact for the following reasons:

- rather than remove the mangrove forest it will be managed as a more open habitat, Coastal Saltmarsh EEC, which increases the ecological value of the habitat; and

- the majority of mangroves (ie 99.7%) in the study area would be conserved and would be maintained in perpetuity.

Provided that other areas of vegetation are to be retained intact along the river frontage, we believe that there would be limited and manageable ecological impacts.'

It should also be noted that the three vista clearings have been allowed for in the Ecological Australia Assessment of the West Culburra project site (see Figure 3, Appendix 6). This map and the associated credits have been endorsed by OEH.

The proponent strongly presses the limited opening up of foreshore vegetation for Vista Park and the Vista avenues. It is considered that the value of the vistas in conferring legibility and a sense of place on Culburra Beach far outweighs any ecological loss that may be incurred.

8.2 Subdivision Layout

The objectives of the subdivision layout are consistent with Shoalhaven DCP 2014 (Section 911 (DCP 100: - Subdivision Code)).

The subdivision layout including arrangement of local roads and lot layout have been removed from the Concept Plan Only the primary road network is now included in the proposal. These elements and their rationale are discussed below.

Removing the detailed subdivision design removes any consideration of 'useable open space, standard shaped lots, improved solar areas and a more logical and permeable road layout' – all issues stated to be of concern to the Department.

The main elements of the layout are as follows:

1. The Collector Road.

   This is a loop road off Culburra Road of which the first section will be completed as indicated in the Planning Proposal; a second section returning to Culburra Road some 2.5ha west of the proposed roundabout is envisaged as a continuation of this development westwards (see Planning Proposal – Figure 7). The location of this intersection was verified for sight lines on Culburra Road at the on-site meeting. The collector road will, when completed, become the route for the Culburra Beach – Nowra bus service which currently runs along Culburra Road; the service will be diverted off the roundabout into Stages 2, 3 and 4 as they are completed using local roads to form a temporary loop adapted to each stage. Ultimately the bus route will be aligned along the completed collector road which will re-join Culburra Road some 2.5km west of the proposed

roundabout. The proprietor of the local bus service has indicated his willingness to service the proposal as per the routing outlined.

The location of both the roundabout and the Western T-intersection were endorsed at an on-site meeting held in 2014 with officers of DOP, SCC and RMS.

The collector road is the formative element of the layout. It is aligned to be centrally positioned in relation to the long-term view of the location of urban development west of Culburra Beach (see Figure 7 - The Planning Proposal). The major part of this predicted urban development is within 400m of the bus route when aligned along the collector road.

The design of the collector road is consistent with sections G11 of DCP 100 (DCP 2014).

2. The Vista Roads.

   The two vista roads are designed to give visual legibility and physical access to the major parts of the residential area. Bus stops will be located at the intersection of the two vista roads with the collector road as well as at the proposed oval (see section 5.2, 5.3 and 5.4 Appendix R, EA).

3. The Crescents.

   The location of the two crescents has been designed to (i) achieve high levels of physical access to key locations; and (ii) to minimise the area of surface water drainage that will flow by infiltration into the SEPP 14 Wetlands adjacent to Billys Island (see Water Cycle Management Report, November 2016) and the Addendum to that Report. Martens 2017 (see Appendix 7).

4. The Foreshore Drive.

   The Foreshore Drive is designed to give access to the Foreshore Reserve which is expected to become a destination for both local and tourist populations. This road will act as an APZ along the foreshore.

5. The cycle/walkways

   The two principal cycle/walkways are aligned east-west and connect Stages 2, 3 and 4 to the town centre. One is co-aligned on the south side of the collector road providing direct access to the town centre. The second is aligned through the foreshore reserve and is designed as a leisure/recreation route connecting items of significant heritage

interest (aboriginal middens), significant outlooks and selected locations highlighting distinctive eco-systems (eg, the saltmarshes and the mangrove forest) together with recreation uses located adjacent to but outside the foreshore reserve.

The first stage of the foreshore cycle/walkway will be constructed from Canal Street East to Vista Road East; Council has given provisional agreement to this route being located on the foreshore zone of the STP which is Council owned land.

The cycle/walkway co-aligned with the collector road will be constructed concurrently with Stage 2 of the residential development. It will be aligned along the north side of Culburra Road extending from Canal Street East to the roundabout thereafter crossing to the south side of the Collector Road where few crossings are planned.

6. Local Roads

The local roads will be planned stage by stage and will be subject to normal development applications submitted to Council.

Street tree planting will be designed in co-operation with Council having regard to Council's 'Street Tree Planting Strategy'.

It is considered that the principal road network and local road network will be designed to be consistent with section G11 of Shoalhaven DCP 2014 (DCP 100: Subdivision Code).

It is considered that the overall layout of Stages 2, 3 and 4 includes very usable public open space (the oval) well located in relation to the distribution of proposed and potential future urban (residential) development. The waterfront reserve will complement the oval providing a range of passive recreational opportunities.

It is considered that the north facing slopes are ideal for residential development and that individual lots will have excellent solar access when the detailed design of each stage of residential development is completed.

8.3 Water Quality

The water quality issue as defined by the Department (7 April 2014) was to 'demonstrate a neutral or beneficial effect (NorBE) on the Crookhaven Estuary, SEPP14 Wetlands and Lake Wollumboola'. The proponent interpreted the water quality issue as expressed to focus on the interface between the land and the Crookhaven Estuary. The initial submission on

water quality (Water Cycle Management Report: Appendix P.EA. Martens Consulting Engineers 2013) used MUSIC (the industry standard) to model the surface flows anticipated to arise from the Concept Plan and devised a treatment train to manage those flows and to achieve NorBE at the interface. The 2013 Water Cycle Management Report was revised and amended to reflect concerns raised and recommendations outlined in a peer review by BMT WBM (6 March 2014) and by NSW OEH (5 June 2014).

Flowing from those concerns and recommendations, the proponent undertook to (i) revise the water cycle management plan; (ii) to model the Crookhaven Estuary; and (iii) to assess the impact of the output of the stormwater treatment train on the Crookhaven Estuary. ,

The catchment of the Crookhaven River is estimated to be about 67 square kilometres, of which 48% is agriculture, 42% is forest (mostly swamp forest), 6% is urban and 4% is rural residential. The majority of the land is flat with significant areas of swamp forest. The southern edge, including the site of this plan, is mainly dry sclerophyll forest. The area of the concept plan is about 1% of the catchment. The dominant agricultural use is dairy farming which has a significant influence on water quality in the Crookhaven River. Both total nitrogen (TN) and total phosphorous (TP) frequently exceed ANZECC limits and the suspension of oyster farming is not uncommon, particularly following periods of heavy rainfall. The estuary is tidal and the constant flushing enables the aquatic ecology to maintain good condition (see Appendix 8 - West Culburra Aquatic Ecology Impact Assessment, Ecological Australia 2017). The characteristics of the Crookhaven catchment are set out in Section 2 of the Estuarine Process Modelling Report (EPMR) (Martens November 2016).

The model was developed over a period of some three years with close collaboration between the peer reviewers (BMT WBM) and Martens. It is a ‘stand alone’ model that can be used for assessing any impact on the estuary.

Section A of the EPMR outlines the process of the building of the estuary model. This is represented as a flowchart in Table A. The model building and sensitivity analysis is more fully developed in Attachments C, D, E and F and the outputs of the model are presented in Attachments J, K (with infiltration) and L (without infiltration).

The matter of infiltration became a major issue. Infiltration refers to the take-up of pollutants by vegetation. At issue was whether or not the mature woodland in the 100m wide foreshore protection zone would

absorb, and to what degree, nutrients (TN and TP specifically) after being substantially neutralised having passed through the surface water treatment train (Water Cycle Management Report, Martens November 2016). The Peer Reviewer insisted that no uptake would occur whereas the proponents' Consultants, Martens, considered uptake would occur and cited parallel cases where a degree of uptake occurred.

The output of the estuarine model was presented for both with and without infiltration scenarios. These results are presented in Tables 9 and 10, Attachment C, (EPMR, Martens 2016). The measured difference between nutrients and suspended solids demonstrated an insignificant variation between the 'with' and 'without' infiltration scenarios.

Whilst the proponents are strongly of the view that the 'with infiltration' case is technically sound it became clear that the Peer Reviewers opinion was favoured by the Department.

Consequently the proponent undertook to further review the landslide Water Cycle Management Report (WCMR, Martens 2016) with the object of achieving NorBE at the interface between the residential zone and the foreshore protection zone (SLEP 1985). The results of this review are presented in an addendum to the WCMR emailed to the proponent on 8 June 2017 (see Appendix 7).

The review required a re-assessment of the inputs into the MUSIC model with the aim of increasing the percentage of pervious surface in the area covered by the plan. The most significant improvement in the model output was achieved by reducing the area allocated to industrial uses by 50% and retaining it as woodland. Further improvements were gained by reviewing the permeability of all roads and applying Council standard carriageway widths, and also by reviewing roof areas by lot size based on surveys of recent estates in Shoalhaven.

The proposed treatment train was also modified to accord with the peer reviewers' recommendations. Consequently the wetland/infiltration systems previously adopted were removed with the areas allocated to these facilities left undeveloped – thus also increasing the percentage of pervious land.

The results of the final model run are shown in Table 2 of the Addendum, demonstrating that each of the criteria (TSS, TN and TP) achieve a beneficial effect in each of the receiving waters – the Crookhaven River, the SEPP 14 Wetlands, the seagrass and oyster leases and Curleys Bay.

To further test the impact of the Concept Plan on the water of the Crookhaven Estuary, Ecological Australia were commissioned to

undertake an assessment of the Aquatic Ecology of the Crookhaven Estuary (West Culburra Aquatic Ecology Impact Assessment. Proposed Mixed Use Subdivision. EA. May 2017 (see Appendix 8)). This study investigated the condition of existing marine vegetation (sea-grasses, mangrove forest and saltmarsh) and found it to be healthy and in good condition, despite the numerous existing catchment pressures, primarily dairy farming and poorly serviced urban development. The study then used the output of the estuarine processes model as submitted in 2016 to assess the impact of the development proposed in the Concept Plan on each of the existing marine ecologies.

Each ecology was interrogated with respect to the specific data relating to each ecology and concluded that 'the proposed subdivision would not alter the health, extent or values of the estuarine ecology'.

The aquatic study was undertaken prior to the review of the landslide treatment train. The results of the review, reported above, indicate that all criteria in all catchments are superior to existing conditions in the estuary, achieving a beneficial effect on the waters of the Crookhaven Estuary.

The Addendum to the Water Cycle Management Report clearly sets out in Table 2 the degree on improvement, the beneficial effect, in each of the catchments. The aquatic ecology assessment demonstrates, using the 2016 data generated by the Estuarine Process Modelling Report, that there would be no significant effect on the marine ecology of the several catchments.

These results demonstrate the NorBE objective is achieved by a significant margin.

8.4 Traffic and Access

One of the key decisions that drives the shape of the West Culburra Plan was the location of the principal access to the area west of the STP. The factors to be taken into account were: (i) the divide which defined the southern boundary of the Concept Plan site; this divide progressively diverged from the alignment of Culburra Road in a westwards direction; (ii) the location of the industrial zone adjacent to the STP; whilst this was considered good zoning practice, the existence of this zone in this location was considered a negative factor in seeking to create an attractive entrance to the new residential district; and (iii) the majority of trips and the major desire line of movement generated by the new residential district was clearly going to be eastbound towards Culburra Business centre and associated facilities and services.

The solution was to select an access point at a topographically acceptable location as close as possible to the existing development at Culburra that provided an easy, efficient and shortest possible connection to the new residential district. The collector road is that connection and the roundabout is the access point.

A roundabout form of intersection was adopted because it provides a strong statement of arrival at Culburra Beach, particularly if appropriately landscaped; it fits comfortably into the topography being in a shallow defile that is the headwaters of Wattle Creek. This arrangement enables the main access to the new residential district to be aligned up a gentle slope to the divide beyond which the new residential district will be developed. This achieves the objective of creating a distinctive and attractive access to the new residential district.

A major footpath/cycleway is proposed to be aligned on the south side of the collector road. This will be the most direct access to the business centre and associated facilities. This footpath/cycleway will cross the collector road at a suitable location north of the roundabout and will then be aligned along the north side of Culburra Road to link with the existing pedestrian footpath running through the business centre. This footpath links, at its eastern end, with an existing shared cycleway/footpath aligned along Prince Edward Avenue extending to the sports ground and Crookhaven Heads.

The secondary footpath/cycleway, referred to here as the leisure route, is a less direct route being aligned along the waterfront. It is anticipated that this route will link to a possible new footpath/cycleway aligned along Brighton Parade and Mowbray Road providing access to the beach (see EA, Appendix 12 Figure 2.7 and Figure 3.4).

8.5 Bushfire Management

The Bushfire Report (EA Appendix H, ELA, March 2015) sets out the dimensions of the Asset protection zones (APZ's) required. We have made some minor modifications to the layout since that report was prepared. The current APZ's are shown on Figure 14.

The collector road with the associated footpath/cycleway forms the southern APZ generally aligned along the catchment divide. This APZ extends to the roundabout and then Culburra Road becomes the APZ through to the town centre.

The foreshore drive forms the northern APZ extending from Cactus Point (west) to the STP (east).

A 10m fire trail (APZ) surrounds the STP on the west, south and east sides; the STP has within its boundaries a somewhat depleted 100m wide retained woodland buffer zone.

The western end of Stage 4 has a 25m wide APZ within which the planned subdivision will be contained. Subject to the area to the west be rezoned for further residential development, as is proposed in the current Planning Proposal, this boundary arrangement will be designed as an integrated subdivision. The two crescents will form the temporary boundaries of the progressive development of Stages 2, 3 and 4 of the Concept Plan and will function as 25m wide APZ's during the construction phase (upon approval it is expected that the development site will be cleared).

The provisional plan for Stage 1 of the Concept Plan is bounded by a 25m APZ in the form of a road and cleared area on the south side. The west side is bounded by the Council owned former waste tip. The APZ for this boundary is a 10m fire trail with an additional no-build zone 10m wide, making this a 20m wide APZ in total. The eastern boundary of Stage 1 is a 20m roadway and a 70m wide area (zoned special uses in SLEP 1985) of grassland that the proponent intends to develop for residential uses (see Figure 7 – The Planning Proposal). The eastern boundary of the site is an existing retirement village. Detailed site investigations demonstrate that the area that can be drained by gravity is some 80-125m south of the actual divide which runs diagonally across the site, skewed to south of east with a fall of some 2.75m from west to east over a distance of some 295m. That is a gradient of less than 1% or 1 in 100. The provisional plan for Stage 1 of the Concept Plan is shown in Figure 15.

8.6 Foreshore Area and Zoning; Permissibility of proposals for the Foreshore Zone and Cactus Point Leisure Hub

The justification for the proposed Cactus Point Leisure Hub is that this location is exceptionally well suited to recreation uses. The environmental attributes are: (1) north facing grassy slope; (2) attractive outlook over expansive reach of Crookhaven River which is here some 400m wide; (3) shallow river edge safe for children;' and (4) concentration of regionally significant middens around Cactus Point (see Figure 10).

The latter point underlines the natural attractiveness of this location as a gathering point. The archaeological evidence suggests this area was intensively used by aboriginals over many decades. The owner confirms that this location is also very attractive for campers, who frequently seek permission from the owner to camp at Cactus Point. In our opinion it is ideally suited as a recreation focus for a limited range of tourist facilities. The area covered by the Concept Plan is zoned 2(c) in SLEP 1985. The

objectives of this zone 'are to provide for new residential areas with a range of housing types with provision for urban services to serve the local community. Being a significant retirement and holiday destination, it is considered that recreation and tourist facilities that are compatible with a residential environment would satisfy the qualification of 'urban services that serve the local populations'. In essence the 2(c) zone in SLEP 1985 is a broad general purpose urban zone designed to facilitate urban development. In SLEP 1985 there are no sub-zones identified for open space, schools, commercial premises; it has to be assumed that these non-residential uses would be located in the detailed planning stage of the 2(c) zone. It is our view that the leisure hub as proposed in this concept plan is consistent with the intentions of the 2(c) zone in SLEP 1985.

Shoalhaven LEP 2014 also includes an R1 General Residential Zone which is appropriate for areas of new urban development where detailed designs of local roads, lot sizes etc may not be finally determined – such as this Concept Plan. Tourist and visitor accommodation is permitted in that zone with consent; tourist and visitor accommodation (hotels and motels) may include a public café or restaurant. Shops (retail premises) are permitted in the R1 zone; but cafés and restaurants as stand-alone facilities are not permitted. All are permitted with consent in the SP3 Tourist zone.

The uses considered feasible in the leisure hub include motels, tourist accommodation, cafes and kiosks as well as residential development of various kinds. All these uses are permissible with consent in the Residential 2(c) zone. SLEP 1985 also has provision for a Residential 2(d) zone which identifies land suitable for tourist facilities; permissible uses with development consent include, besides dwellings, motels but does not include food and drink premises or kiosks. SLEP 2014 has provisions for a SP3 tourist zone which permits with consent, inter alia, food and drink premises, kiosks, tourist and visitor accommodation.

It is our view that the proposed uses, a motel, tourist and visitor accommodation and food and drink premises are permissible in the Residential 2(c) zone (SLEP 1985).

It is also our view that certain combinations of accommodation and café/restaurants are permissible with consent in the Residential R1 zone of SLEP 2014.

Our preference is for tourist accommodation and public access cafes/restaurants to be located at Cactus Point. That preference is based on knowledge of other locations where such uses exist in attractive waterfront locations (Shellharbour is one example, as is Greenwell Point).

As noted elsewhere, the proposed leisure hub is located in Stage 4 of the Concept Plan which is scheduled for development in 2022-5. The lead-time available will allow the Planning Proposal to be finalised which it is expected will embrace lands covered by the concept plan, including the land proposed here as a leisure hub. The permissibility or otherwise of the leisure hub is thus a matter that is not critical to the overall project at this time.

We recommend the proposed uses be approved as being consistent with SLEP 1985.

The Aboriginal Heritage Study (EA, Appendix H; see Figure 11) identifies some 20 shell middens that are of reginal representative significance located along the foreshore of the Crookhaven River adjacent to the site of the Concept Plan.

The proponent considers these middens to be at risk on account of the proposed development; it is considered inconceivable that future residents, both adult and children, will not wish to explore and utilise this waterfront for a variety of activities, and that the middens may, as a consequence, be damaged and their significance diminished.

The proponent acknowledges that some of these sites are in the 30m wide Crown foreshore reserve. All are within the proposed 100m wide foreshore reserve which will be dedicated as open space. It is the proponents' view that this foreshore zone be managed in such a way as to conserve the middens and the areas of significant ecological interest by controlling access through design. This is particularly true for the cluster of middens at Cactus Point, all of which are readily accessible; it is also true for the waterfront at Cactus point which is also readily accessible.

The proponent envisages a managed waterfront along the entire 3.3km frontage of the Concept Plan site (including the Council owned section of foreshore being part of the STP site). The principal management element will be the cycle/walkway aligned along the 3 length of the waterfront from Canal Street East to Cactus Point with associated facilities such as viewing shelters and interpretation panels. Subordinate elements may include minor walkways, and/or boardwalks to particular features.

The initial concept for the Cactus Point waterfront identified this area as a key access zone to the Crookhaven Estuary.

The original plans for Cactus Point indicated a low sea-wall designed to 'tidy-up' the waterfront at what was considered likely to become a popular and well-used recreational area. In addition it suggested this would be an appropriate location for boat access ramps and possibly a small jetty for

craft to tie-up. It is now considered that the water depth would prohibit normal boat access but light craft such as kayaks may be appropriate for the water depths. The works envisaged would be on crown land and require a range of approvals. The waterfront concept has been deferred because this component of the plan (Stage 4) is not likely to be developed until some 5-8 years following any approval of the concept plan. Consequently it is omitted from the current concept plan.

Cactus Point lends itself to recreation activities. The land-water interface is readily accessible and the north orientation of the gentle slopes leading down to the Point are ideal for recreation. The attractive outlook over the broad expanse of the Crookhaven River estuary with Billys Island at close quarters and Mount Coolangatta in the distance marks the Point out as a place of distinction. It is ideally situated to be a low-key – local leisure hub for West Culburra. The uses that are appropriate include motels, cafes and restaurants and some unit accommodation. These leisure oriented uses are adjacent to but separated from the main residential areas. The uses are considered to be compatible with a residential environment.

The foreshore waterfront park is considered to be an important additional public good for Culburra Beach residents. The proponent envisages the design of the waterfront being a co-operative exercise between it and members of the Aboriginal community, the Culburra Beach community, Shoalhaven City Council, OEH and an Aboriginal Heritage Conservation Specialist. The foreshore waterfront park will be developed in stages and it is anticipated that the design of each stage will be put on public exhibition prior to it being adopted by Council and implemented by the proponent. The costing is expected to be incorporated in a Voluntary Planning Agreement yet to be arranged with Council.

The elements associated with this concept for a foreshore waterfront park have yet to be worked out in detail and involve numerous government agencies. Consequently they are omitted from the Concept Plan at this stage.

8.7 Economic Impacts

The economic base of Culburra Beach is very limited. There is a lack of employment opportunities in Culburra. The town's principal asset is the beach and it is this that attracts retirees, holiday home owners and visitors. Other places of interest are Lake Wollumboola and Curleys Bay. The latter is virtually inaccessible; the former is attractive for young children and ornithologists.

The bowling club and the surf club are facilities that are widely used by the local community as well as visitors. There are few other attractions.

The proponents take the view that it is both necessary and desirable to diversify the economic base for the benefit of current and future residents and visitors. To this end the proponents have identified locations where it believes the economic base can be enhanced and diversified. Opening up access to the Crookhaven River and identifying sites for activities that could take advantage of a waterfront outlook is considered one way of diversifying the array of leisure opportunities available to the Culburra Beach community. Others include strengthening the existing town centre by intensifying the shopping experience and by enhancing its sense of place (this is outside the scope of this Concept Plan). A third is by creating streets that have a distinctive appeal – an address – such as the proposed vista avenues that anchor the place to the local topography (views to Mount Coolangatta and Crookhaven Heads).

The deletion from the Concept Plan of the detailed layout of streets, specifically the Circus which was conceived as a mixed-use development, removes the concern expressed in relation to an implied competition of commercial uses with the existing town centre. The proponent has consistently supported the reinforcement of the existing town centre by both the intensification of commercial uses within the existing centre and by increasing the density of residential uses within walking distance of the town centre.

Because of the simplification of the Concept Plan there is now no proposal to introduce new mixed use commercial development in the plan. Consequently consideration of DCP67 (now DCP 2014 – Chapter G 17) does not apply (it is notable that the illustration at the head of this chapter of the DCP shows a water view being exploited with a café terrace – an illustration that exemplifies the objectives of the proponent with respect to selected locations in the Concept Plan) including Cactus Point.

Should commercial development be contemplated in Stages 1, 2, 3 and 4 of the Concept Plan, then Chapter G17 of SDCP 2014 will be fully considered.

9. The Encroachments

As noted in Section 2 of this report the ridgeline between the catchments of Lake Wollumboola and the Crookhaven River was adopted by the Department and included in the DGR's as a boundary for the definition of the site for the Concept Plan. At that time it was understood that there was significantly higher land to the south of the site that, although

technically within the lake catchment, was able to be drained to the Crookhaven River.

Subsequent to the endorsement of the Concept Plan as a Major Project, the Minister endorsed a Planning Proposal (see Section 6 above) which included land in the lake catchment, located generally south of the site of the Concept Plan. The details of and justification for the four encroachments on the ridgeline is outlined below.

9.1 The Access Road

The location of the principal access road, the Collector Road, is determined by the location of the intersection of the Collector Road with Culburra Road. The preferred location of the intersection is the most efficient in linking the proposed large residential area west of the STP with Culburra Town Centre and associated facilities. The preferred location was endorsed at an onsite meeting of representatives from RMS, SCC, DPE and the proponent. The first section of the Collector Road is, perforce, in the catchment of Lake Wollumba and linked to the roundabout (see under).

9.2 The roundabout and associated roadworks.

As outlined in Section 2 of this report, the major component of the Concept Plan is the 600 lot subdivision west of the STP. Access from Culburra Road to this new estate must be west of Strathstone Street (the access road to the industrial zone and the STP). Culburra Road west of Strathstone Street is, for a distance of some 3.5km, within the lake catchment. Any access convenient to Culburra from the new estate will unavoidably be within the lake catchment. There are 3 culverts along this section of road; two on arms of Downs Creek and one on Wattle Creek. There are no pollutant traps or other devices along this section of road or at any of the culverts.

The location of the roundabout has now been agreed by SCC and RMA. Detailed plans are shown in the accompanying plan (see Figure 12). The determination of the location is shaped by traffic safety considerations.

The location is at the head of the Wattle Creek catchment; Wattle Creek flows into Lake Wollumboola.

A drainage swale is proposed. The effectiveness of the treatment train proposed is demonstrated in Table 19 of the accompanying Water Cycle Management Report (Martens August 2014) which shows the NorBe objectives are achieved.

9.3 The Oval

The location of the oval was selected because the site analysis showed this was the only area that was sufficiently flat (almost no regrading is required) and because it was centrally located in relation to the likely future pattern of urban development north of Culburra Road (see Figure 7).

It should be noted that the area around the oval and south of the divide, and therefore in the catchment of Lake Wollumboola, is sufficiently elevated (to a height of RL30) above the divide (at RL16 adjacent to the oval) to enable it to be easily drained by gravity to the Crookhaven estuary. This topographical anomaly has led many to believe the divide is actually located along the higher ridge, as would normally be expected. The proposed residential zone in Draft SLEP 2009, for example, adopts the higher ridge as its southern boundary. The proponent has always been aware of the urban potential of the area south and west of the oval site – a fact now recognised in the Planning Proposal (see Figure 7).

The oval will drain to a wetland on its eastern side. The wetland is depicted in and the wetland input parameters are shown in of the Water Cycle Management Report and Addendum demonstrating that NorBE is achieved.

9.4 Part of the road reserve within the 3.4ha medium density site

The collector road adjacent to the oval is aligned along the catchment which hereabouts is virtually level at RL 16. The alignment of the collector road and of some of the house lots on the north side of the collector road, marginally encroaches upon the lake catchment. All the lots on the north side of the collector road, and the collector road are designed to drain by gravity to the Crookhaven (see Appendix 7).

9.5 Stage 1, South of Culburra Road

Stage 1 is part of Lot 6 DP 1065111, which, together with Lot 5 DP 1065111, form most of the lands covered by the Concept Plan. Part of both these lots appears as a single paddock on the South side of Culburra Road located between the Retirement Village and the former waste tip, owned by Council.

Stage 1 has a 195m frontage to Culburra Road, a depth of 170m and an area of 2.55ha. The eastern section is zoned 5(a) Special Uses (community purposes) and the western section is zoned Residential 2(c) (SLEP 1985). Stage 1 is limited to the area zoned for residential purposes.

The intention of the proponent is to use the whole of the paddock, with a total frontage to Culburra Road of 285m, for residential purposes, principally small lots. The paddock is substantially cleared and easily developed. A comprehensive plan for the entire paddock area has been prepared but only that section zoned for residential uses in SLEP1985 can be developed at present. Access to the site is an important determinant of the layout because it is linked to a future road north of Culburra Road aligned alongside Vista Park which will ultimately connect to a second future road being an extension to Brighton Parade. The intended Vista Park road and the access to Stage 1 are to be aligned to form a cross roads at their intersection with Culburra Road. The location selected for the access was discussed with SCC Traffic Engineer on site and no problems were foreseen in relation to the general location. Culburra Road here is straight and flat and has high quality visibility (see view 11, Appendix V, EA).

Stage 1 is near flat with a fall from west to east of 1.9m over the width of the residential zoned section, effectively a 1 in 100 slope. The dividing ridgeline is 50m south of the boundary with Culburra Road at the western boundary increasing to 80m at the eastern boundary. Detailed survey of the site for Stage 1 shows that a site 190m in depth can be drained by gravity to Culburra Road.

The water quality implications of the proposal are considered in the Water Cycle Management Report (Martens 2016).

The location of Stage 1 is within 450m of Culburra town centre. It is the only site currently available for some higher density development than that which currently prevails in Culburra Beach. A small lot subdivision of some 45 lots is proposed.

The ready availability of stage 1 for residential development, its accessibility to the town centre and its comparative low environmental impact (the adjoining retirement village has a depth of 300m+ from Culburra Road), make it ideal for a small lot development.

The encroachment on to the lake catchment is justified because Stage 1 represents the only available opportunity to implement a proposal of moderately increased density close to the town centre at virtually no environmental cost. There will be no impact on Lake Wollumboola because all drainage is to Culburra Road.

The justification for this encroachment is three-fold. In the first instance the depth to the actual ridge, circa 50m, only allows for a single row of conventional lots fronting Culburra Road; this is considered to be a very poor form of development. In the second instance this is the only site

currently available for residential development that is within comfortable walking distance (450m) of the town centre and its associated facilities. The site is considered ideal for some medium density development, particularly one that is suited to the older age cohorts and down-sizers. In the third instance the site is cleared and can be easily and economically developed.

This encroachment will have no impact on water quality in Lake Wollumboola. All surface water drainage will be to Culburra Road and the Crookhaven catchment.

9.6 Part of Stage 5, the Industrial Zone

The Industrial Zone has an area of 3.5ha of which about 1.1ha is within the catchment of Lake Wollumboola. The major part of the industrial zone is near flat with a fall from west to east of 1m over a distance of about 450m; there are slightly steeper falls from north to south and from south to north.

The drainage of the whole of the industrial zone is designed to drain to the Crookhaven catchment. The zone will be drained to the Sediment Basin located in the NW corner of the Industrial Zone, and then to the Crookhaven River as per the MUSIC Model.

10. Summary of Undertakings

The undertakings are as follows:

1. To provide the offsets as outlined in Section 8.1 of this report;

2. To undertake the monitoring program as outlined in the Water Quality Monitoring Plan (Martens August 2014);

3. To provide Asset Protection Zones throughout the entire project as indicated on the Concept Plan (see Figure 14);

4. To construct the roundabout as shown in Figure 12;

5. To comply with Councils' DCP's where relevant or to comply with a location specific DCP developed in conjunction with Council in particular circumstances (eg Stage 1 small lot residential development).

6. To make and embellish the waterfront Reserve and associated cycle/waterway including conservation of Aboriginal middens,

removal of noxious weed growth, provision of shelters as outlined in Sections 8.2 and 8.6 of this report.

7. To implement the recommendation that an Aboriginal Conservation Specialist be on hand when earthworks including the making of swales, roadworks, sewer lines and the like are undertaken within 200m of the shore line as recommended in the Aboriginal Heritage study.

11. Conclusion

We consider the proposal to satisfy all the requirements set out in the DGR's. The proponent intends to implement the proposal as soon as consent is granted.

John Toon
July 2017

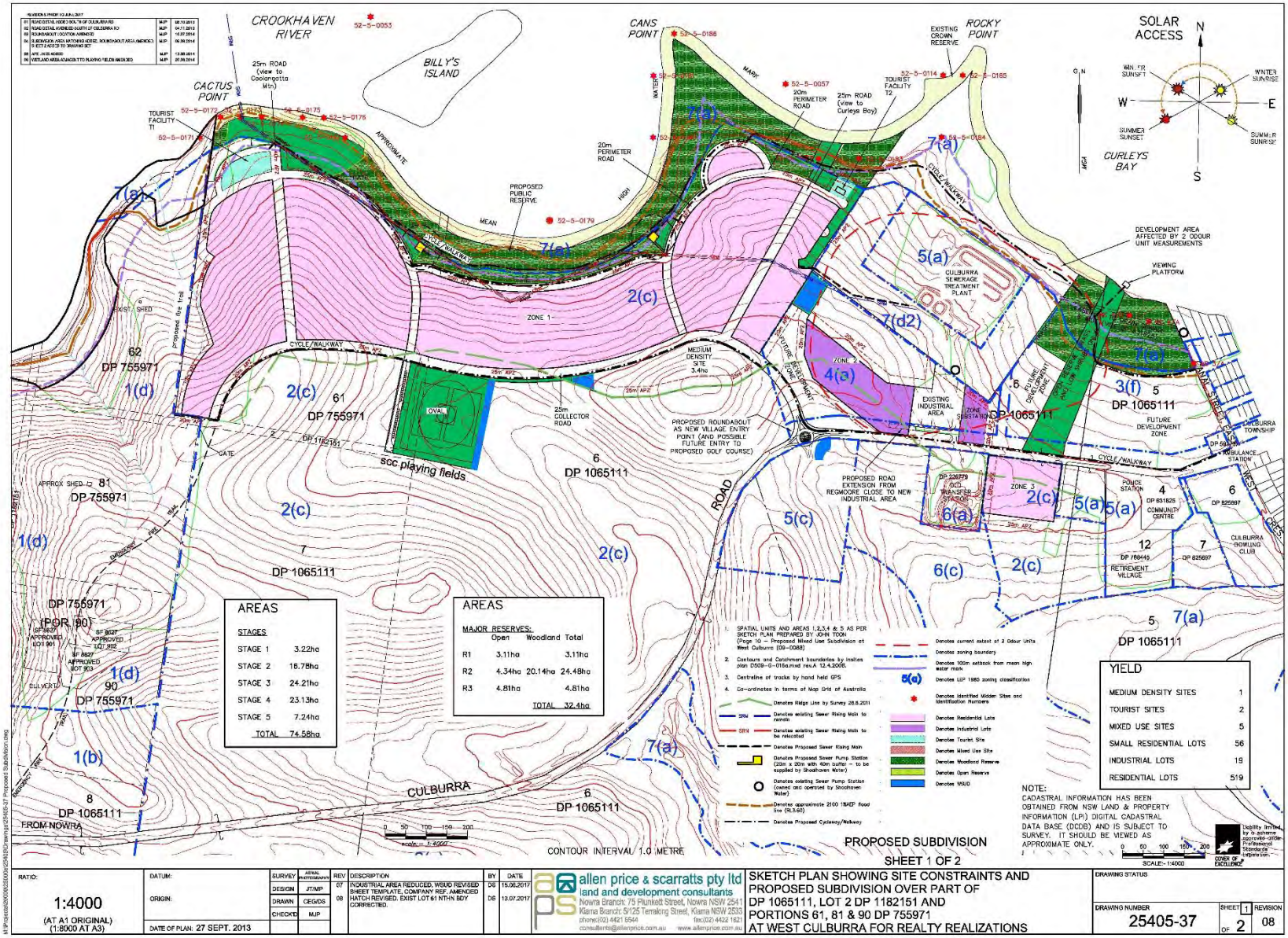

Figure 1. The Concept Plan

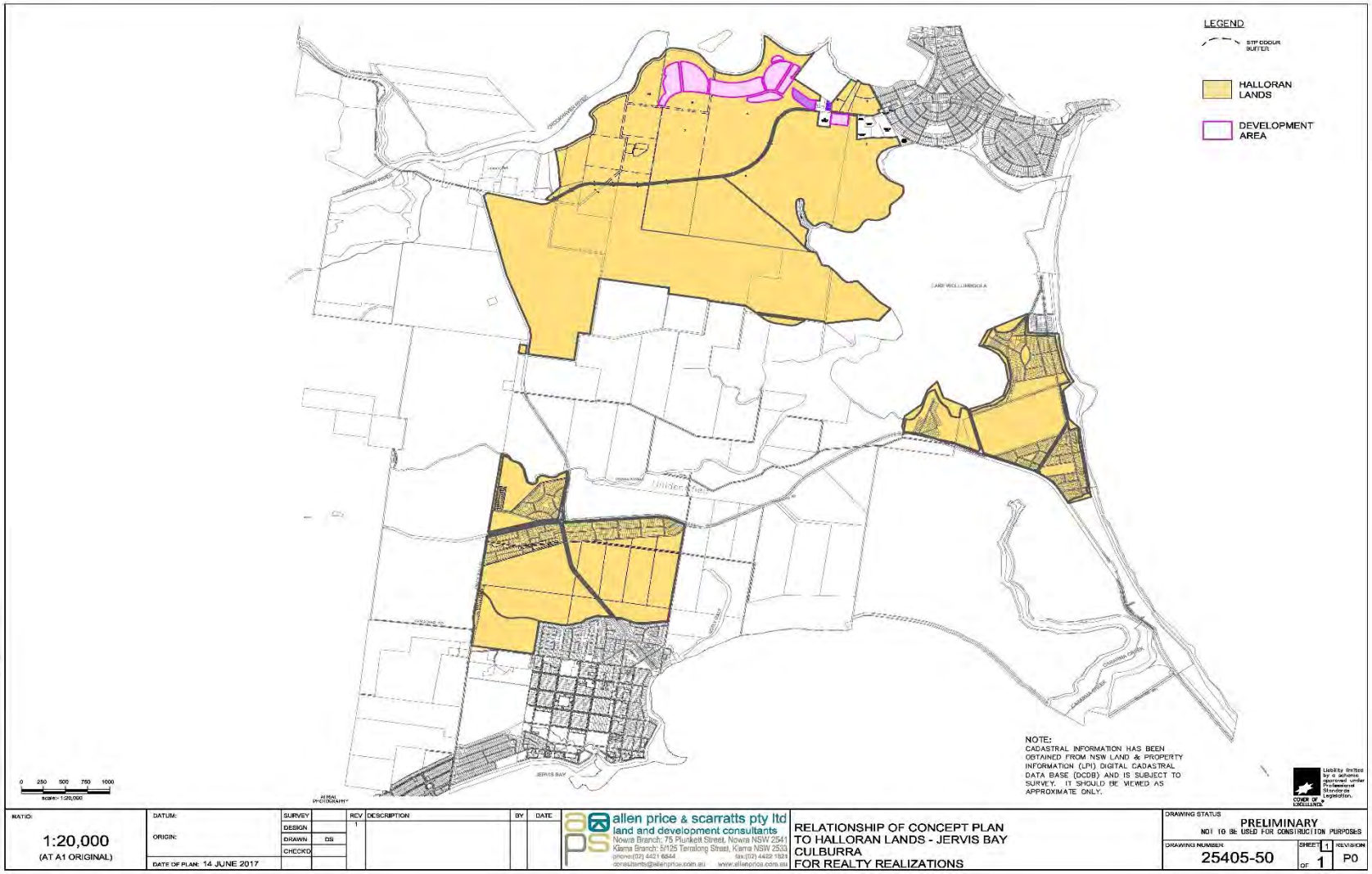

Figure 2. The Halloran Lands at Jervis Bay, showing the context of the Concept Plan

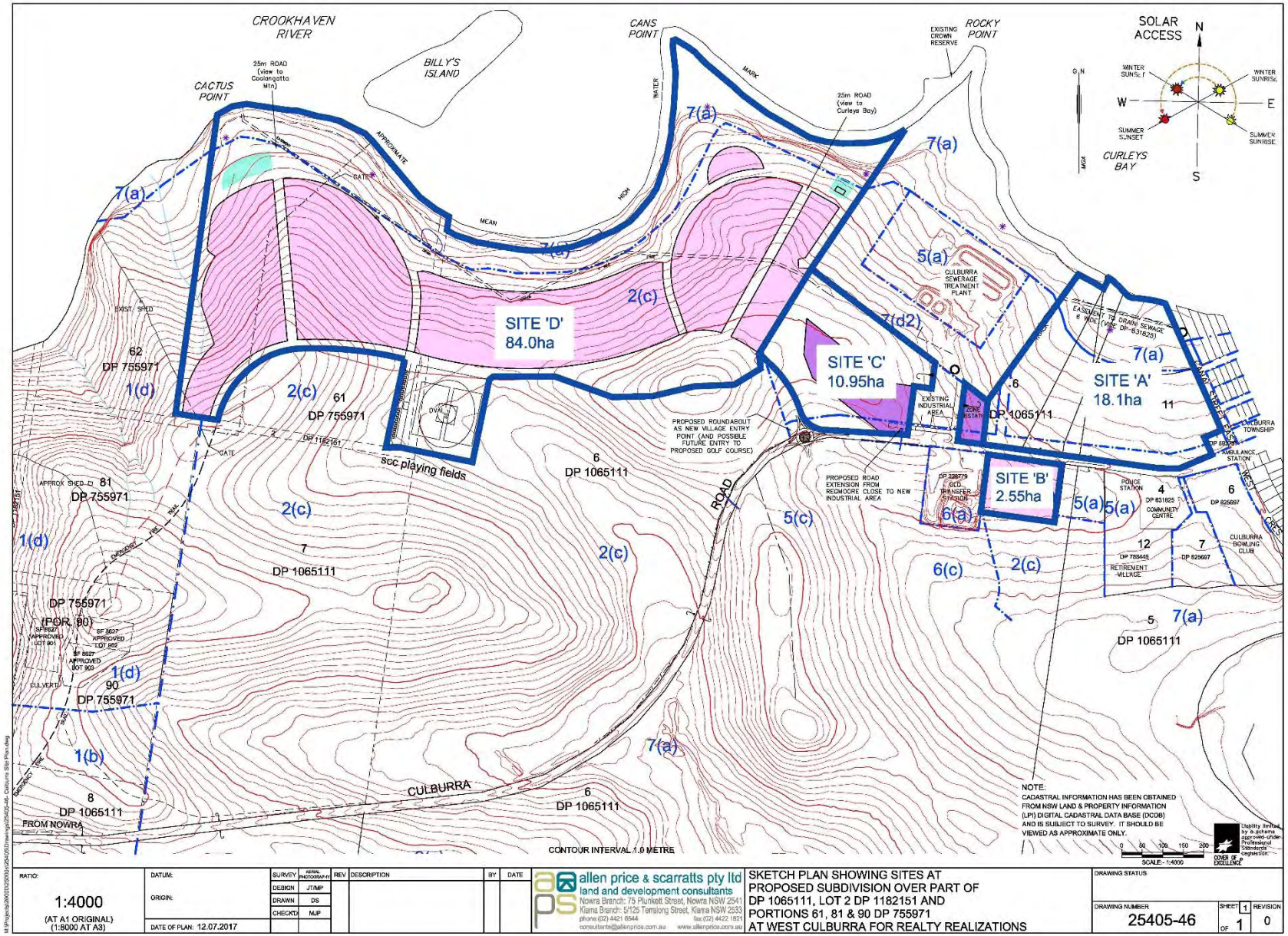

Figure 3. Lands covered by the Concept Plan

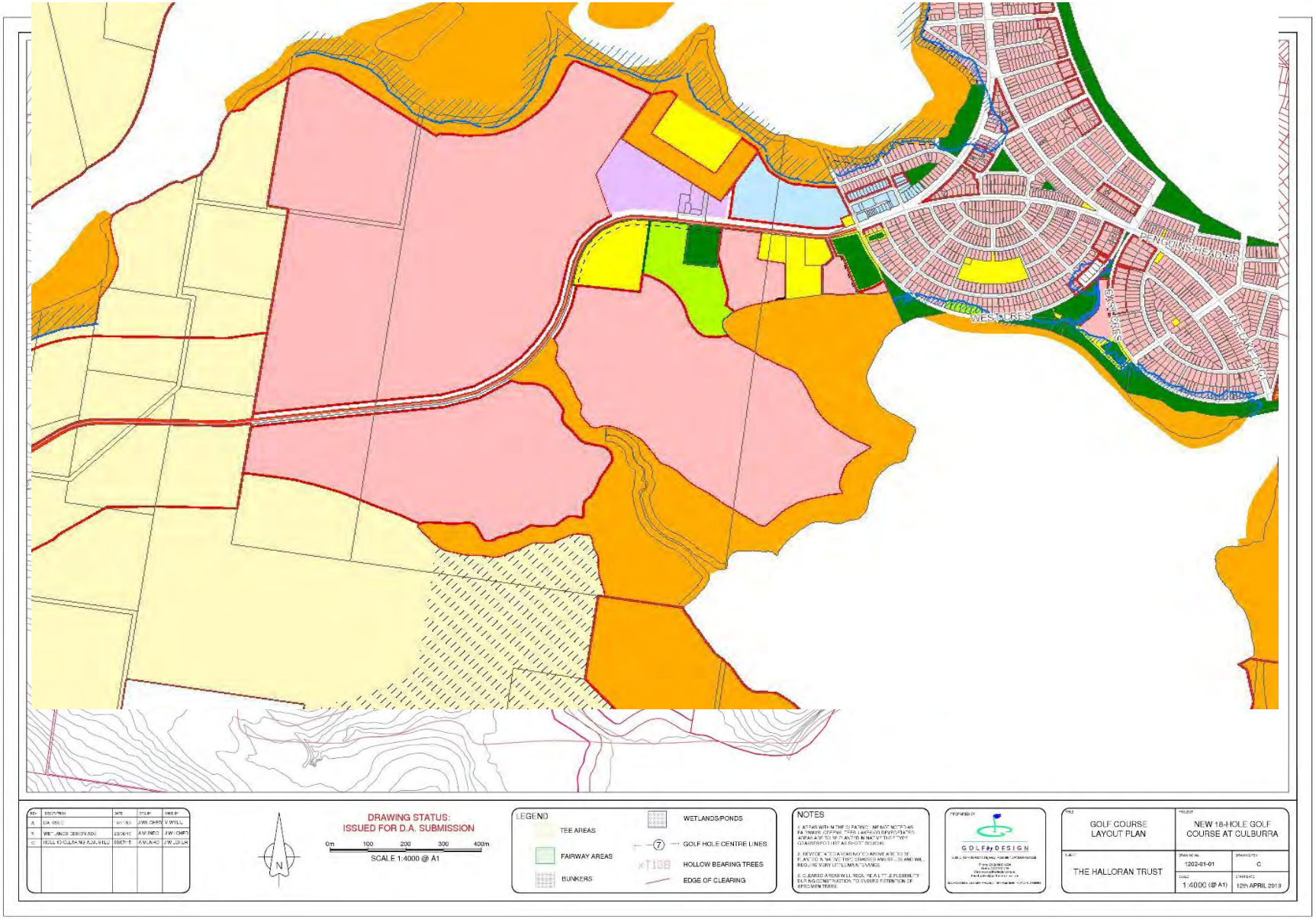

Figure 4. Shoalhaven Local Environmental Plan 1985

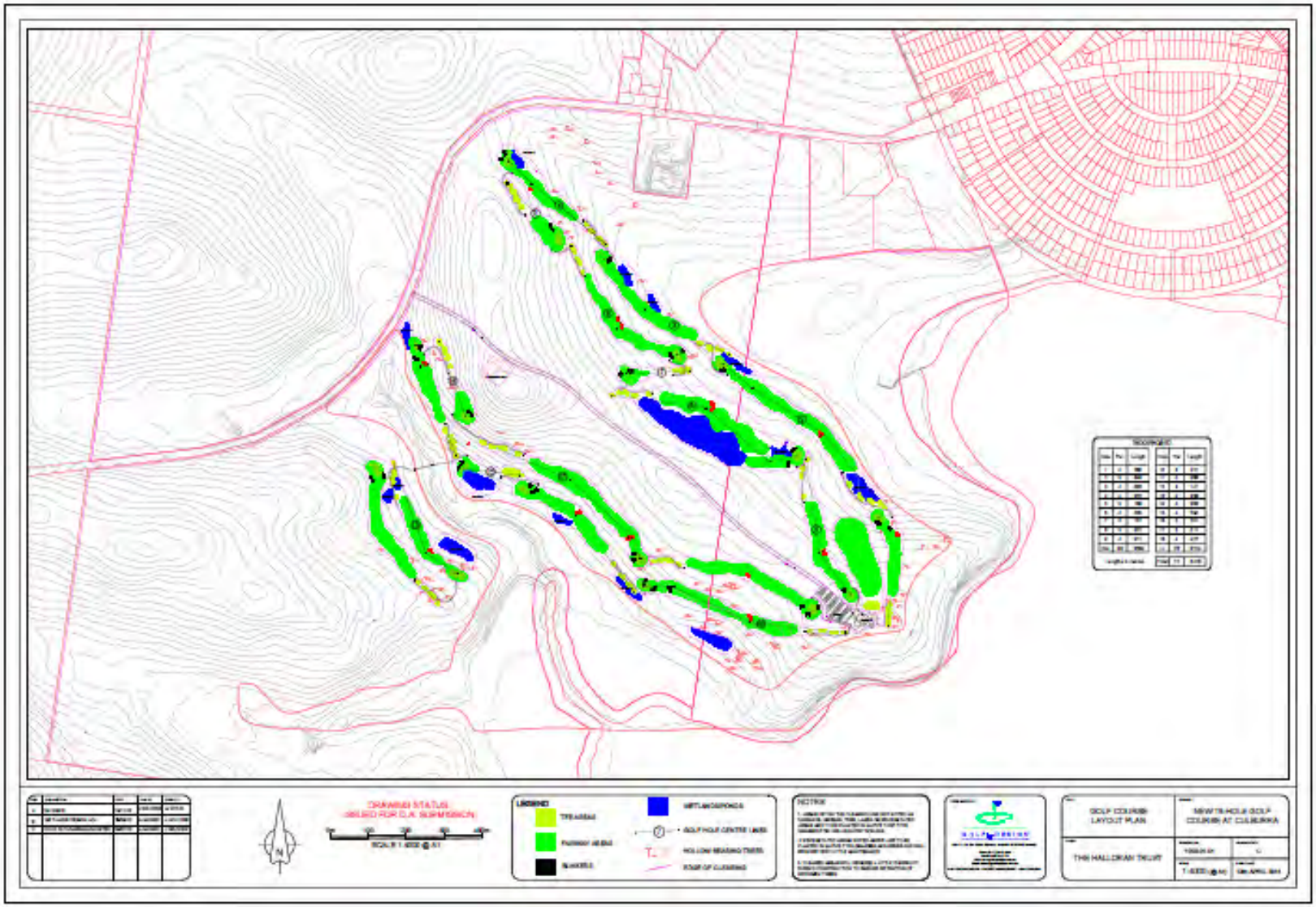

Figure 5. The Golf Course Development Application at Long Bow Point.

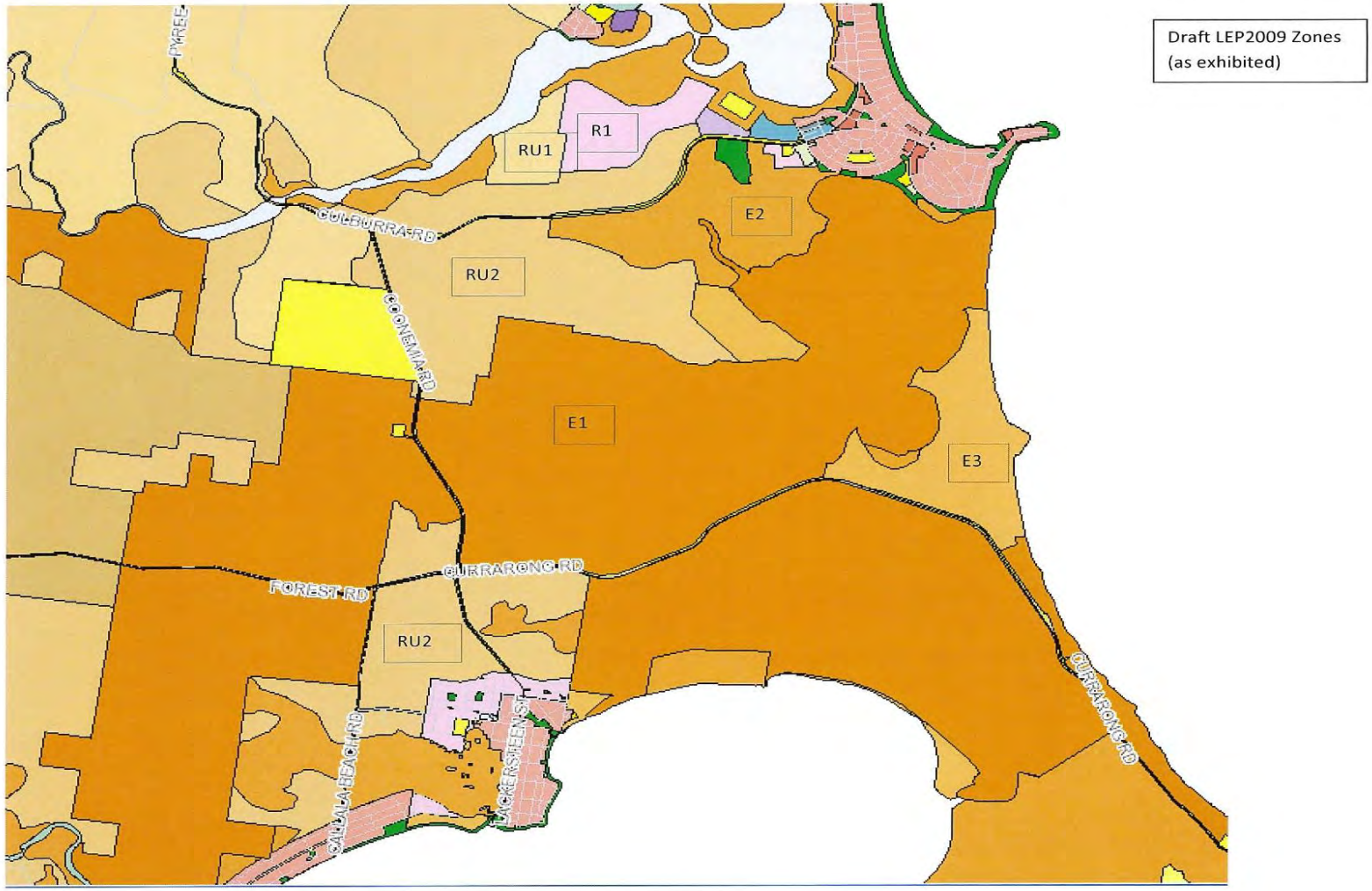

Figure 6. Draft Shoal Local Environmental Plan 2009

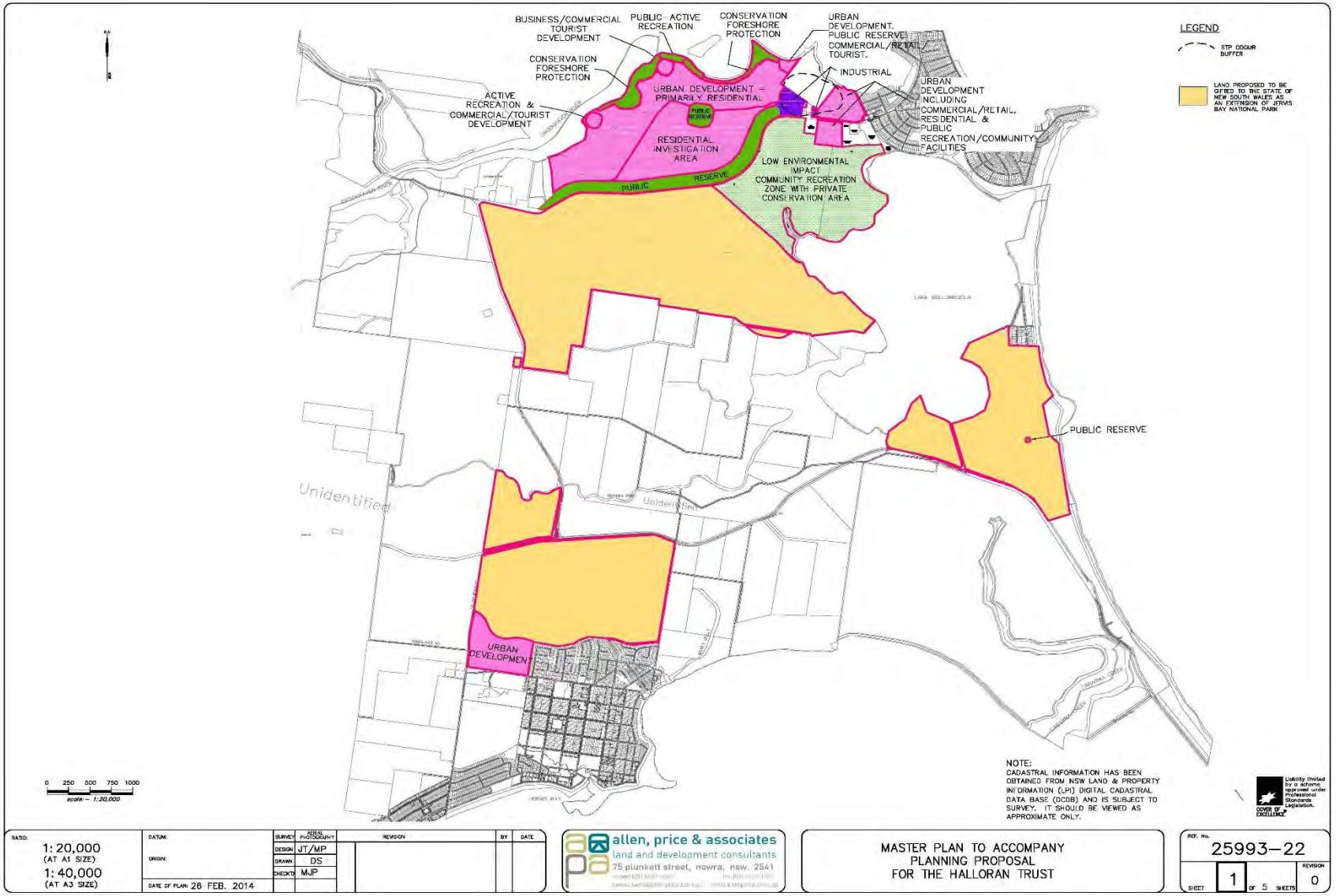

Figure 7. The Planning Proposal allowed through the 'Gateway' by the Minister November, 2015

Figure 8. Shoalhaven Local Environmental Plan 2014 (Jervis Bay Area)

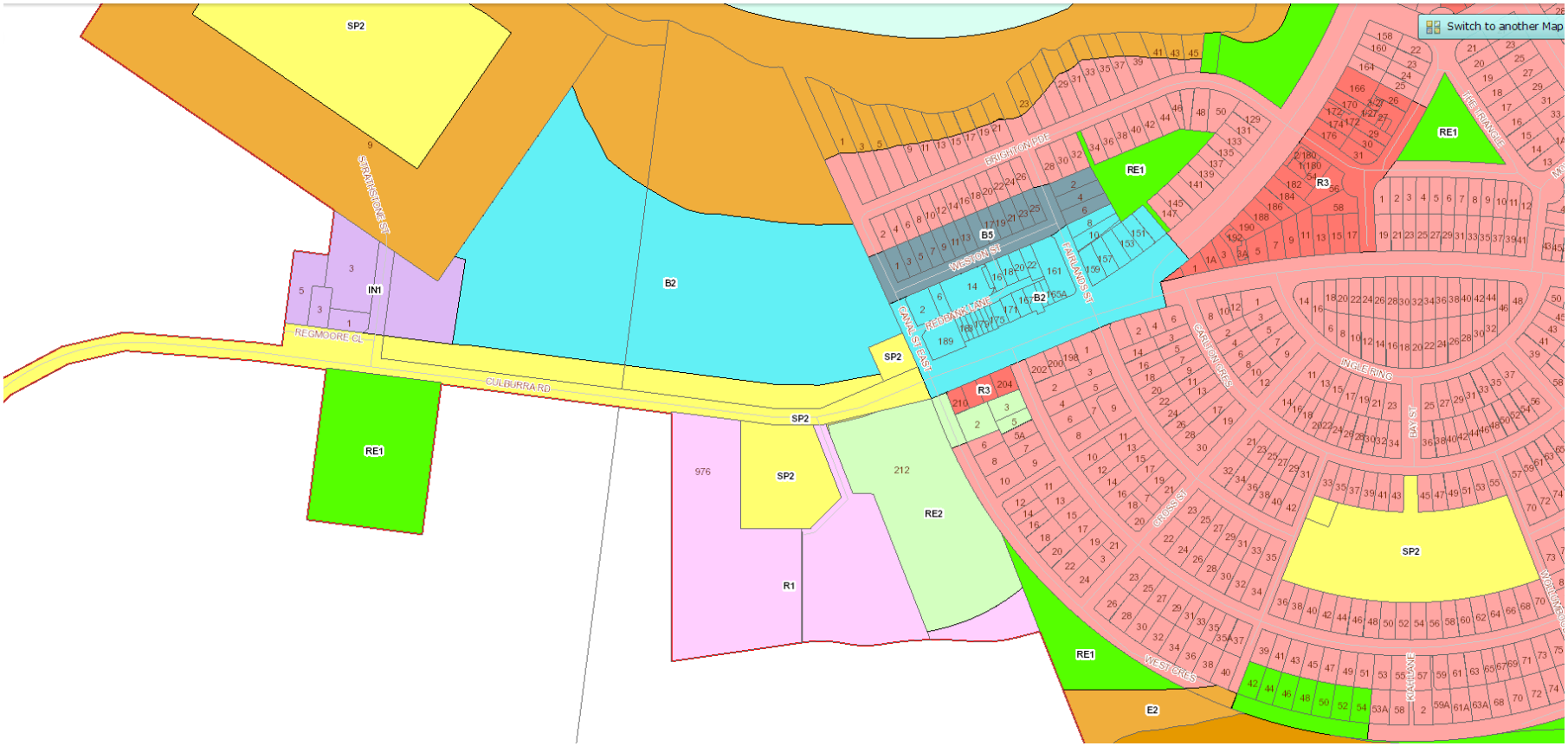

Figure 9. SLEP 2014 (detail) showing the B2 Local Centre Zone at Culburra Beach

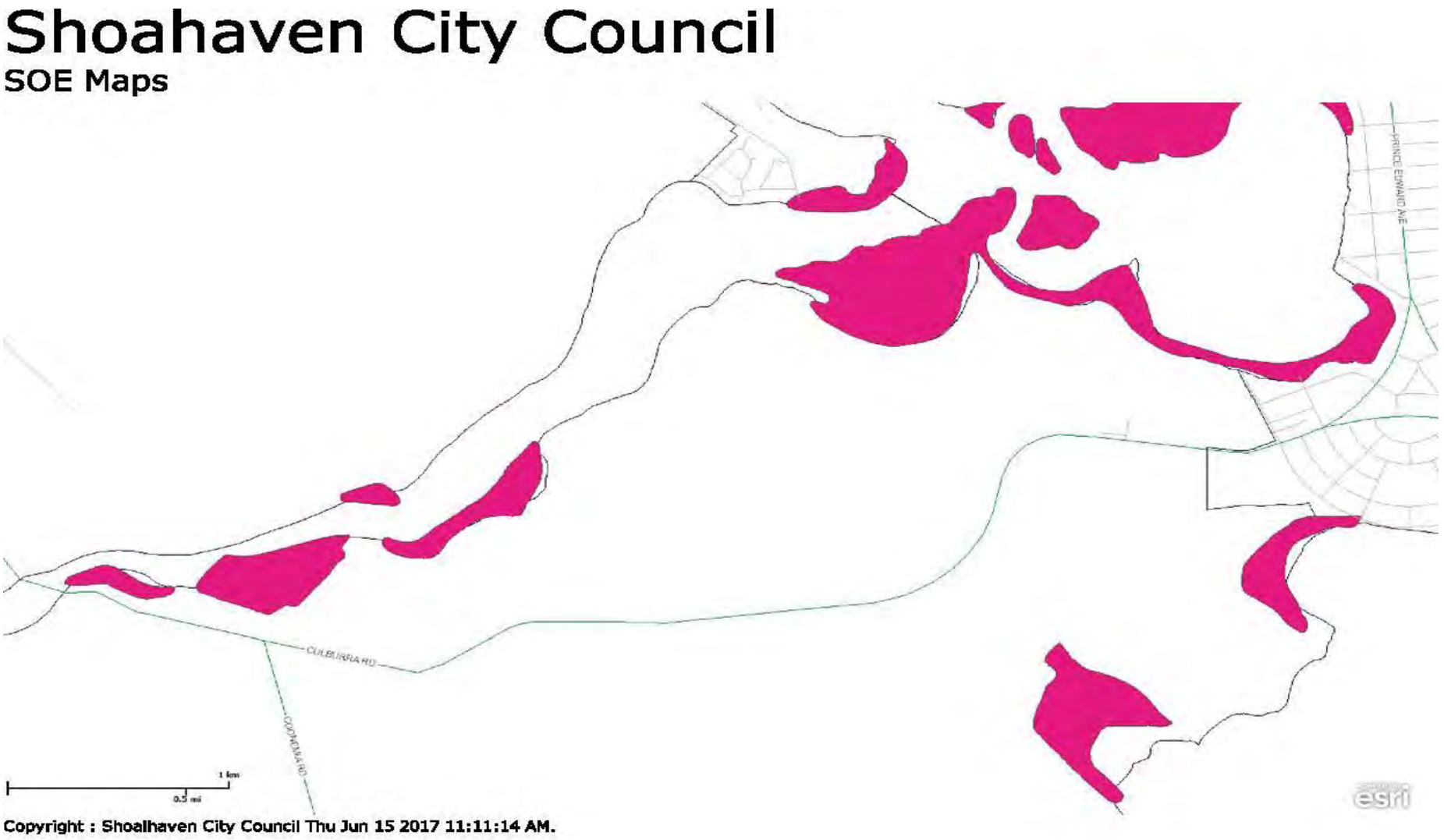

Figure 10. Plan showing location of SEPP 14 Wetlands

Figure 11. The location of Aboriginal Middens along the Crookhaven Foreshore

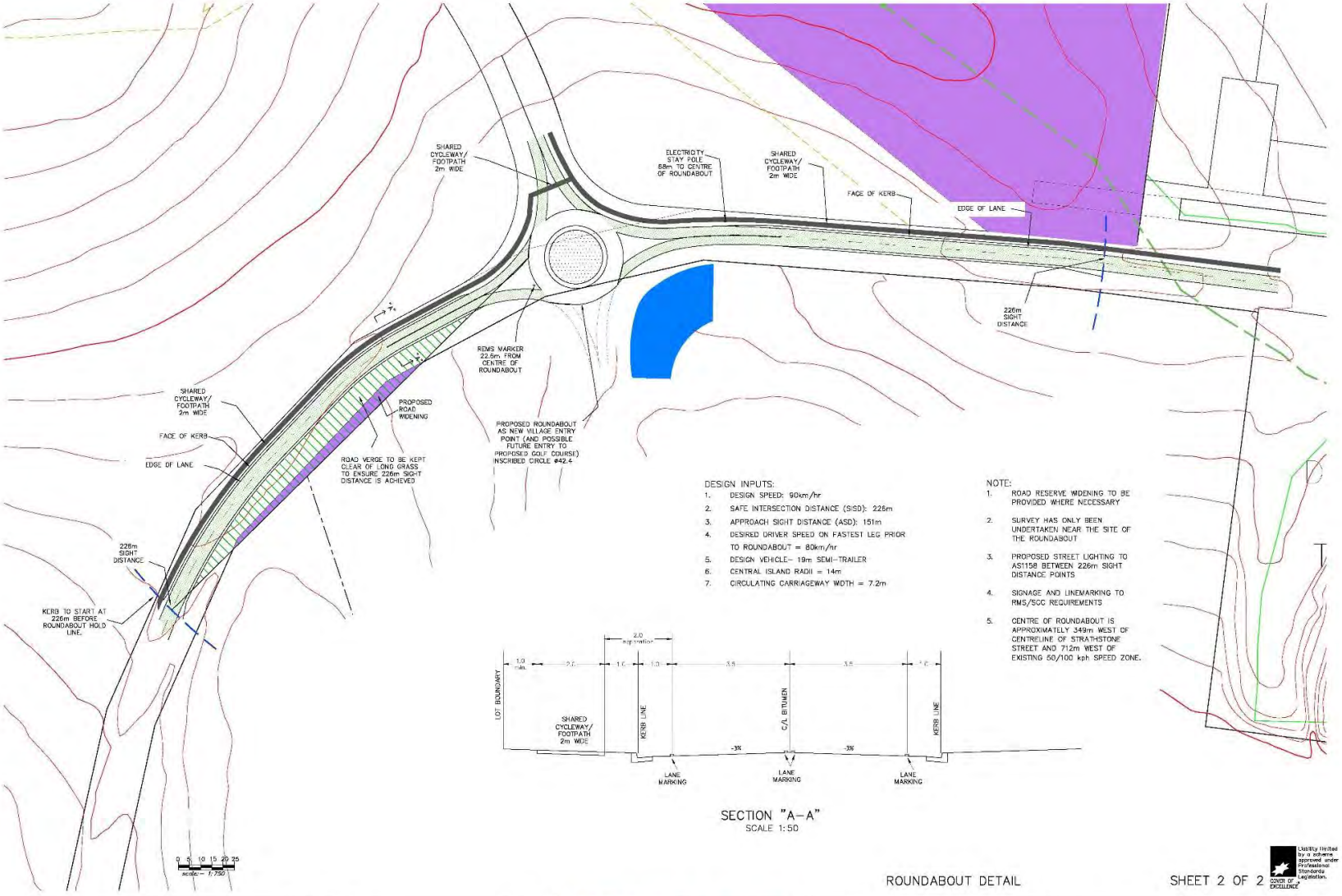

Figure 12. The layout of the roundabout

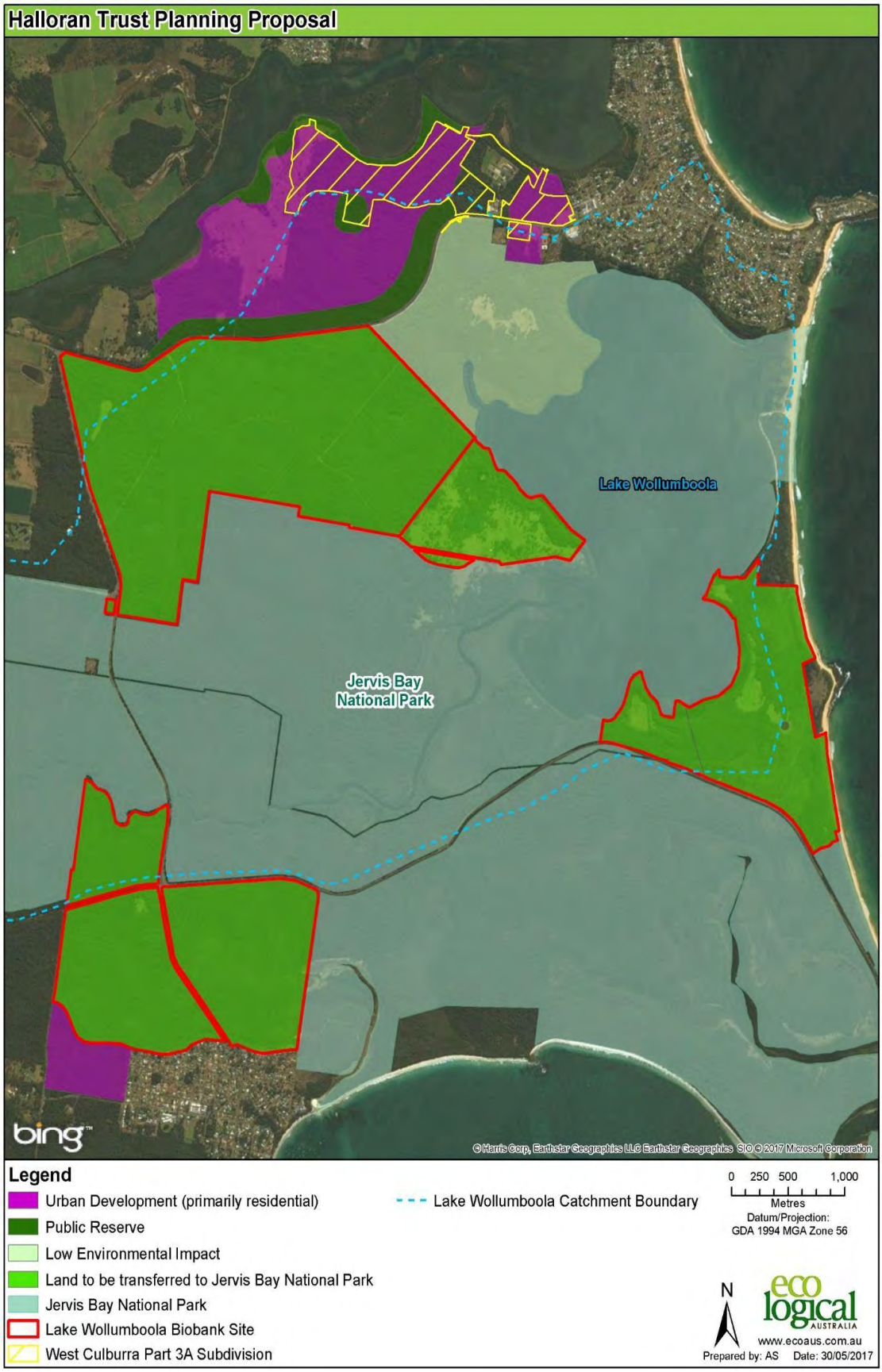

Figure 13.
Concept Plan in the Context of the Halloran Lands at Jervis Bay covered by Planning Proposal

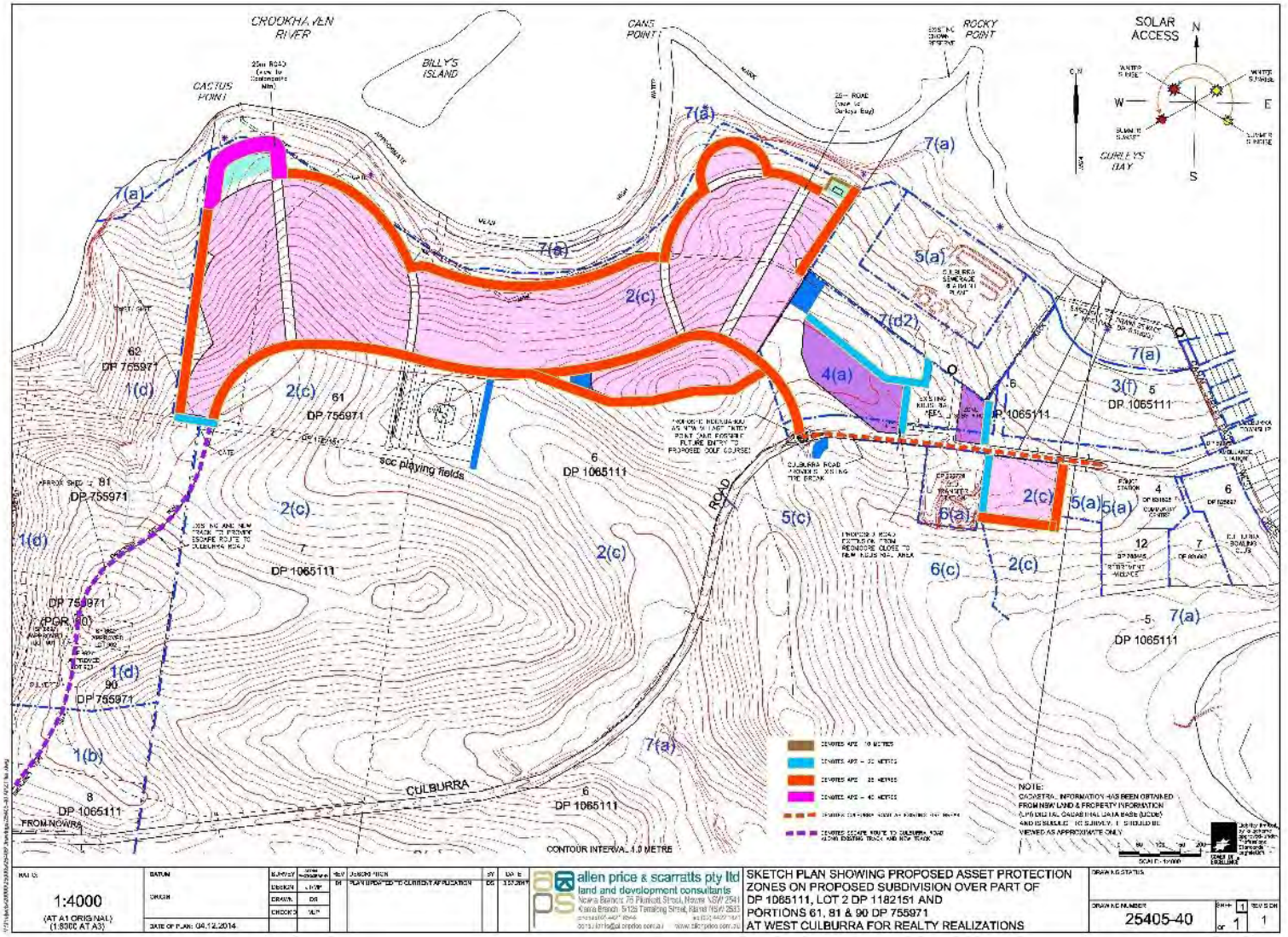

Figure 14. Plan showing the APZ's for the Concept Plan.

Figure 15. Provisional Plan for Stage 1.

APPENDIX 1

Letter from DPI dated 2/7/13

Planning & Infrastructure

Contact: Heather Warton
Phone: (02) 9228 6461
Fax: (02) 9228 6455
Email: heather.warton@planning.nsw.gov.au

Our ref.: 09_0088

Mr John Toon
John Toon Pty Ltd
17 Bunyana Avenue
Wahroonga NSW 2076

- via email -
evjotoon@bigpond.com.au
mattphilpott@allenprice.com.au

Dear Mr Toon

Subject: Submissions received on proposed Concept Plan for a mixed use subdivision at Culburra West – part lot 5, part lot 6 and part lot 7 in DP 1065111 and lot 61 in DP 755971, Culburra Beach (09_0088)

The exhibition of the Environmental Assessment (EA) for the above project ended on 7 June 2013. Following on from our letter dated 17 June 2013, a total of 37 public submissions and seven public authority submissions were received. Two of the public submissions were petitions.

The public submissions and public authority submissions received can be viewed on the department's website at:

http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=3846

A summary of the department's issues are included with this letter.

As this application is due to be transitioned to State significant development, a Response to Submissions (RTS) is required to be prepared in accordance with clause 85A of the *Environmental Planning and Assessment Regulation* 2000. The RTS must address the issues raised by the department and all submissions.

The RTS is required to be submitted to the department by **1 October 2013**.

I suggest that a meeting be held to discuss these issues in more detail. Please contact Ray Lawlor, Planning Officer, on 9228 6468 or at ray.lawlor@planning.nsw.gov.au to arrange a suitable time to meet with you.

Yours sincerely

Heather Warton
Director
Metropolitan and Regional Projects North

2/7/13

Department of Planning and Infrastructure – Key Issues

Concept Plan for Mixed Use Subdivision at Culburra West – MP09_0088

The following information is a list of the department's issues with many issues being supported by the public authority submissions. The issues listed below are not exhaustive - all submissions, from the public and public authorities must be thoroughly addressed by the proponent in the Response to Submissions and PPR.

1. Zoning/ Planning controls

As the application is to be transitioned to State significant development and be determined under Part 4 of the Act, the application needs to address Section 79C of the Act. This includes but is not limited to:

- the current and proposed zoning across the whole site – and the uses proposed in each zone;
- addressing the relevant clauses with Shoalhaven Local Environmental Plan 1985 (LEP1985) and the draft LEP2013; and
- addressing Development Control Plan 67 (DCP67) and DCP100 in greater detail.

There are a number of non-permissible uses (under LEP1985) proposed in the current scheme which could not have been considered if the project remained under Part 3A of the Act (because the site is located in a 'sensitive coastal location', as defined in State Environmental Planning Policy (SEPP) (Major Development) 2005), and which cannot be considered under Part 4 of the Act. These uses will need to be removed from the proposal:

- the residential development proposed in stage 1, within the 5(a) Special Uses – Community Uses is not permissible. Housing for the 55+ age group is not considered to be a 'community use'; and
- the works proposed in the 7(a) Environment Protection zone such as car parking, boat ramp, jetty, water sensitive urban design (WSUD) infrastructure, vista clearing, asset protection zones (APZ) and, recreational open space and infrastructure are all not permissible uses.

2. Development in Lake Wollumboola Catchment

The application does not provide enough justification for the following elements to be allowed within the within the Lake Wollumboola Catchment:

- parts of the collector road and corresponding parts of the some residential lots;
- the roundabout;
- the oval;
- part of the road reserve within the 3.4ha medium density site;
- the southern part of Stage 1; and
- the south western part of the Stage 5 industrial estate.

It is acknowledged some development is unavoidable in the catchment, eg the roundabout but it is still important to justify all breaches and address any adverse environmental impacts and mitigation measures.

3. Subdivision layout/ Urban design

The subdivision layout will require a significant redesign to make it more energy efficient, more permeable to pedestrians and to include useable open space. Considering a subdivision layout of more small-medium blocks of east-west orientated lots designed around useable open space may overcome many of the issues. Guidelines produced by Landcom, particularly the 'Street Design Guidelines' and the 'Open Space Design Guidelines' should be reviewed. They can be found here:

http://www.landcom.nsw.gov.au/news/publications-and-programs/the-landcom-guidelines.aspx

The department wishes to meet to discuss some amendments to the design in more detail.

4. Foreshore area

The foreshore area, zoned 7(a) Environment Protection should be managed as such to provide a buffer between the proposed development and the Crookhaven River. The foreshore area will act as a filter and also contains sensitive vegetation and Aboriginal heritage.

As mentioned in 'Zoning/ Planning controls' (above), the majority of uses proposed in this area are not permissible uses and the concept plan will need to be revised accordingly.

5. Water Quality/ Water Sensitive Urban Design

The submitted Water Cycle Management Report requires further work. The claim made in the report that a water sensitive urban design (WSUD) treatment system can be implemented to improve water quality from the site post-development does not seem possible given the relatively undisturbed and vegetated state of the site. See the comments from Office of Environment and Heritage (OEH) and Fisheries NSW (Department of Primary Industries (DPI)) for more details.

- The potential impacts on oyster aquaculture within the Crookhaven River estuary must be addressed.
- No WSUD infrastructure will be permitted in the 7(a) zone due to reasons outlined in 'Zoning/ Planning controls' and 'Foreshore area'.
- A long term water monitoring program to be implemented prior to stage 1 is required.

6. Threatened species and Offset strategy

The OEH is satisfied that development is unlikely to have a significant impact on threatened species and their habitats subject to no development or clearing occurring in the foreshore area and a suitable offset area being agreed.

Further details, comments and issues to be addressed are found in both the OEH submission and council's submission. It is acknowledged that the OEH has worked closely with the ecological consultant, SLR to resolve many issues and therefore some of the issues in council's submission (which precedes the comments by OEH) have now been resolved.

The biobanking assessment prepared by Cumberland Ecology on the request of SLR to inform an offset ratio for the development was received by the department on 19 June 2013. The department is seeking its own independent review of the assessment. It is acknowledged the final determination of an offset ratio will be subject to further discussion amongst all parties.

7. Traffic / transport/ access

As detailed in the submissions from the RMS and council, the submitted Transport and Accessibility Impact Assessment requires more work in terms of addressing the impacts of the proposal on the road network from the site to the Princes Highway with particular attention needed for the intersection of the Princes Highway and Kalandar Street. Required infrastructure upgrades will need to be proposed and submitted.

The RMS and council do not support the separate access to the stage 5 industrial area off Culburra Road, for safety reasons. All access to the stage 5 industrial area should be off the proposed roundabout and new collector road.

8. Bushfire

- All APZs and fire trails required for the development must be within the subject site and not encroach 7(a) zoned land or land within the Lake Wollumboola catchment. Some encroachment areas include: the 'leisure hub' showing 40-70m APZ partially in 7(a) land; the 3.4ha medium density site showing a 25m APZ within the catchment; Stage 1 showing the APZ within catchment land; and there appears to be a fire trail off the far western boundary of the site in the adjoining property.
- Any APZ to 55+ housing generally needs to be 70m.
- Council does not support an APZ within the land that contains the sewage treatment plant.
- The plan within the bushfire report shows APZs encroaching some lots, eg the northern industrial lots, the eastern residential lots and the northern road (road is 20m wide but a 25m wide APZ is needed). The subdivision layout will need to be altered or alternatively the development potential of affected lots will need to be demonstrated if they are partially restricted by APZs.

9. Landscaping

The planting of street trees should be consistent with council's 'Town Street Tree Planting Strategy' (ref. POL08/282) which can be found via the link below. An extract forms part of council's submission. Norfolk Island Pines do not form part of council's tree planting strategy.

http://doc.shoalhaven.nsw.gov.au/displaydoc.aspx?record=POL08/282

10. Aboriginal Cultural Heritage

- More work would be required if development were to proceed in the foreshore area as the current assessment did not look at the impacts of development on middens within the 'leisure hub' area.
- Further assessment involving test excavations should be undertaken within the survey area WC15 and a sample of the portions of WC 9 and 14 within the zone of high potential for subsurface deposits of artefacts with 200m of the shoreline.

11. Social/economic justification

The Social Impacts Scoping Study requires further work. The application must justify the residential mix proposed, the need for commercial/ retail uses, the impacts on the existing Culburra Beach commercial area and demand for community and health related uses as a result of the proposal.

12. Other

- Further details need to be provided with regard to the 3.4ha 'medium density site' on the southern side of the collector road. A 20m tower within this area is not supported because the structure and height are inappropriate in the context of the area.
- The heights proposed within stage 1 (4 storeys), stage 2 (3 storeys) and stage 4 (up to 3 storeys within the commercial development) have not been justified in the context of the site's location. The Culburra Beach area predominantly consists of single storey development and anything more than 2 storeys is unlikely to be supported.
- The 'future development zones' within stage 5 and within the area to the east of the industrial estate are not part of the concept plan application and as such should not be annotated on the proposed concept plan map.
- The clearing for vistas proposed in the land east of the industrial estate, in front of stage 2 and any clearing in front of the 'leisure hub' will not be supported due to the clearing not being a permissible use under the 7(a) zoning. The clearing of vegetation for view lines is not considered to be a legitimate reason for the clearing healthy, indigenous vegetation.
- The application must address the staging/ timing of dwelling construction in relation to the provision of electricity infrastructure. The proposal will rely on the Tomerong Transmission Substation to be established and it is programmed to be commissioned by the end of 2014.
- The site will require a 1ha area for a substation. A 0.9ha area is shown in the land to the east of the industrial estate. Endeavour Energy has requested the substation be proposed closer to Culburra Road.
- Odour impacts – Shoalhaven Water has reiterated that no residential allotment should be permitted within the 400m buffer zone of the sewage treatment plant despite the submitted Odour Impact Assessment. Any modification to this requirement will require full consultation/ approval from Shoalhaven Water. The proponent is advised to liaise directly with Shoalhaven Water.

APPENDIX 2

Letter from DPI dated 7/4/2014

NSW | Planning & Infrastructure

Contact: Sally Munk
Email: sally.munk@planning.nsw.gov.au
Phone: 02 9228 6431

Our ref: MP09_0088

Mr John Toon
John Toon Pty Ltd
17 Bunyana Avenue
Wahroonga NSW 2076

Dear Mr Toon

Subject: Mixed Use Subdivision Concept Plan at West Culburra – MP 09_0088

I refer to the Response to Submissions (RtS) report dated October 2013 for the above project. The agency has undertaken a thorough review of the proposed concept plan as outlined in the RtS and has considered eight submissions from government agencies received in response to our referral of this document.

Following this review and a visual inspection of the site on Thursday 3 April 2014, the agency considers that the following key issues must be addressed in a Preferred Project Report (PPR) prior to determination of the concept plan:

1. Environmental Offsets - an environmental offset package is required that is consistent with the requirements of the Office of Environment and Heritage;
2. Subdivision Layout - the subdivision layout should have regard for Council's subdivision code (DCP 100), including more usable public open space, standard shaped lots, improved solar access and a more logical and permeable road layout;
3. Water Quality - water quality information should demonstrate a Neutral or Beneficial Effect (NorBE') on the Crookhaven Estuary, SEPP 14 Wetlands and Lake Wollumboola (please refer to the attached independent review report by WBM BMT for details);
4. Traffic and Access – resolution is required regarding the Culburra Road intersection; appropriate access arrangements must be provided for Stages 1 and 5 including the electricity substation; and further consideration must be given to impacts on the surrounding road network (e.g. safety, pavements, car parking);
5. Bushfire Management – the concept plan should illustrate the extent of all relevant APZs wholly within lot boundaries with appropriate emergency access arrangements for Stages 3 and 4 defined (south-west road connection to Culburra Road);
6. Foreshore Area and Zoning – the Cactus Point Leisure Hub requires further justification, including consideration of zoning/permissibility issues, landowners consent and the location of boat infrastructure and sea-wall revetment works on and adjacent to freehold land;
7. Economic Impacts – consistency with council's DCP 67 with respect to the extent of commercial development in the Culburra Expansion Area should be demonstrated or sufficient justification provided for any inconsistencies.

As discussed with Ms Sally Munk, A/Team Leader, the agency would like to meet with you at 2pm on Wednesday 9 April 2014 to explain and discuss these issues further prior to the preparation of the PPR.

Yours sincerely

7/4/14

Dan Keary
Director
Industry, Key Sites and Social Projects

NSW | Planning & Infrastructure

Contact: Sally Munk
Email: sally.munk@planning.nsw.gov.au
Phone: 02 9228 6431

Our ref: MP09_0088

Mr John Toon
John Toon Pty Ltd
17 Bunyarra Avenue
Wahroonga NSW 2076

Dear Mr Toon

Subject: Mixed Use Subdivision Concept Plan at West Culburra – MP 09_0088

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4. Traffic and Access – resolution is required regarding the Culburra Road intersection; appropriate access arrangements must be provided for Stages 1 and 5 including the electricity substation; and further consideration must be given to impacts on the surrounding road network (e.g. safety, pavements, car parking);
5. Bushfire Management – the concept plan should illustrate the extent of all relevant APZs wholly within lot boundaries with appropriate emergency access arrangements for Stages 3 and 4 defined (south-west road connection to Culburra Road);
6. Foreshore Area and Zoning – the Cactus Point Leisure Hub requires further justification, including consideration of zoning/permissibility issues, landowners consent and the location of boat infrastructure and sea-wall revetment works on and adjacent to freehold land;
7. Economic Impacts – consistency with council's DCP 67 with respect to the extent of commercial development in the Culburra Expansion Area should be demonstrated or sufficient justification provided for any inconsistencies.

As discussed with Ms Sally Munk, A/Team Leader, the agency would like to meet with you at 2pm on Wednesday 9 April 2014 to explain and discuss these issues further prior to the preparation of the PPR.

Yours sincerely

7/4/14

Dan Keary
Director
Industry, Key Sites and Social Projects

APPENDIX 3

Tabulated responses to issues raised by DPI/DPE.

APPENDIX 3

Tabulated Responses to Issues Raised by DPI/DPE

Principle Issue	Elaboration of Issue	Action Taken	Where Located in RT5
1. Zoning/Planning Controls	1.1 Current and proposed zoning.	All proposed land uses consistent with SLEP 1985.	Note: no zoning changes from SLEP 1985 proposed. See Appendix 4. Reported in Sections 2, 3 and 5.
	1.2 Relevant clauses of SLEP 1985 and draft SLEP 2013.	Noted. No action required.	
	1.3 Addressing DCP67 and DCP100 in greater detail.	Mixed use in 'The Circus' deleted; DCP100 to be adopted for road design unless varied by a site specific DCP.	Only major roads shown on plan See also section 8.2.
	1.4 Removal of uses: Stage 1 in 5(a) zone.	Residential uses removed from 5(a) zone; roads (a permitted use) retained for access.	See Concept Plan and Figure 15 for preliminary layout of Stage 1.
	1.5 Works proposed in 7(a) Environmental Protection Zone (car parking, boat ramp, jetty, water sensitive urban design infrastructure, vista cleaning, asset protection zones, recreational open space and infrastructure.	All ancillary works such as bio-swales, children's play areas etc have been removed from the 7(a) Environmental Protection Zone in the Concept Plan. All proposed development below mean high water mark, such as sea-walls, boat ramps and jetties have been removed from the Concept Plan. Only the indicative route of the proposed cycle/walkway is retained (see Section 8.5). The proponent seeks approval for the clearing of the foreshore vegetation (primarily mangroves) for the three vistas. This proposal was conditionally supported by Cumberland Ecology (see section 8.1).	See Concept Plan and Section 8.6.

Principle Issue	Elaboration of Issue	Action Taken	Where Located in RT5
2. Development in Lake Wollumboola catchment – justification for elements of the Concept Plan that are located within the catchment of Lake Wollumboola.	General applying to each encroachment.	Each encroachment reviewed and confirmed.	See Section 2 and Section 9. See also Water Cycle Management Report, Martens, November 2016 and Addendum to that reported dated 9 June 2017 (Appendix 7).
	2.1 Parts of collector road and some residential lots.	Parts of the collector road. Collector Road retained; residential lots deleted adjacent to industrial zone.	See Section 9.1 and Concept Plan.
	2.2 The roundabout.	The roundabout. Retained in its location. Swale added to Wattle Creek.	See Section 9.2, Figure 12 and Addendum to Water Cycle Management Plan (Appendix 7).
	2.3 The oval.	The oval is located on the most suitable site. Oval and associated access and pondage retained. Location endorsed by Council.	See Section 9.3, Concept Plan and Addendum to Water Cycle Management Plan (Appendix 7).
	2.4 Part of the road reserve in the 3.4ha medium density site.	Collector road alignment adjacent to the oval retained.	See Section 9.4 and Concept Plan.
	2.5 The southern part of Stage 1.	Southern part of Stage 1 retained. Detailed site survey enabled area that can be drained by gravity to Culburra Road to be proved up.	See Section 9.5, Concept Plan and Figure 15 for preliminary layout of Stage 1.
	2.6 The south-western part of Stage 5.	South-western part of Stage 5 (the industrial zone) is retained.	See Section 9.6, Concept Plan and Addendum to Water Cycle Management Plan (Appendix 7).
3. Subdivision layout/urban design	3.1 Energy efficiency. 3.2 Permeability. 3.3 East-west oriented lots. 3.4 Useable open space.	All local roads and all indicative residential and industrial subdivisions removed from Concept Plan. Issues no longer relevant in Concept Plan and will be dealt with in Part 4 applications to Council.	See Concept Plan, Stages 1-5; see also Sections 6 and 8.2 of RTS.
4. Foreshore Area	4.1 Buffer zone. 4.2 Proposed uses not permissible.	All the non-permissible uses have been removed.	See 1.5 above.
5. Water Quality/water sensitive urban design (WSUD)	5.1 Potential impacts on oyster leases.	The land-side Water Cycle Management Plan has been re-worked to accord with the peer-reviewers' recommendations. A marine ecology report has been completed	See Water Quality Monitoring Plan, November 2016, Martens and Addendum to that report dated 9 June 2017 (Appendix 7). See also Section 8.3 and Appendix 8)

Principle Issue	Elaboration of Issue	Action Taken	Where Located in RT5
		indicating that the marine ecology (mangroves, sea-grasses and salt marsh eco-systems) in the Crookhaven estuary are in good condition and no adverse impact is considered likely because NorBE is achieved as described in the Addendum.	
	5.2 No WSUD infrastructure in the 7(a) zone.	All WSUD devices now located in the land-side of the 7(a) zone. Following the recent review of the land-side water Cycle Management Plan all WSUD infrastructure has been deleted from the Concept Plan (see Appendix 7).	Section 8.3.
	5.3 Long term water quality monitoring plan.	Monitoring Plan proposed.	See Water Quality Monitoring Plan November 2016, Martens; and Section 8.3 and Section 10.2.
6. Threatened species and offset strategy	6.1 Determination of offset ratio.	See email from Ecology Australia outlining the number of credits required using the biobanking formula and indicating where the required credits will be sourced (see Appendix 6).	Section 8.1 and Appendix 6.
7. Traffic/transport access	7.1 Sub-regional network.	No action was required on the sub-regional network.	
	7.2 Access to the industrial zone.	Access to the industrial zone is still under consideration, being part of an assessment of the performance of Culburra Road from the roundabout to the existing edge of the settlement (Canal Street East).	For current plan see Figure 12.
8. Bushfire	8.1 All APZ's and bushfire trails to be within the subject site and not encroach on the 7(a) zone.	See Figure 14 and Section 8.5. All APZ's are within the site, none encroach on the 7(a) zone.	See Figure 14.

Principle Issue	Elaboration of Issue	Action Taken	Where Located in RT5
	8.2 APZ for 55+ housing.	The 55+ housing estate has been replaced with a small lot subdivision.	See Figure 15 – Stage 1 Residential development and Concept Plan.
	8.3 No APZ on STP site.	There are no APZ's on the STP site.	See Figure 14.
	8.4 APZ's affecting proposed industrial lots.	The industrial zone has been reduced in area with consequent adjustments to the APZ's.	See Concept Plan and Figure 14.
9. Landscaping	9.1 Street tree planting to be consistent with SCC 'Town Street Tree Planting Strategy'.	Noted. Street planting will be determined in co-operation with SCC.	See Concept Plan and Section 8.2 – Local Roads.
10. Aboriginal Cultural Heritage	10.1 Impact of development on middens in the 'leisure hub' area.	Action reviewed.	See Sections 8 and Figure 11.
	10.2 Further assessment of survey areas WC15, WC9 and WC14 within 200m of shoreline.	Action reviewed.	See Section 10.7 and Figure 11.
11. Social/economic justification	11.1 Justification of residential mix proposed.	No further action on residential mix.	See Sections 2 and 3; and Figure 15 for indicative mix of lot sizes.
	11.2 Need for commercial/retail uses.	No commercial or retail uses other than tourist/recreation oriented businesses are proposed.	See Concept Plan for 'Leisure Hub', and Section 3 for employment generation.
	11.3 Demand for community and health related uses.	No proposals for community or health facilities are proposed, other than the cycle/walkways and associated facilities.	See Section 4 and 8.2.
12. Other	12.1 Medium Density site details.	The medium density site has been amended to general residential. The proponent considers that the area zoned Local Centre in SLEP 2014 is well suited to medium density development but residential development is not permitted in the zone.	See Concept Plan and Section 1.
	12.2 Heights of development.	No heights are shown anywhere.	

APPENDIX 4

Summary of relevant zonings in SLEP 1985, Draft SLEP 2009 and SLEP 2014 for each land component of the Concept Plan.

APPENDIX 4

Summary of relevant zonings in SLEP 1985, Draft SLEP 2009 and SLEP 2014 for each land component of the Concept Plan

Description of Land Component of Concept Plan	SLEP 1985	Zoning Draft SLEP 2009	SLEP 2014	Proposed Use in Concept Plan
1. **Area**: 18.1 ha Land north of Culburra Road to HWM between Canal Street East and STP, part Lot 5 and part Lot 6, DP1065111.	3(f) Business (village); 7(a) Environmental Protection.	B2 local centre; foreshore E2 Environmental Conservation.	B2 and E2 as per draft LEP 2009.	Vista Park and associated works; Culburra Road to HWM. No other uses proposed.
2. **Area**: 2.55 ha Land south of Culburra Road extending to Downs Creek, west of retirement village to former tip, part Lot 5 and part Lot 6 DP1065111.	Part 2(c) residentiqal and part 5(a) special uses.	Part E2 and part special uses.	Vacant (planning proposal).	Part residential in 2(c) zone as per SLEP 1985. Access Road is 5(a) zone.
3. **Area**: 10.95 ha Land south of STP and north of Culburra Road, defined by zone boundary at west, part Lot 6 DP1065111.	4(a) Industry (general).	IN 1 General Industry.	Existing industry, vacant (planning proposal).	Part industrial; (including site for sub-station) part woodland and part road access (the Collector Road).
4. **Area**: 84.0 ha Land west of STP extending to western boundary of Portion 61, DP755971, generally north of divide (except oval) extending to Crown reserve (foreshore), part lot 6 DP1065111 and Portion 61 DP755971	2(a) residential; foreshore 7(a) Environmental Protection.	R1 General Residential to high ridge (soouth boundary) then to low ridge at east; foreshore E2.	Foreshore E2 over Lot 6 DP1065111, not over Portion 61 DP755971; vacant (planning proposal).	Residential, sports oval, leisure hub; foreshore retained woodland and associated recreation facillities (outside E2 zone), all in 2(c) residential zone as per SLEP 1985.

APPENDIX 5

Culburra West and Millaben: A Preliminary Biobanking Assessment Report. Cumberland Ecology, September 2014.

CULBURRA WEST & MILLALEN

Preliminary BioBanking Assessment Report

For:

The Halloran Trust

September 2014

Final

PO Box 2474
Carlingford Court 2118

Report No. 14073RP1

The preparation of this report has been in accordance with the brief provided by the Client and has relied upon the data and results collected at or under the times and conditions specified in the report. All findings, conclusions or recommendations contained within the report are based only on the aforementioned circumstances. The report has been prepared for use by the Client and no responsibility for its use by other parties is accepted by Cumberland Ecology.

Revision	Date Issued	Reviewed by	Approved by	Date Approved	Revision Type
1	18/08/2014	DR	DR	18/08/2014	draft

Approved by: David Robertson

Position: Director

Signed: David Robertson

Date: *10 September, 2014*

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Executive Summary

The purpose of this report is to address three residual ecological issues for a proposed residential development that is being assessed as a major project (09_0088 Mixed Use Subdivision West Culburra Concept Plan) under the NSW *Environmental Planning and Assessment Act 1979*. These issues are:

- the suitability of a proposed offset;
- the need for retention of north-south habitat corridors within the proposed development; and
- the ecological impacts of proposed viewing corridors through mangroves and other native vegetation adjacent to the proposed development.

The NSW BioBanking Credit Calculator has been run for both the development site at Culburra West and the proposed offset site at Millalen, Sussex Inlet. The results show that the development site would require to be offset by the purchase of 5,936 credits (if BioBanking were used to determine the offset). The BioBanking assessment of the offset site shows that it provides broadly the correct forms of credits, but that it only supplies about a quarter of the credits required under BioBanking.

We note that as the Culburra Project is being assessed as a Major Project and that as such it does not need to have a BioBanking outcome. We consider the offset to be adequate because of its high quality vegetation and its strategic location, specifically:

- The offset is located directly adjacent to Conjola National Park to the north and west, as well as within close proximity to Corramy Regional Park to the north;
- 90% of the offset boundary is formed by the waters of Tullarwalla Lagoon, St Georges Basin and Wandandian Creek. The area is therefore almost completely protected from disturbance and access by its natural surrounds;
- The total size of the offset is 286.06 ha, while the proposed clearing for development is 87.29 ha, 14.13 of which is cleared introduced grassland which results in an offset ratio of 1:3.2, or 1:3.9 if the grassland is excluded:
- The offset comprises a total of almost 300 hectares of native open forest and woodland in what is assumed to be excellent to good condition, including:
  - 168.33 ha of *Bangalay Sand Forest in the Sydney Basin and South East Corner Bioregions* EEC; and
  - 8.09 ha of *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC;

The proponent intends to create a public foreshore cycling/walking trail and to undertake substantial weed removal and rehabilitation works within the foreshore park, as well as creating three view corridors out into the Crookhaven River, the details of which are discussed in this report.

Chapter 1

Introduction

1.1 Purpose

The purpose of this report is to address three residual ecological issues for a proposed residential development that is being assessed as a major project (09_0088 Mixed Use Subdivision West Culburra Concept Plan) under the NSW *Environmental Planning and Assessment Act 1979*. These issues are:

- the suitability of a proposed offset;
- the need for retention of north-south habitat corridors within the proposed development; and
- the ecological impacts of proposed viewing corridors through mangroves and other native vegetation adjacent to the proposed development.

1.2 Project Background

In September 2013 Cumberland Ecology was commissioned by SLR Consulting Australia Pty Ltd to prepare a preliminary BioBanking assessment for a potential development site in Culburra West (Cumberland Ecology 2013). The proposed development area is approximately 87 ha in size of which 14.13ha is grassland, It is located at Culburra, which is in the Shoalhaven Local Government Area (LGA) and in the Southern Rivers Catchment Management Authority (CMA). The total size of the property is approximately 247 ha (**Figure 1.1**).

The BioBanking assessment was based on a vegetation map and ecological assessment provided by SLR (2013). The results of the preliminary BioBanking assessment determined what type and quantity of BioBanking credits would be needed if the development was to be offset under the NSW BioBanking scheme. This current report includes the unaltered findings from that original assessment.

The Office of Environment and Heritage (OEH) in 2013 issued a media release and published seven new principles for offsets for Major Projects on their website. These seven principles now form the principles of the current Draft Framework of Biodiversity Assessment (FBA) for Major Projects (2014). The principles state that:

- Before offsets are considered, impacts must first be avoided and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts;
- Offset requirements should be based on a reliable and transparent assessment of losses and gains;
- Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities
- Offsets must be additional to other legal requirements;
- Offsets must be enduring, enforceable and auditable;
- Supplementary measures can be used in lieu of offsets;
- Offsets can be discounted where significant social and economic benefits accrue to NSW as a consequence of the proposal.

In summary, NSW offset principles for major projects (OEH 2014) state that unavoidable impacts of a proposed development can be offset, as long as these offsets:

- Aim to result in a net improvement in biodiversity over time;
- Are enduring;
- Are supplementary, i.e. not already managed for conservation; and
- Are enforceable.

A potential offset area chosen by the proponent satisfies necessary criteria as it is in private ownership and is not covered by any existing conservation agreements (**Figure 1.3**). This report provides a preliminary BioBanking assessment for this area in order to ascertain its suitability as an offset.

It is to be noted that the Culburra West Development Project is being assessed as a Major Project and that as such it does not need to have a BioBanking outcome. The assessment of both, the development and offset sites, under the NSW BioBanking scheme (OEH 2012) is therefore indicative only.

This report is a desktop assessment and is based on third party information. No staff member of Cumberland Ecology has visited the proposed offset or development area.

1.3 OEH comments

A letter from OEH (OEH 2013), which was written in response to the Concept Plan for this project, dated 21/06/2013 states that:

"The EA required the need for a local corridor to be identified linking the site to areas in both the North and South of the site in the Director Generals Requirements and in the South Coast Regional Strategy recommendation. OEH considers that while it is imperative to maintain the foreshore buffer for a range of environmental and cultural heritage reason, this may not necessarily provide a functional local corridor as vegetation in the surrounding local area is likely to be cleared in the future. Rather, it is critical for the potential offset options to provide enhanced connectivity at the landscape or regional scale."

The north-south corridor issue is further discussed in **Section 5.3** of this report.

1.4 BioBanking

The Biodiversity Banking and Offsets Scheme endeavours to address the loss of biodiversity in NSW by enabling landowners in NSW to establish BioBanking sites to secure conservation outcomes and offset impacts on biodiversity values. The landowners create BioBanking credits by committing to improve and/or increase the habitat of threatened species and ecological communities. Developers can buy the credits to offset impacts from their development. They will need to source particular types of credits in accordance with the offset rules in the BioBanking Assessment Methodology and Credit Calculator Operational Manual (DECC 2009):

- Ecosystem credits can only be used to offset biodiversity impacts in the same ecological community, or in another community of the same formation that has an equal or greater percentage of land cleared and the same predicted threatened species; and
- Species credits can only be used to offset biodiversity impacts on the same threatened species.

The BioBanking offsetting rules are more stringent than the NSW or federal requirements for offsets, as they are based on scientific data and detailed survey techniques. The strict like-for-like rules might not always be applicable in reality. While an offset might not achieve all the requirements under the BioBanking rules, it cannot be automatically rejected, as it might form an important and valuable contribution to biodiversity conservation. The NSW Government has recognized this and the BioBanking scheme is currently under review. The new Framework for Biodiversity Assessment (FBA) is in draft form and available for public comment (OEH 2014). Under the FBA, monetary contributions can be deposited into the NSW Biodiversity Offset Fund, rather than each developer having to source his own offsets. The new scheme will include a policy document and a new calculator tool.

1.5 Proposed Development Site – Culburra West

The proposed development area is approximately 87 ha in size, located at Culburra and comprises part of DP 1065111, Lot 2 of DP 1182151 and portions 61, 81 & 90 of DP 755971. It forms part of a larger property, which is approximately 247 ha (**Figure 1.1**).

The ecology of the site has been extensively researched by SLR Consulting Australia Pty Ltd (SLR 2013). The following documents have been used for this report:

- "Ecological & Riparian Issues & Assessment Report for Culburra West Urban Development Project, Culburra Beach", by SLR, dated 2013; and
- "Sketch Plan showing site constraints & proposed subdivisions over part of DP 1065111, Lot 2 DP 1182151 and portions 61, 81 & 90 DP 755971 at West Culburra for Realty Realizations", by allen, price & associates, dated September 2013.

The proposed development is considered a Part 3A project and the land is zoned for urban development in the relevant planning instrument (Shoalhaven LEP 1985).

The vegetation of the proposed development site has been assessed, described and mapped by SLR (**Figure 1.2**) and has not been ground-truthed by Cumberland Ecology staff.

The vegetation communities as described by SLR were related to the closest corresponding Biobanking Vegetation Types (BVTs). It should be noted that BVTs consist of broad definitions of vegetation communities and can encompass several 'variant' communities, some which may be classified as Endangered Ecological Communities (EECs) under the TSC Act. Therefore some non-listed vegetation communities may be treated as EECs under the Biobanking Scheme due to the broad-nature of BVTs

Based on the BVT definitions, the following vegetation communities will be cleared for the proposed development, three of which are an Endangered Ecological Community (EEC):

- Bangalay Woodland/Open Forest (2.24 ha), forming part of the *Bangalay Sand Forest in the Sydney Basin and South East Corner Bioregions* EEC;
- Swamp Oak Closed Forest (0.49 ha), forming part of the Swamp oak floodplain forest of the *NSW North Coast, Sydney Basin and South East Corner* EEC;
- Bangalay/Woolybutt/Rough-barked Apple Open Forest (0.39 ha), forming part of the *Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC;
- Blackbutt Open Forest (36.35 ha);
- Forest Red Gum Open Forest (0.26 ha);
- Black She-oak Closed Forest (9.02 ha);
- Grey Ironbark/Rough-barked Apple Open Forest (0.44 ha);
- Hard-leaved Scribbly Gum Woodland (23.97 ha); and
- Pasture/grassland (14.13 ha).

1.6 Proposed Offset Site - Millalen

The proposed offset is directly adjacent to Conjola National Park and surrounded by the waters of the St Georges Basin and Tullarwalla Lagoon (**Figure 1.3**). It comprises Lot 8 in DP 755937 and part of Lot 1 in DP 1174562. It is called Millalen, is almost 300 ha in size and is located on and adjacent to the Tullarwalla Peninsula.

The following document has been used in preparation of this report:

- "Plan showing Masterplan over Lot 52 DP 1033684 & Lot 2 DP 1094024 at Sussex Inlet Road, Sussex Inlet for Realty Realizations Pty Ltd", by allen, price & associates, dated 8th October 2013.

The vegetation communities on the proposed offset site have not been assessed on-ground. This preliminary assessment is based on a vegetation map by OEH (2010) (**Figure 1.4**) and the corresponding BVTs to these vegetation communities. The vegetation communities within the offset, based on the BVT definitions are listed below, two of which are EECs:

- Coastal Sand Forest (168.33 ha), forming part of the *Bangalay Sand Forest in the Sydney Basin and South East Corner Bioregions* EEC;
- Floodplain Swamp Forest EEC (8.09 ha), forming part of the *Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC;
- Morton Mallee-Heath (4.98 ha);
- Illawarra Gully Wet Forest (1.9 ha);
- Currambene-Batemans Lowlands Forest (73.38 ha); and
- Southern Turpentine Forest (29.38 ha).

Coordinate System: MGA Zone 56 (GDA 94)

Legend

- Development Boundary
- Property Boundary

BioBanking Assessment Circles

- 1000 ha Circle
- 100 ha Circle

Native Woody Vegetation

N
Grid North

Image Source:
Image © 2013 TerraMetrics
Image © 2013 DigitalGlobe

CUMBERLAND ECOLOGY

I:\...\14073\Figures\Figure 1.1 Development Locality 20140813

Figure 1.1 Culburra West Preliminary BioBanking - Locality of Development Site

0.5 0 0.5 1 1.5 2 km

Coordinate System: MGA Zone 56 (GDA 94)

Legend

- Development Boundary
- Viewing Corridor

Vegetation Community (Development Area)

- Bangalay Woodland/Open Forest (SR512) (Bangalay Sand Forest EEC)
- Bangalay/Woolybutt/Rough-barked Apple Open Forest (SR648) (Swamp Sclerophyll Forest EEC)
- Swamp Oak Closed Forest (SR649) (Swamp Oak Floodplain Forest EEC)
- Blackbutt Open Forest (SR516)
- Forest Red Gum Open Forest (SR544)
- Grey Ironbark/Rough-barked Apple Open Forest (SR592)
- Black She-oak Closed Forest (SR592)
- Hard-leaved Scribbly Gum Woodland (SR592)
- Cleared (Paddock)
- Cleared (Road)

Vegetation Community (Viewing Corridors)

- Swamp Oak Closed Forest (SR649) (Swamp Oak Closed Forest EEC)
- Black She-oak Closed Forest (SR592)
- Blackbutt Open Forest (SR516)
- Swamp Oak/Bangalay/Woolybutt Forest
- Mangrove Forest
- Cleared (Paddock)

N
Grid North

Image Source:
Image © 2013 DigitalGlobe

Data Source:
SLR 2013,
Ecological & Riparian Issues &
Assessment Report for Culburra
West Urban Development Project,
Culburra Beach

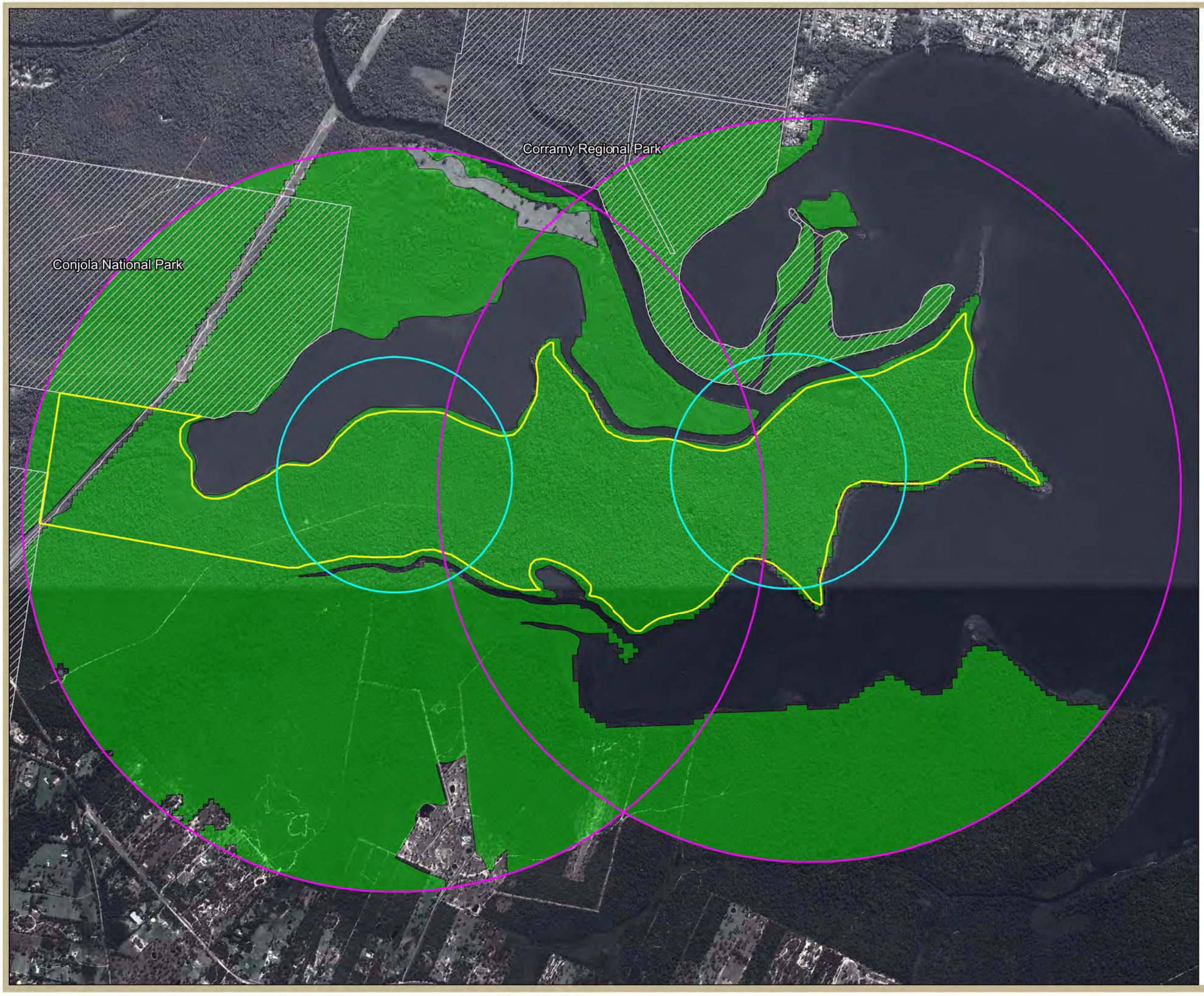
CUMBERLAND ECOLOGY

I:\...\14073\Figures\Figure 1.2 Vegetation Development 20140813

Figure 1.2 Culburra West Preliminary BioBanking - Vegetation on Development Site

200 0 200 400 600 800 m

Coordinate System: MGA Zone 56 (GDA 94)



Legend

- Offset Boundary
- NSW National Park Estate
- Native Woody Vegetation

BioBanking Assessment Circles

- 1000 ha Circle
- 100 ha Circle

N
Grid North

Image Source:
Image © 2013 TerraMetrics
Image © 2013 DigitalGlobe

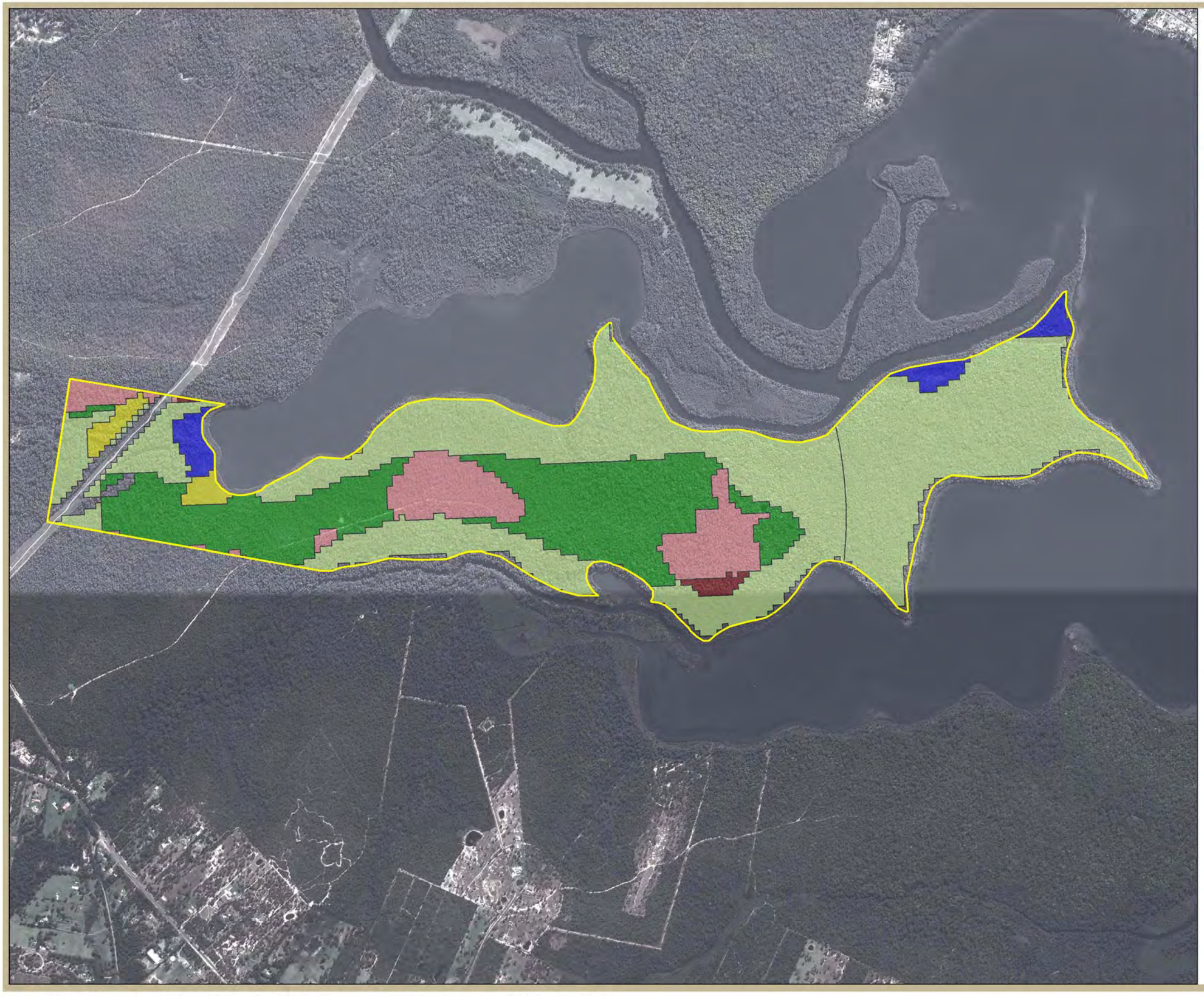
CUMBERLAND ECOLOGY

I:\...\14073\Figures\Figure 1.3 Offset Locality 20140813

Figure 1.3 Millalen Preliminary BioBanking - Locality of Offset Site

0.5 0 0.5 1 1.5 2 km

Coordinate System: MGA Zone 56 (GDA 94)



Legend

Offset Boundary

Vegetation Community

- Floodplain Swamp Forest (SR649) (Swamp Oak Floodplain Forest EEC)
- Coastal Sand Forest (SR512) (Bangalay Sand Forest EEC)
- Morton Mallee-Heath (SR513)
- Illawarra Gully Wet Forest (SR516)
- Currambene-Batemans Lowlands Forest (SR592)
- Southern Turpentine Forest (SR658)

N

Grid North

Image Source:
Image © 2013 TerraMetrics
Image © 2013 DigitalGlobe

Data Source:
SCIVI OEH 2011
(Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. Version 1.0)

CUMBERLAND ECOLOGY

I:\...\14073\Figures\Figure 1.4 Offset Vegetation 20140813

Figure 1.4 Millalen Preliminary BioBanking - Vegetation on Offset Site

0.25 0 0.25 0.5 0.75 1 km

Chapter 2

Methodology

2.1 BioBanking

The BioBanking assessment methodology is outlined in the BioBanking Assessment Methodology and Credit Calculator Operational Manual (DECC 2009) and the Draft Operational Manual for using the BioBanking Credit Calculator v2.0 (OEH 2012). The Calculator Tool used was Version 2.0. The BioBanking Credit Calculator is a computer software program that calculates "biodiversity credits", which are effectively the units of BioBanking transactions.

Biodiversity credits are ecosystem or species credits required to offset the loss of biodiversity values on development sites. It is important to understand that such credits are not directly equivalent to areas in hectares and the credits generated for an area of impact will vary based upon the vegetation types present, the patch size of each vegetation type, threatened species present or likely to occur and the connectivity of vegetation.

Most threatened species are included in ecosystem credit calculations. However, for threatened plants and for a limited number of threatened fauna, BioBanking calculates what is known as species credits. Species credits are created for threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. For flora species the actual number of individual plant specimens is entered into the calculator, while for fauna species the size of potential habitat within the site is estimated, which usually consists of the total area of vegetation communities known to provide habitat for the species in question.

The BioBanking methodology must be applied separately for proposed development sites and for proposed offset sites. The methodology can be divided into three distinct phases:

1. Preliminary Assessment;
2. Field Data Collection; and
3. Generating Credit Profile.

The attached BioBanking assessments are preliminary assessments for the development and offset areas. Cumberland Ecology has not undertaken any survey work for this assessment. The required vegetation plot data is based on BioBanking benchmark values.

2.2 Vegetation Communities

Ecological communities are used in the methodology as a surrogate for general biodiversity values. They are referred to as Vegetation Types. The names used for vegetation types in a BioBanking Assessment are selected from a database within the Credit Calculator itself. The names available differ to some extent from those used in the existing vegetation maps for the sites and also from names used for Commonwealth and State endangered ecological communities (EECs). The selection of vegetation types influences the outcome of the assessment because different vegetation types produce different credit calculations, due to some plant communities supporting more threatened flora/fauna species than others. The vegetation type selected for BioBanking purposes should be the original vegetation type assumed to have originally occurred at the site.

Vegetation community nomenclature can vary depending on the scale and origin of the mapping and it is common for the same vegetation community to be known by several different names. The vegetation communities as described by SLR were related to the closest corresponding BioMetric Vegetation Types (BVTs).

BVTs consist of broad definitions of vegetation communities and can encompass several 'variant' communities, some which may be classified as Endangered Ecological Communities (EECs) under the TSC Act. Therefore some non-listed vegetation communities may be treated as EECs under the Biobanking Scheme due to the broad-nature of BVTs.

As some of the vegetation communities as described by SLR correspond to BVTs that encompass 'variants' that are listed as EECs, these communities have been classified as EECs for the purpose of Biobanking.

Table 4.1 shows the nomenclature used for plant communities, as well as the codes used by SLR and the BVT codes (BVT). The BioBanking reports can be found in **Appendices A and B**.

Chapter 3

Assumptions and Limitations

Although BioBanking methodology is systematic, there is also considerable scope for "professional judgment" to be applied; meaning different operators may arrive at differing credit calculations. Thus, a number of assumptions have been made throughout the assessment process.

The following assumptions are made with respect to the development site assessment:

- The vegetation mapping provided by SLR (SLR 2013) has not been "ground-truthed" by Cumberland Ecology and is assumed to be correct. Any change in vegetation type and area size of each patch will influence the type and number of credits necessary to offset the development;
- The GIS files provided by SLR (SLR 2013) contradict some of the Figures provided by SLR. For the purpose of this assessment it is assumed that the published Figures are correct;
- While some on-ground flora plot surveys were undertaken by SLR (SLR 2013) the BioBanking calculator requires very specific BioBanking plot data with additional information. The existing plot data could therefore not be used for the Biobanking assessment and benchmark values were assumed. Once further field surveys have been conducted these values can be adjusted in the calculator;
- It is assumed that the three patches of land cleared for grazing (14.13 ha) originally formed part of the most common vegetation community on site, i.e. Blackbutt Open Forest (Figure 1.2). The fourth cleared patch (0.06 ha) forms part of the road to the Culburra Sewerage Treatment Plant and has been excluded from this assessment;
- According to the Ecological Assessment Report by SLR (SLR 2013) the cleared areas are "improved pasture dominated by introduced grass species". For vegetation to be in low condition under the BioBanking methodology it has to satisfy the following criteria:
    - The native over-storey percent foliage cover has to be less than 25% of the lower value of the benchmark for this vegetation type; and
    - Less than 50% of the ground-cover has to be native or more than 90% of the ground-cover has to be cleared;

- The cleared areas are therefore assumed to be in low condition. The following benchmark values for these areas have been reduced to zero: native over-storey cover, native mid-storey cover, native ground cover (shrubs), number of trees with hollows, over-storey regeneration and total length of fallen logs. The percent foliage cover for weeds is assumed to be 50%, which is an environmentally conservative figure, given that the pasture is "dominated by introduced species";

- The condition of the remaining vegetation on the site and within the 1,000 ha circle around the site was assumed to be in moderate to good condition. It is possible that some additional patches of vegetation within the site are in low condition. These values can be adjusted in the calculator once additional field surveys have been conducted and the condition of the vegetation has been confirmed;

- No threatened flora species were found on site during the surveys conducted by SLR (SLR 2013). Some of the threatened fauna species found during these surveys are included in ecosystem credits and some produced species credits as outlined in Section 4.2. If further surveys provide evidence of additional threatened flora and fauna species occurring on the development site, species credits might need to be calculated for those new species; and

- It has been assumed that the whole area within the site will be cleared for the proposed development. If some areas within the site could be retained, i.e. would not be impacted by the development, the number of credits generated for the affected vegetation communities may change.

The following assumptions are made with respect to the proposed offset site:

- The vegetation on the offset site has not been surveyed at this preliminary stage. The availability of vegetation mapping for this area is limited. OEH produced a map in 2011 called “The native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. Version 1.0”, which was used for this assessment. The resolution of the GIS layer is low and the boundaries therefore appear pixellated (Figure 1.4). The vegetation communities have not been “ground-truthed” by Cumberland Ecology. Any change in vegetation type and area size of each patch, once the area has been surveyed, will influence the type and number of credits produced;

- No on-ground flora plot surveys have been undertaken and benchmark values were assumed for the Biobanking assessment. Once further field surveys have been conducted these values can be adjusted in the calculator;

- The condition of the vegetation on the site and within the 1,000 ha circle around the site was assumed to be in moderate to good condition; and

- No surveys for threatened flora and fauna species have been conducted and no species credits have been generated by this assessment.

Chapter 4

Key Findings

4.1 Ecosystem Credits

Assuming the entire development site will be cleared, a total of **5,936** ecosystem credits would be required to offset the development. An estimated **1,576** ecosystem credits are generated by the proposed offset site, which is **26.6%** of the required credits if the subject site were to be formally required to undergo BioBanking.

The **Swamp Oak Floodplain Forest EEC** has been 95% cleared within the catchment. It is represented in the offset, as well as the development site and 146.9% of the required ecosystem credits are achieved. The size of this community within the development is 0.49 ha, while the offset contains 8.09 ha, which results in an offset ratio of almost 1:17.

The offset area contains 168.33 ha of the **Bangalay Sand Forest EEC**, which has been 50% cleared within the catchment. The proposed development removes 2.24 ha of this community. Therefore, the offset ratio is 1:75 and under the BioBanking scheme, 520% of the required ecosystem credits are achieved.

The **Swamp Sclerophyll Forest EEC** is not represented within the offset area, while 0.39 ha are proposed to be removed within the development area (SR648 in **Figure 1.2**). If possible, it should be considered to exclude this vegetation community from the development footprint.

While the Forest Red Gum vegetation community is not listed as an EEC, it has been 90% cleared within the catchment. This triggers a “red flag” under the BioBanking methodology. The area of Forest Red Gum is in Stage 1 of the proposal: initial detailed design studies indicate this area being retained as open space within the residential development.

Table 4.1 summarises the areas and ecosystem credits for each vegetation community on the proposed development site as well as the offset site.

4.2 Species Credits

The following threatened fauna species were found on the development site or directly adjacent to the site by SLR (SLR 2013):

- Square-tailed Kite *(Lophoictinia isura);*
- Glossy Black Cockatoo *(Calyptorhynchus lathami);*

- Powerful Owl *(Ninox strenua);*
- East-coast Freetail Bat *(Mormopterus norfolkensis);*
- Common Bent-wing Bat *(Miniopterous schreibersii);*
- Eastern Falsistrelle *(Falsistrellus tasmaniensis);*
- Greater Broad-nosed Bat *(Scoteanax rueppellii);*
- Yellow-bellied Sheath-tail Bat *(Saccolaimus flaviventris);* and
- Grey-headed Flying-fox *(Pteropus poliocephalus)*.

Species credits are generated for two of these fauna species only, the Square-tailed Kite and the Grey-headed Flying-fox. All other surveyed threatened species are included in ecosystem credits by the BioBanking calculator. The species credits created by these two species are:

- **1,180 species credits** for the Square-tailed Kite *(Lophoictinia isura)*; and
- **939 species credits** for the Grey-headed Flying-fox *(Pteropus poliocephalus).*

No other threatened flora or fauna species that might generate species credits are assumed to occur on the development site at this stage.

Since the offset site has not been surveyed, no species credits have been generated by the BioBanking calculator. The proposed offset site seems to be little disturbed, in close proximity of national parks and forest reserved and in good condition. For these reasons, it has been assumed that the same or more threatened species occupy the same vegetation communities as in the development area.

Table 4.1 Ecosystem Credits for Development and Offset per Vegetation Community

Vegetation Community	SLR Code *	BVT **	Area ha (Impact)	Area ha (Offset)	Credits Required (Impact)	Credits Generated (Offset)	% Credits Achieved
Bangalay - Old Man Banksia open forest on coastal sands, Sydney Basin and South East Corner (**Bangalay Sand Forest EEC**)	D2	SR512	2.24	168.33	178	926	520.22%
Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin		SR513		4.98		27	N/A
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	D3	SR516	50.48	1.9	3024	10	0.33%
Forest Red Gum - Rough-barked Apple - White Stringybark grassy woodlands on hills in dry valleys, southern South East Corner	D5	SR544	0.26		21		0.00%
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	D1, D6 & D8	SR592	33.43	73.38	2654	404	15.22%
Swamp Mahogany swamp sclerophyll forest on coastal lowlands, Sydney Basin and South East Corner (**Swamp Sclerophyll Forest EEC**)	D4	SR648	0.39		27		0.00%
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner (**Swamp Oak Floodplain Forest EEC**)	SOF	SR649	0.49	8.09	32	47	146.88%
Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner		SR658		29.38		162	N/A
TOTAL			**87.29**	**286.06**	**5936**	**1576**	**26.55%**

* Vegetation Code used by SLR (2013)

** BioBanking Vegetation Type (OEH 2012)

Chapter 5

Discussion

5.1 Suitability of Offset

The proposed offset has a number of desirable environmental features that include the following points:

- **Location and connectivity of the offset:**

The offset is located directly adjacent to Conjola National Park to the north and west, as well as within close proximity to Corramy Regional Park to the north. Ninety percent of the offset boundary is formed by the waters of Tullarwalla Lagoon, St Georges Basin and Wandandian Creek. The area is therefore almost completely protected from disturbance and access by its natural surrounds (**Figure 1.3**). The offset will assure conservation in perpetuity of Tullarwalla Lagoon and the St Georges Basin foreshore by protecting a substantial area of foreshore and the southern shoreline of the lagoon. Additionally, the offset land will enhance connectivity between existing natural habitat, such as the adjacent Conjola National Park and other reserves and parks.

- **Area size and high ecological value of vegetation:**

The offset comprises a total of almost 300 hectares of native open forest and woodland in what is assumed to be excellent to good condition, including:

- 168.33 ha of *Bangalay Sand Forest in the Sydney Basin and South East Corner Bioregions* EEC;
- 8.09 ha of *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC;
- Fringing coastal saltmarsh and mangroves; and
- It is noted that these EEC's are of higher ecological value than the Red Gum Forest which is not an EEC, yielding a net environmental benefit.

- **Like-for-like development/offset:**

The offset is located within the area of the same catchment authority as the proposed development and contains similar vegetation communities. It can therefore be assumed that the offset provides habitat to same suite of threatened flora and fauna species as the development site. The total size of the offset is 286.06 ha, while the proposed clearing for development is 87.29 ha, of which 14.13 is cleared grassland. This results in an offset ratio

of 1:3.2. The offset can be dedicated to the OEH immediately on provision of approval for the Culburra West Concept Plan.

5.2 Environmental Benefits of Proposed Concept

The following components of the Concept Plan (09-0088) are environmentally beneficial:

- **Crookhaven River Foreshore Park**:

An additional 20.14 ha of private open forest and woodland, between the Crookhaven River and the Culburra West Development will be rehabilitated and dedicated to be the Crookhaven River Foreshore Park. All of this land is to be dedicated for biodiversity conservation purposes with some limited and carefully designed and constructed boardwalks and paths, educational signage and 'look outs'. Another 4.34 ha of existing mostly cleared grassland at the western end of the Crookhaven River Foreshore Park will be dedicated in part for community recreation purposes (open grassy space, paths, picnic tables, barbecues etc.) and in part for biodiversity conservation.

- **Maintenance and Protection of Aboriginal Heritage:**

The culturally significant middens along the Crookhaven River Foreshore will be maintained and protected. Additionally, educational material within the Crookhaven River Foreshore Park with respect both to ecological values and Aboriginal heritage will be provided.

- **Improvement of Fauna Habitat**

Tree-hollows will be salvaged where applicable and re-used, as well as the provision of artificial nest boxes at a ratio of 2 replacements for each hollow lost. New habitat and resources for aquatic biota will be created within the detention basins and bio-retention swales within the development site (on the southern side of the Crookhaven River Foreshore Park).

5.3 Biodiversity Corridor Link (North-South)

As confirmed in a letter by OEH (OEH 2013), the establishment of a north-south Biodiversity Corridor, the location of which has not been specified, has been considered, but is deemed unnecessary.

The following fauna groups have been recorded within or adjacent to the proposed development area by SLR (2013), as listed in Appendix L of the assessment report:

- Aquatic and estuarine birds;
- Raptors and parrots;
- Forest Birds, including nocturnal ones;
- Woodland birds;
- Possums and gliders;

- Kangaroos and wallabies;
- Small mammals (e.g. bandicoot, antechinus);
- Microchiropteran bats;
- Frogs; and
- Skinks, snakes and lizards.

None of these fauna groups are likely to travel between the water of the estuarine habitat and the inland woodland/forest habitats. The water in the estuary is brackish and there is no evidence of any fauna species drinking the water. Aquatic and estuarine birds are unlikely to leave their aquatic habitat to venture inland and the species within the forest/woodland habitat have no reason to access saltwater. Additionally, local fauna would be likely to be able to find adequate alternate means of dispersing around the subject land. There seems to be no ecological benefit of creating a north-south fauna corridor, since such a corridor would connect two entirely different habitats. We believe that there is little ecological benefit to be gained from provision of such a link.

5.4 Viewing Corridors

The proponent is considering the creation and maintenance of three viewing corridors (**Figure 1.2**), which are effectively gaps through the mangroves and other riparian vegetation to afford a view of the water. The intention is that vegetation above 50cm height be cleared for a width of 50m in the case of the two westerly corridors and 70-80m in the case of the corridor to the east. The object of these vistas is to heighten the awareness of Culburra being a place surrounded by water. These corridors would also provide managed access to the Crookhaven River for the public via a proposed continuous foreshore cycle/walkway, which will be commenced at Canal Street East and continue to Cactus Point, just west of Billys Island. At a later stage it is proposed this cycle/walkway will be extended westwards to the extremity of the proponents land.

The vegetation that would be impacted by the three viewing corridors outside the development footprint is a total of 3.5 ha and comprises (**Figure 1.2**):

- 0.17 ha of Blackbutt Open Forest (SR516);
- 2.31 ha of Black She-oak Closed Forest (SR592);
- 0.38 ha of Swamp Oak Closed Forest EEC (SR649);
- 0.54 ha of Swamp Oak/Bangalay/Woolybutt Forest;
- 0.12 ha of Mangrove Forest; and
- 0.24 ha of pasture/cleared land.

We recommend that the mangrove vegetation within the viewing corridors be carefully reduced and that the lower lying areas be managed to promote the growth of shrubs and groundcover plants that are part of the *Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC.

Coastal Saltmarsh occurs at the highest portions of the intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. It is frequently found as a zone on the landward side of mangrove stands. Characteristic plants include *Baumea juncea*, Sea Rush (*Juncus krausii subsp. australiensis*), Samphire (*Sarcocornia quinqueflora subsp. quinqueflora*), Marine Couch (*Sporobolus virginicus*), Streaked Arrowgrass (*Triglochin striata*), Knobby Club-rush (*Ficinia nodosa*), Creeping Brookweed (*Samolus repens*), Swamp Weed (*Selliera radicans*), Seablite (*Suaeda australis*) and Prickly Couch (*Zoysia macrantha*). Occasionally mangroves are scattered through the saltmarsh. Note that the species in bold are typically already present in mangrove forests in NSW and would not need to be introduced.

It is important to note that SLR (2013) surveyed over 40 ha of Mangrove Forest along the foreshore, of which only 0.12 ha will be modified, which is 0.3%.

The remaining vegetation within the viewing corridors could be managed as a low shrubby version of the original vegetation community, which would entail removal of the canopy stratum only.

These viewing corridors are unlikely to have any ecological impact for the following reasons:

- Rather than removing the mangrove forest, it will be managed as a more open habitat, Coastal Saltmarsh EEC, which increases the ecological value of the habitat;
- The majority of mangroves (i.e. 99.7%) in the study area would be conserved and would be maintained in perpetuity.

Provided that other areas of vegetation are to be retained intact along the river frontage, we believe that there would be limited and manageable ecological impacts.

Chapter 6

Conclusion

We consider the proposed biodiversity offset to be adequate because of its high quality vegetation and its strategic location. The conservation of Millalen and its potential addition to the adjacent Conjola National Park would result in a positive net environmental outcome. The size of the EECs to be protected within the offset is significantly larger than the relatively small patches of these EECs proposed to be cleared for the development. The remaining vegetation to be cleared is still well represented within the catchment.

Although under the BioBanking scheme, however, only 26.6% of the ecosystem credits required under the biobanking scheme are provided by the proposed Millallen offset area, that offset area is substantially larger, by a factor of 4, than the proposed area of native forest to be removed for the development. In addition the offset area is only part of the total package proposed. The total package includes a range of additional offsets for the required removal of native forest from the development site. These additional offsets are consistent with the Draft FBA offset principles for Major Projects which allow for reduced offsetting requirements in proportion to the economic benefits of the proposed development.

The ecological benefit of the north-south corridor recommended by OEH is not transparent and thus deemed unnecessary.

We consider the proposed viewing corridors to have minimal environmental impact if they are managed as discussed within this report.

References

Cumberland Ecology (2013). Preliminary BioBanking Assessment for Culburra West.

DECC (2009). BioBanking Assessment Methodology and Credit Calculator Operational Manual. Hurstville, NSW, Department of Environment and Climate Change.

OEH (2010). SCIVI (Native vegetation of southeast NSW: a revised classifiction and map for the coast and eastern tablelands).

OEH (2012). Draft BioBanking Assessment Methodology. Hurstville, NSW, Office of Environment and Heritage.

OEH (2012). Draft Biobanking Credit Calculator v2.0 Operational Manual. Hurstville, NSW, Office of Environment and Heritage.

OEH (2012). "Vegetation Types Database." Retrieved 3/7/13, 2013, from http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm.

OEH (2013). Exhibition of Environmental Assessment for Concept Plan Approval - Mixed Use Subdivision, West Culburra (MP09_0088).

OEH (2014). Draft Framework for Biodiversity Assessment - NSW Biodiversity Offsets Policy for Major Projects, Office of Environment and Heritage.

SLR (2013). "Ecological & Riparian Issues & Assessment Report for Culburra West Urban Development Project, Culburra Beach."

Appendix A

Development BioBanking Credit Report

BioBanking Credit Calculator

BioBanking credit report

This report identifies the number and type of credits required at a DEVELOPMENT SITE.

Date of report: 14/05/2013 Time: 10:47:45AM Tool version: 2.0

Development details

Proposal ID:	0057/2013/0670D
Proposal name:	13046 - Development
Proposal address:	1 Mountain Street Epping NSW 2121
Proponent name:	Cumberland Ecology
Proponent address:	1 Mountain Street Epping NSW 2121
Proponent phone:	(02) 9868 1933
Assessor name:	David Robertson
Assessor address:	PO BOX 2474 Carlingford Court NSW 2118
Assessor phone:	9868 1933
Assessor accreditation:	0057

Improving or maintaining biodiversity

An application for a red flag determination is required for the following red flag areas

Red flag	Reason
Forest Red Gum - Rough-barked Apple - White Stringybark grassy woodlands on hills in dry valleys, southern South East Corner	Vegetation type being > 70% cleared; or it contains an endangered ecological community;
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Vegetation type being > 70% cleared; or it contains an endangered ecological community;

The application for a red flag determination should address the criteria set out in the BioBanking Assessment Methodology. Please note that a biobanking statement cannot be issued unless the determination is approved.

Additional information required for approval:

- ☐ Change to percent cleared for a vegetation type/s
- ☐ Use of local benchmark
- ☐ Change negligible loss
- ☐ Expert report
- ☐ Predicted threatened species not on site
- ☐ Change threatened species response to gain (Tg value)

Ecosystem credits summary

Vegetation type	Area (ha)	Credits required	Red flag
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	2.24	178	No
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	14.13	138	No
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	36.35	2,886	No
Forest Red Gum - Rough-barked Apple - White Stringybark grassy woodlands on hills in dry valleys, southern South East Corner	0.26	21	Yes
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	33.43	2,654	No
Swamp Mahogany swamp sclerophyll forest on coastal lowlands, Sydney Basin and South East Corner	0.39	27	No
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	0.49	32	Yes
Total	87.29	5,936	

Credit profiles

1. Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin, (SR592)

Number of ecosystem credits required	2,654
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	Offset options - CMA sub-regions
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin, (SR592)	Jervis Richmond - Tweed (Qld - Scenic Rim) (Part A) Macleay Hastings - Northern Rivers Coffs Coast & Escarpment Bateman Illawarra South East Coastal Ranges (Part C)

2. Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin, (SR516)

Number of ecosystem credits required	138
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	

Offset options - vegetation types	Offset options - CMA sub-regions
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin, (SR516) Brown Barrel - Mountain Grey Gum tall moist forest on basalts of the Southern Highlands, Sydney Basin, (SR526) Sydney Peppermint - White Stringybark moist shrubby forest on elevated ridges, Sydney Basin, (SR655)	East Gippsland Lowlands (Part A) East Gippsland Lowlands (Part B) South East Coastal Ranges (Part A) South East Coastal Ranges (Part B) East Gippsland Lowlands (Part C) Burragorang Moss Vale - Southern Rivers Ettrema Jervis Bungonia - Southern Rivers Bateman Illawarra New South Wales Alps - Southern Rivers Kybeyan - Gourock (Part A) Kybeyan - Gourock (Part B) South East Coastal Ranges (Part C) Monaro (Part A) Monaro (Part B) Monaro (Part C) South East Coastal Plains Southern Rivers - marine zone

3. Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin, (SR516)

Number of ecosystem credits required	2,886
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	Offset options - CMA sub-regions

Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin, (SR516) Blackbutt - Pink Bloodwood shrubby open forest of the coastal lowlands of the North Coast, (HU508) Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast, (HU543) Sydney Blue Gum open forest on coastal foothills and escarpment of the North Coast, (HU640) Spotted Gum - Grey Ironbark shrubby open forest of the Richmond Range of the North Coast, (NR248)	Jervis Clarence Lowlands Richmond - Tweed (Qld - Scenic Rim) (Part A) Washpool Yengo - Hunter/Central Rivers Wyong Macleay Hastings - Hunter/Central Rivers Macleay Hastings - Northern Rivers Upper Manning Comboyne Plateau - Northern Rivers Dalmorton Chaelundi Coffs Coast & Escarpment Clarence Sandstones Rocky River Gorge Cataract Ettrema Bateman Illawarra South East Coastal Ranges (Part C) Upper Hunter Woodenbong Stanthorpe Plateau

4. Forest Red Gum - Rough-barked Apple - White Stringybark grassy woodlands on hills in dry valleys, southern South East Corner, (SR544)

Number of ecosystem credits required	21
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	**Offset options - CMA sub-regions**
Forest Red Gum - Rough-barked Apple - White Stringybark grassy woodlands on hills in dry valleys, southern South East Corner, (SR544) Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner, (SR669)	Jervis Clarence Lowlands Wyong

	Walcha Plateau - Northern Rivers Macleay Hastings - Hunter/Central Rivers Macleay Hastings - Northern Rivers Coffs Coast & Escarpment Clarence Sandstones Pittwater Bateman Illawarra South East Coastal Ranges (Part C) Stanthorpe Plateau

5. Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner, (SR512)

Number of ecosystem credits required	178
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	**Offset options - CMA sub-regions**
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner, (SR512)	Jervis Clarence Lowlands Richmond - Tweed (Qld - Scenic Rim) (Part A) Murwillumbah (Qld - Southeast Hills and Ranges) Wyong Macleay Hastings - Hunter/Central Rivers Macleay Hastings - Northern Rivers Coffs Coast & Escarpment Bateman Illawarra South East Coastal Ranges (Part C) Stanthorpe Plateau

6. Swamp Mahogany swamp sclerophyll forest on coastal lowlands, Sydney Basin and South East Corner, (SR648)

Number of ecosystem credits required	27
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	Offset options - CMA sub-regions
Swamp Mahogany swamp sclerophyll forest on coastal lowlands, Sydney Basin and South East Corner, (SR648)	Jervis Clarence Lowlands Richmond - Tweed (Qld - Scenic Rim) (Part A) Murwillumbah (Qld - Southeast Hills and Ranges) Wyong Macleay Hastings - Hunter/Central Rivers Macleay Hastings - Northern Rivers Coffs Coast & Escarpment Bateman Illawarra South East Coastal Ranges (Part C) Stanthorpe Plateau

7. Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner, (SR649)

Number of ecosystem credits required	32
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

Offset options - vegetation types	Offset options - CMA sub-regions
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner, (SR649) Swamp Oak swamp forest fringing estuaries, Sydney Basin and South East Corner, (SR650)	Jervis Bateman Illawarra

Species credits

Common name	Scientific name	Extent of impact	Number of species credits required
Square-tailed Kite	Lophoictinia isura	87.35	1,180
Grey-headed Flying-fox (Breeding)	Pteropus poliocephalus	87.35	939

Appendix B

Offset BioBanking Credit Report

BioBanking credit report

This report identifies the number and type of credits required at a BIOBANK SITE.

Date of report: 23/07/2014 Time: 12:45:57PM Tool version: v2.1

Biobank details

Proposal ID:	0057/2014/1232B
Proposal name:	14073 - Offset
Proposal address:	Shoalhaven LGA Shoalhaven NSW 2121
Proponent name:	Cumberland Ecology
Proponent address:	PO Box 2474 Carlingford Court NSW 2118
Proponent phone:	98681933
Assessor name:	David Robertson
Assessor address:	PO BOX 2474 Carlingford Court NSW 2118
Assessor phone:	9868 1933
Assessor accreditation:	0057

Additional information required for approval:

- ☐ Use of local benchmark
- ☐ Expert report...
- ☐ Request for additional gain in site value

Ecosystem credits summary

Vegetation type	Area (ha)	Credits created
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	168.33	926.00
Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin	4.98	27.00
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	1.90	10.00
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	73.38	404.00
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	8.09	47.00
Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner	29.38	162.00
Total	286.06	1,576

Credit profiles

1. Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin, (SR592)

Number of ecosystem credits created	404
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

2. Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner, (SR658)

Number of ecosystem credits created	162
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

3. Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin, (SR516)

Number of ecosystem credits created	10
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

4. Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner, (SR512)

Number of ecosystem credits created	351
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

5. Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner, (SR512)

Number of ecosystem credits created	575
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

6. Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin, (SR513)

Number of ecosystem credits created	27
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

7. Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner, (SR649)

Number of ecosystem credits created	27
CMA sub-region	Jervis
Minimum percent native vegetation cover class	31-70%
Minimum adjacent remnant area class	>100 ha

8. Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner, (SR649)

Number of ecosystem credits created	20
CMA sub-region	Jervis
Minimum percent native vegetation cover class	>70%
Minimum adjacent remnant area class	>100 ha

Species credits summary

Additional management actions

Additional management actions are required for:

Vegetation type or threatened species	Management action details
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	Exclude miscellaneous feral species
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	Feral and/or over-abundant native herbivore control
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	Fox control
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin and South East Corner	Maintain or re-introduce natural flow regimes
Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin	Exclude miscellaneous feral species
Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin	Feral and/or over-abundant native herbivore control
Banksia - Red Bloodwood - Hard-leaved Scribbly Gum heathy open woodland on sandstone plateaux, southern Sydney Basin	Fox control
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	Exclude miscellaneous feral species
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	Feral and/or over-abundant native herbivore control
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	Fox control
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin	Maintain or re-introduce natural flow regimes
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	Exclude miscellaneous feral species
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	Feral and/or over-abundant native herbivore control
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	Fox control
Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest on coastal foothills, southern Sydney Basin	Maintain or re-introduce natural flow regimes
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Feral and/or over-abundant native herbivore control
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Fox control
Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Maintain or re-introduce natural flow regimes

Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner	Exclude miscellaneous feral species
Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner	Feral and/or over-abundant native herbivore control
Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner	Fox control
Turpentine - Red Bloodwood - Sydney Peppermint shrubby open forest on the foothills, southern Sydney Basin and northern South East Corner	Maintain or re-introduce natural flow regimes

APPENDIX 6

Summary of Biodiversity Offset Strategy for the West Culburra Part 3A project, letter from Ecological Australia dated 18 May 2017

ECO LOGICAL AUSTRALIA PTY LTD
ABN 87 096 512 088
www.ecoaus.com.au

Mr John Toon
C-/ The Halloran Trust

17SYD 6840

18/05/17

Dear John

Summary of Biodiversity Offset Strategy Summary for the West Culburra Part 3A project

The purpose of this summary report is to describe the methodology and results of a biodiversity offset assessment for the proposed West Culburra Part 3A residential/industrial subdivision on land owned by the Halloran Trust on the NSW South Coast. This summary report also provides a brief overview of the biodiversity offset assessment process for the Halloran Trust planning proposal.

Background:

An ecological and riparian assessment report for the West Culburra Part 3A residential/industrial subdivision was prepared by SLR Consultants in 2013 (*West Culburra Ecological & Riparian Issues & Assessment Report SLR March 2013*).

The Office of Environment and Heritage (OEH) advised the applicant in letters dated June 2013 and May 2014 that the Office was "*satisfied that the development is unlikely to have a significant impact on threatened species and their habitats*" and that "*the development should only proceed if suitable offsets can be located and secured to ensure overall biodiversity values are maintained*". OEH stated its position that an offset parcel should be located in the Lake Wollumboola catchments in accordance with the South Coast Regional Strategy 2007.

The Planning Proposal – brief description

Eco logical Australia (ELA) was employed by the Halloran Trust in 2015 to undertake an extensive ecological survey across approximately 2,500 ha of Trust owned land at Jervis Bay and Sussex Inlet. The survey included detailed mapping of 32 different biometric vegetation zones, the collection of over 220 biometric vegetation plots and targeted surveys for a range of threatened flora and fauna species. The ecological survey phase concluded in May 2017 and the results will feed into a biocertification assessment of lands impacted by vegetation clearance for proposed development areas in the planning proposal and biobank assessments of four proposed biobank sites used to offset the impact of the West Culburra Part 3A subdivision and proposed development areas in the Halloran planning proposal.

The biobank site assessments including credit calculations and report preparation are currently in progress to be submitted to OEH around the end of the 2016/17 financial year. After a period of five to seven years of management as biobank sites, one of the biobank sites will be transferred to Jervis Bay National Park, another site will be transferred to Lake Conjola National Park and the remaining two will continue to be managed as private biobanks site at Sussex Inlet.

Figure 1: Halloran Trust Planning Proposal

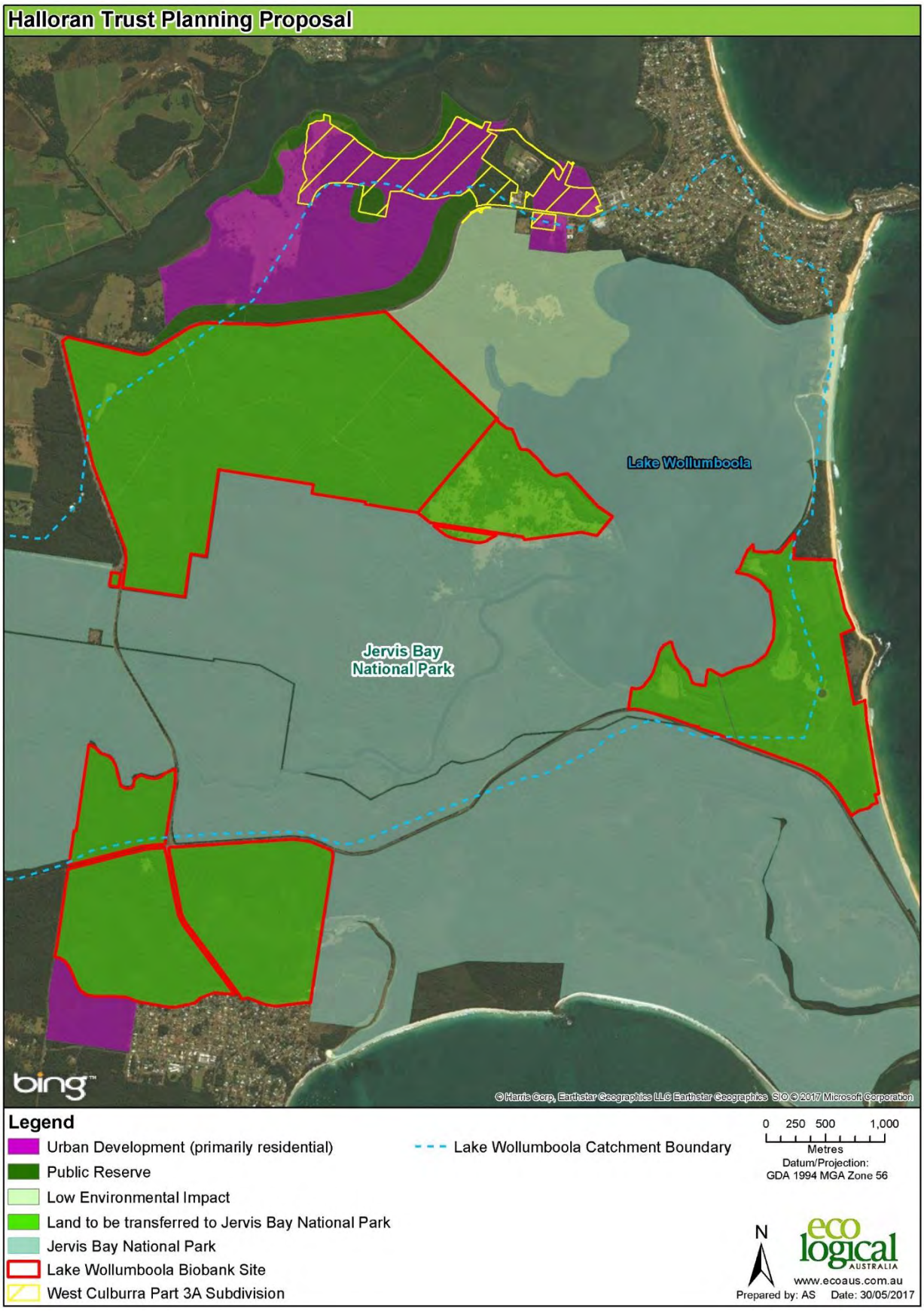
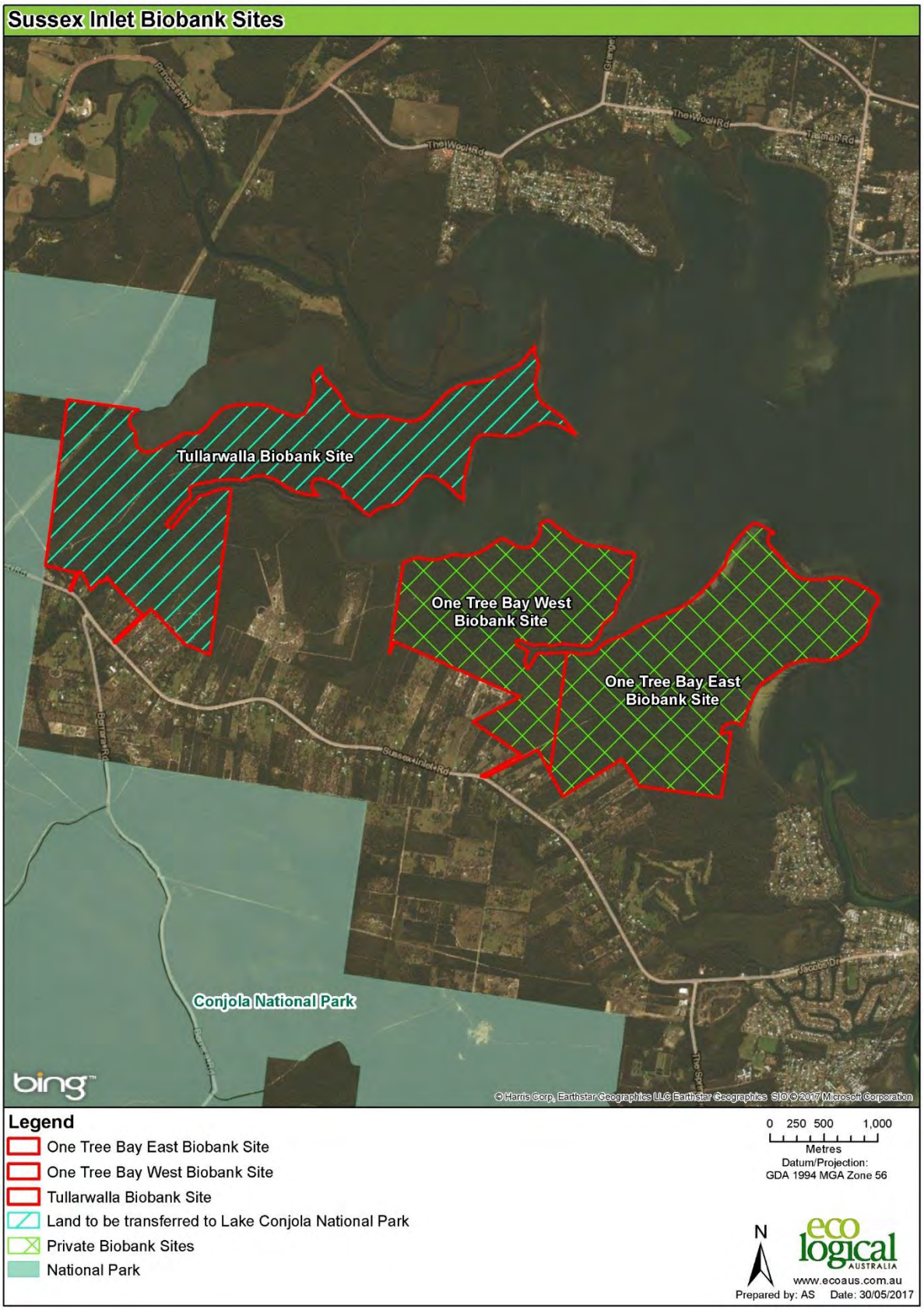


Figure 2: Sussex Inlet Biobank Sites



Biodiversity offset requirement for the West Culburra Part 3A residential/industrial subdivision:

The applicant was advised by OEH that the biodiversity offset for the West Culburra Part 3A subdivision should be determined using the Framework for Biodiversity Assessment (FBA) methodology 2014. An assessment for an impact site determines the number of 'ecosystem credits' (a measurement of threatened vegetation types and threatened habitat types that can be reliably predicted to occur within a vegetation type) and 'species credits' (all threatened plants and threatened fauna species that cannot be reliably predicted to use a vegetation type) that must be retired to offset the impact of the development..

The *West Culburra Ecological & Riparian Issues & Assessment Report SLR March 2013* did not identify an impact on species credit species; this was confirmed and agreed to in an email from OEH, accordingly, the FBA assessment was for ecosystem credits only.

The FBA credit calculator was used to calculate ecosystem credits required to offset impacts from the West Culburra subdivision. Data from 23 vegetation plots (exceeding the minimum plot number required in accordance with the FBA) for ten vegetation zones representing eight vegetation types and a landscape analysis was used in the credit calculation. The credit calculation was submitted for OEH review on Friday 4th November 2016 and then following an initial review and modification to the landscape score was re-submitted on Thursday 22nd December 2016. OEH has inspected the site with the lead ELA field ecologist and advised that they were satisfied with the vegetation mapping and credit calculations. The eight biometric vegetation types are shown in **Figure 3** and the biometric vegetation types for the entire area of subject Halloran Lands (including the Halloran Planning Proposal, Sussex Inlet Biobank and the West Culburra Part 3A subdivision) are shown in

The number of ecosystem credits required to offset the West Culburra Part 3A subdivision for eight biometric vegetation types is shown in **Table 1.** The table includes the vegetation formation, class and % cleared status in the southern rivers catchment management area because this information is relevant when matching credit profiles under the offsetting rules established in the FBA.

A total of 5,472 credits are required for the clearance of 91.65 ha of native vegetation at the West Culburra subdivision. A total of 9.57 ha comprising of four endangered ecological communities (EEC) listed under the NSW *Threatened Species Conservation Act 1997* (TSC Act) and 1.11 ha comprising of one critically endangered ecological community (CECC) listed under the *Commonwealth Environment Protection and Biodiversity Protection Act 1999* (EPBC) will be impacted. Note: two biometric types, SR650 Swamp Oak swamp forest fringing estuaries and SR649 Swamp Oak Floodplain swamp forest belong to one EEC.

SR592 Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest requires by far the greatest number of credits (4,542) for offset. This is followed by SR516 Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies (340) and SR512 Bangalay - Old-man Banksia open forest on coastal sands (327). SR 592 Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest known as the local vegetation type, Currambene-Batemans Lowlands Forest dominates Halloran Trust lands included in this assessment. Blackbutt - Turpentine - Bangalay moist open forest and Bangalay - Old-man Banksia open forest also occur extensively on the lands proposed for offset as well as the other impacted vegetation types.

OEH has advised both the applicant and Shoalhaven City Council that the credit requirement for West Culburra Part 3A subdivision may be recalculated in accordance with the Biocertification methodology (BCAM 2011) post approval which will result in a reduction of credits required in the vicinity of 1500 - 2000 credits. The excess credits may then be used to offset development in the Halloran Trust Planning proposal.

Table 1: No of ecosystem credits required to offset the West Culburra subdivision

BVT	Formation	Sub - formation	Class	TSC and EPBC	% cleared in SRCMA	Ha impacted	Credits Required	Source of Credits for offset
SR592 Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest	Wet Sclerophyll Forests	Grassy	Southern Lowland Wet Sclerophyll forests	N/A	45	**76.66**	**4,542**	**LWB**
SR516 Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies		Shrubby	North Coast Wet Sclerophyll Forests	N/A	50	**5.28**	**340**	**LWB and Sussex Inlet**
SR650 Swamp Oak swamp forest fringing estuaries	Forested Wetlands		Coastal Floodplain Wetlands	EEC N/A	95	**0.35**	**18**	**LWB**
SR648 Swamp Mahogany swamp sclerophyll forest			Coastal Swamp Forests	EEC N/A	50	**1.25**	**93**	**LWB**
SR649 Swamp Oak Floodplain swamp forest				EEC N/A	95	**1.66**	**88**	**LWB and Sussex Inlet**
SR512 Bangalay - Old-man Banksia open forest on coastal sands	Dry Sclerophyll Forests	Shrubby	South Coast Sands Dry Sclerophyll Forests	EEC N/A	50	**5.2**	**327**	**LWB and Sussex Inlet**
SR669 Woollybutt - White Stringybark - Forest Red Gum grassy woodland	Grassy Woodlands		Coastal Valley Grassy Woodlands	EEC CEEC	95	**1.11**	**53**	**LWB**
SR575 Mangrove Forests in estuaries	Saline Wetlands		Mangrove Swamps		50	**0.14**	**11**	**Sussex Inlet**
Total						**91.65**	**5472**	

LWB: Lake Wollumboola Biobank Site

Sussex Inlet: Any or a combination of Tullarwalla, One Tree Bay East and One Tree Bay West Biobank Sites

Figure 3: Biometric vegetation types mapped in the West Culburra Part 3A subdivision

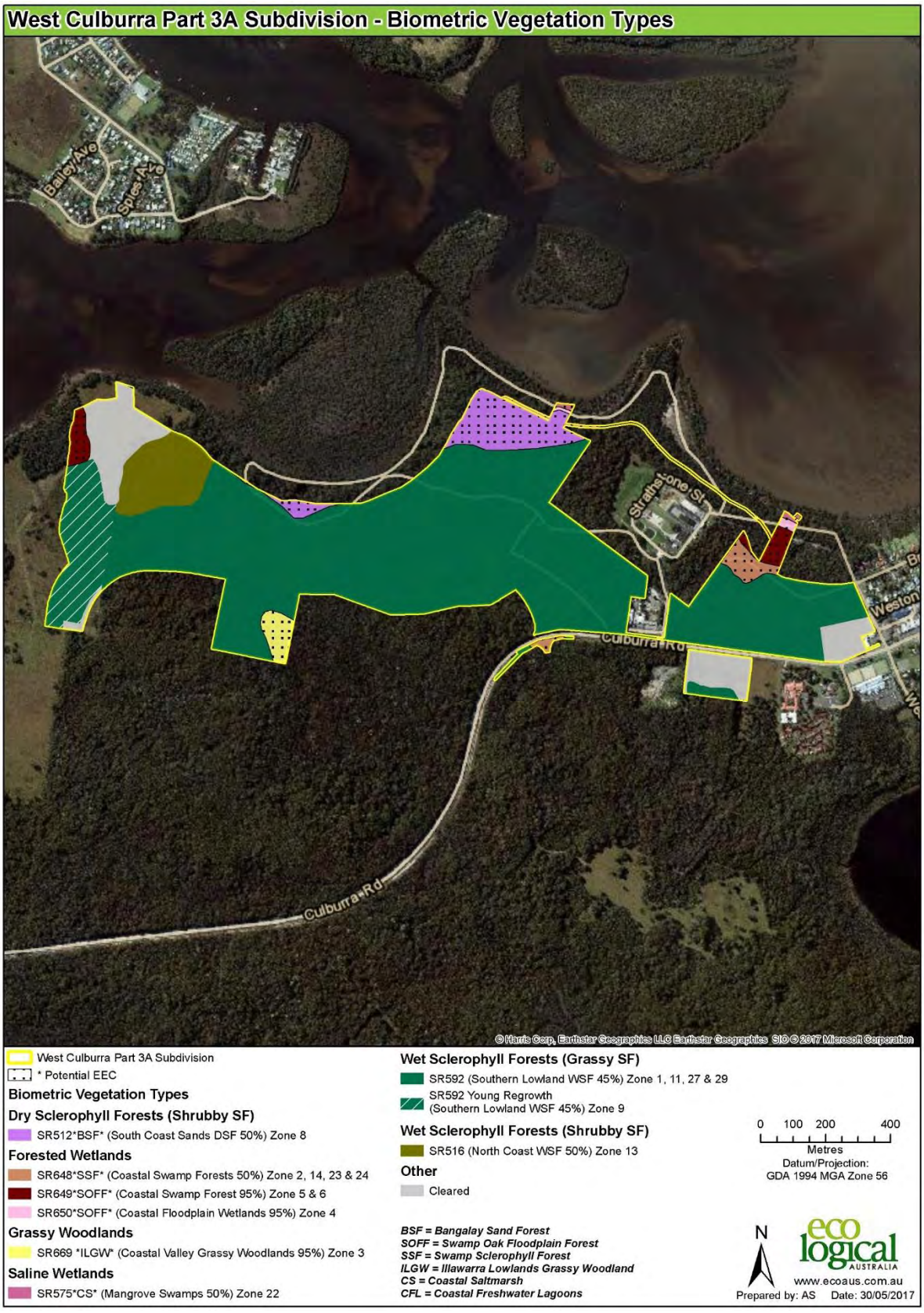
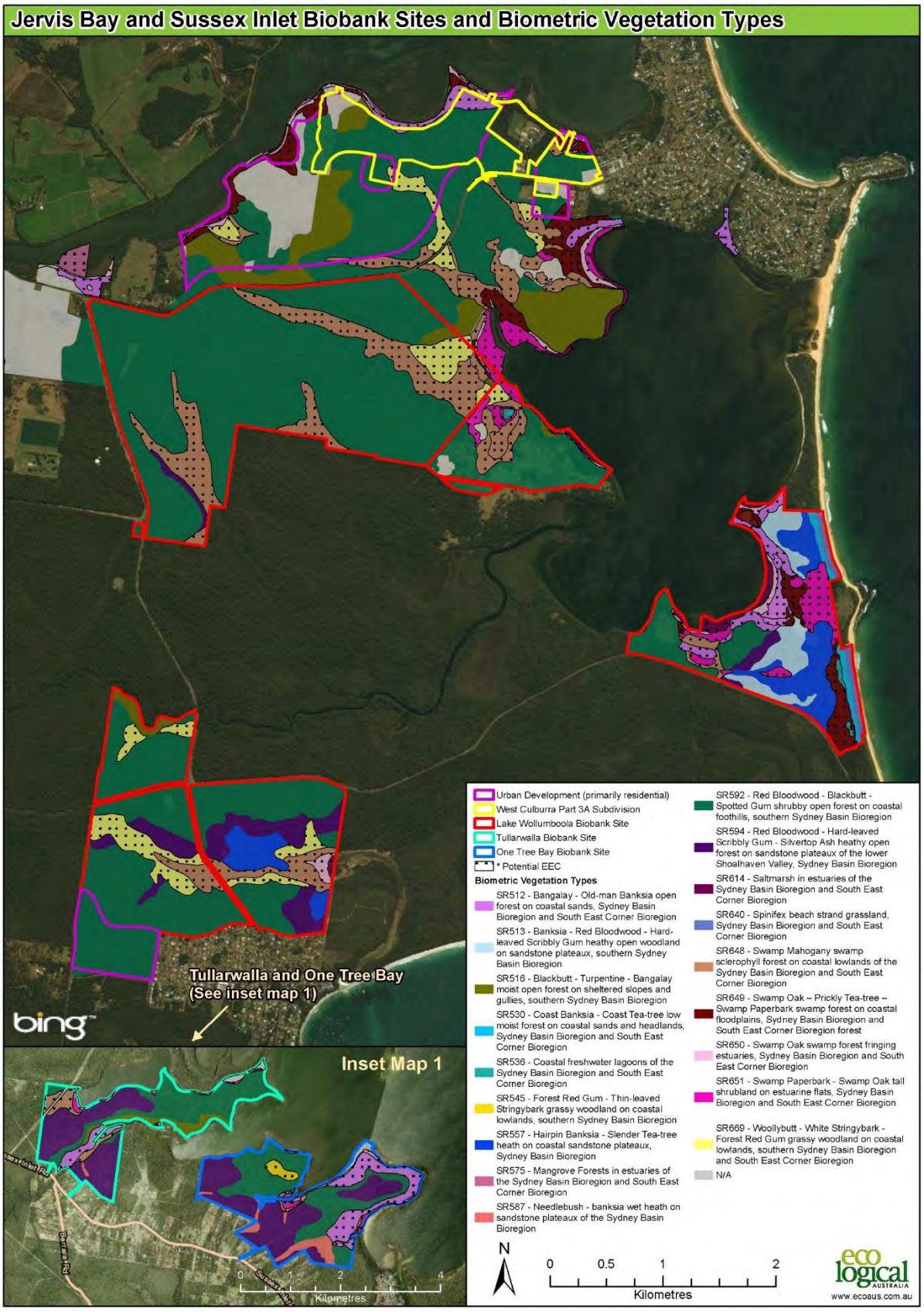


Figure 4: Biometric vegetation types mapped on the subject Halloran Lands



Biodiversity Offset Sites

Four biobank sites on lands owned by the Halloran Trust are currently being assessed for registration by ELA. The four proposed biobanking sites are "stand alone" biobank sites i.e. they are not part of the offset lands included in the Jervis Bay Biocertification assessment area. As well as providing the source of credits to offset the West Culburra Part 3A subdivision they will be used to provide credits for the Halloran Trust planning proposal assessed in the Jervis Bay Biocertification assessment. The biobanking site names and approximate areas are as follows:

- Lake Wollumboola Biobank Site (Jervis Bay): 1,057 ha
- Tullarwalla Biobank Site (Sussex Inlet): 477 ha
- One Tree Bay – East (Sussex Inlet): 361 ha
- One Tree Bay – West (Sussex Inlet): 260 ha

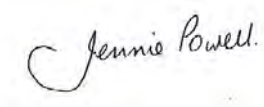
Lake Wollumboola Biobank Site is extensive and comprises of three separate areas of diverse intact vegetation which are contiguous with Jervis Bay National Park (Culburra, Kinghorne and Woods Estate). The majority of the site is within the catchment of Lake Wollumboola and it protects foreshore areas of this significant estuary. Tullarwalla and One Tree Bay Biobank Sites protect foreshore areas of St Georges Basin and are also in excellent condition and have high ecological values. The four biobank sites are shown in **Figure 1** and **Figure 2**.

After a period of five to seven years of management by the Halloran Trust as biobank sites, Lake Wollumboola Biobank Site will be transferred to Jervis Bay National Park and Tullarwalla Biobank Site will be transferred to Lake Conjola National Park. The National Parks and Wildlife Service advised that they were not interested in One Tree Bay site because it is not contiguous with a national park. The One Tree Bay site has been split into two biobank sites and it is envisaged that ownership will be transferred from the Trust to private individual(s) who will manage the sites into the future in accordance with the registered BioBank Agreements once the in perpetuity BioBank Management Trust account has been fully met by the Halloran Trust.

Although formal calculations (i.e. using the biobanking credit calculator) of the credits generated by the biobank sites are yet to occur, based on a conservative estimate of 10 credits/ha generated for vegetation in moderate to good condition with a high landscape value score (e.g. protecting buffers of an estuary such as Lake Wollumboola and St Georges Basin), there are sufficient credits available to offset the credits required by the West Culburra subdivision.

Table 1 shows that the majority of the credits required by the West Culburra subdivision can be sourced within the catchment of Lake Wollumboola with the Lake Wollumboola Biobank site supplying all of the 4,542 credits for SR592 Red Bloodwood - Blackbutt - Spotted Gum shrubby open forest and all of the credits required for five other biometric vegetation types. There with be a moderate credit shortfall for the two remaining BVTs, SR516 Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies and SR512 Bangalay - Old-man Banksia open forest on coastal sands which can be supplied by the Sussex Inlet Biobank Sites.

Yours sincerely,



Jennie Powell

Senior Consultant

APPENDIX 7

Addendum to Water Cycle Management Report, Mixed Use Subdivision, West Culburra (SSD 3846).
Martens, 8 June 2017

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consulting engineers since 1989

'Posted	☐	
Faxed	☐	
Emailed	☐	Robert.Byrne@planning.nsw.gov.au
Courier	☐	
By Hand	☐	
Contact:		Megan Kovelis / Andrew Norris
Our Ref:		P1203365JC49V01
Pages:		3
cc.		John Toon

June 08, 2017

NSW Department of Planning and Environment
Att: Robert Byrne
By Email

Dear Robert,

RE: WATER CYCLE MANAGEMENT REPORT ADDENDUM; MIXED USE SUBDIVISION, WEST CULBURRA (SSD 3846)

1.0 Introduction

We understand that following review of the most recent version of the Water Cycle Management Report (November, 2016) and associated water quality (MUSIC) modelling, the Department's Peer Reviewer maintains their concern with the water quality modelling approach and the specified stormwater treatment solution. Specifically, the Peer Reviewer does not support modelling which includes approach which includes nutrient assimilation with the vegetation in the 7(a) protection zone between the development and the Crookhaven River.

To address the Peer Reviewer's concern, water quality modelling has been revised to achieve NorBe *without* the treatment of infiltrated water. The specific performance standard adopted is that NorBe be achieved at the 7(a) protection zone boundary. In order to achieve this objective, the proponent has made substantial modifications to the development proposal and footprint.

This addendum outlines:

1. Modifications to the development proposal and subsequently to the water quality model in order to achieve revised water quality objectives.

2. Results of water quality modelling.

3. Final proposed treatment train.

2.0 Development Proposal Modifications

In order to achieve water quality objectives without reliance on the assimilation of nutrients in the 100+ m buffer vegetated zone in the 7(a) land, the proponent has made substantial modifications to the development footprint and proposal:

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Hornsby NSW 2077, Australia
Ph 02 9476 9999 **Fax** 02 9476 8767

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www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

1. Most significantly, the proponent has removed 50% of the proposed industrial area. The area previously proposed as industrial is now to be retained with existing forest vegetation. Within the water quality model, the industrial zone was contributing a significant proportion of nutrients generated by the development to seagrass areas and the Crookhaven River. By removal of 50% of this area, water quality objectives are more easily achieved.

2. Project planners (Allen Price & Scarratts - AP&S) completed a detailed assessment of subdivision design based on similar residential land releases in the Shoalhaven region. Through this assessment, the following project modelling assumptions were refined:

    a. Road areas: Impervious road area assumptions were modified from the previously assumed 50% to an impervious percentage calculated for each road, based on its intended use. AP&S confirmed paved width required was generally 6m with wider widths of 9m along future bus roads and 10m in the industrial zone.

    b. Roof areas: Previously a roof area of 40% of lot area was applied to the entire site, regardless of location or lot size. Based AP&S's specification, roof areas have been adjusted to range from 200m^2 (smaller lots) – 275m^2 (larger lots). It is anticipated that final roof area shall be confirmed at detailed design stage once a final lot layout and extent is prepared.

3.0 Water Quality Model Modifications

The MUSIC water quality model was amended as follows to reflect development proposal modifications and achieve NorBe objectives:

1. Vegetation uptake node (treating infiltrated water) was removed from the pre and post development models and infiltration from treatment devices (e.g. bioswales) was discharged directly to the model outlet, untreated, as required by Peer Reviewer.

2. All base flow 'secondary routing' was deleted from pre and post development model as is normal modelling practice. MUSIC manages and routes the baseflow by its inbuilt routines.

3. Terminal wetland/infiltration systems were removed from the model (excluding catchment O6 which discharges to Lake Wollumboola). These areas are to be left undeveloped.

4. 50% of the industrial area was removed from the model and replaced with forest.

5. Roof areas were refined to 200 - 275 m^2 as discussed in Section 2.0. Pervious residential areas were increased by an equivalent area.

6. Road reserve percentage impervious is specified on a **sub-catchment basis** based on required pavement width rather than a model-wide assumption.

7. The wetland in catchment O6 (Lake Wollumboola catchment) was increased in size and permanent pool volume in order to increase water storage available to better meet reuse demands. This improved the treatment efficiency of the wetland.

4.0 Results

Results of iterative modelling conclude that NorBe objectives, as prescribed in Section 1.0 are achieved as a result of the development proposal modifications. Results are tabled below (Table 1 and Table 2) for each required receiving environment as previously reported in Table 10 – Table 14 of Marten and Associates, November 2016.

Table 1: MUSIC results – Pre Development catchment pollutant load.

Parameter	Pre Development Loads					
	SEPP 14 /O2	Curleys/O5	Lake	Seagrass	River	Total
TSS (kg/year)	1580.0	9140.0	293.0	12000.0	13600.0	13900.0
TP (kg/year)	4.7	18.0	0.9	28.9	33.6	34.5
TN (kg/year)	50.5	115.0	9.3	203.0	253.0	263.0
Gross Pollutants	0.0	899.0	0.0	899.0	899.0	899.0

Table 2: MUSIC results – Post Development catchment pollutant load and NORBE assessment

Parameter	Post Development Loads					
	SEPP 14 /O2	Curleys/O5	Lake	Seagrass	River	Total
TSS (kg/year)	587	6960	136	8110	8670	8810
Change (%)	-62.8	-23.9	-53.6	-32.6	-36.3	-36.6
TP (kg/year)	4.3	14.2	0.8	22.7	27.0	27.8
Change (%)	-8.3	-21.1	-4.8	-21.5	-19.6	-19.4
TN (kg/year)	49.6	102.0	8.5	190.0	240.0	248.0
Change (%)	-1.8	-11.3	-9.1	-6.4	-5.1	-5.7
Gross Pollutants	0.0	782.0	0.0	782.0	782.0	782.0
Change (%)	0.0	-13.0	0.0	-13.0	-13.0	-13.0

Note: Change is difference/predevelopment. Zero or negative values indicate NorBE test is met.

5.0 Implications on Estuarine Process Modelling

Estuarine Process Modelling (EPM) completed to date assessed the impact of the development on water quality within the Crookhaven Estuary. Two scenarios, each using different landside pollutant generation profiles, were considered:

1. Land-side stormwater quality using MUSIC modelling with treatment of infiltrated water by downslope vegetation (i.e. inclusion of vegetation uptake node).

2. Land-side stormwater quality using MUSIC modelling without treatment of infiltrated water by downslope vegetation.

Modelling scenario 1 achieved NorBe at the receiving environment, while scenario 2 did not. EPM results indicated that under both modelling scenarios, the impact on change in water quality within the Crookhaven Estuary was negligible.

Given the results of water quality modelling for the modified development as documented in Section 4.0 are between Scenario 1 and Scenario 2 above, and much nearer to the lower load of scenario 1, no impact on water quality within the Crookhaven Estuary would be expected. It is therefore unnecessary to re-run EPM in light of these latest modifications.

6.0 Revised Treatment Train

The treatment train developed to achieve NorBE water quality objectives is:

- Roofs discharge to 5KL rainwater tanks on each dwelling.
- Roofs of medium density residential discharge to rainwater tanks of 3KL – 5KL per unit.
- Tank overflows, remaining lot areas and road runoff is treated by roadside bioswales.
- Bioswales discharge into Enviropods and Stormfilters.
- Stormfilters discharge to the outlet.

In the Lake Wollumboola catchment, the treatment train for runoff from the small area of road and oval includes:

- Road areas treated by roadside swales.
- Roadside swale and oval discharge into a wetland of 3,200 m^2 with a permanent pond volume of 3.2 ML.
- Stored water is available for reuse to irrigate the oval.
- Overflow discharges to the Lake.

7.0 Conclusion

To address the Department's Peer Reviewer's concerns regarding the modelling of stormwater, the MUSIC water quality model has been amended to incorporate changes requested by the Peer Reviewer related to the treatment of infiltrated water. The water quality objective has been revised to require that NorBe be achieved at the 7(a) protection zone boundary. This mean no modelling allowance for the treatment of infiltrated water by the vegetation buffer between the development and the estuary is made. By implementing this change, the revised model addresses the Peer Reviewer's concerns.

To achieve the modified performance objective the application has modified, most notably by removing half the proposed industrial area. This, along with additional model refinements, achieves revised water quality objectives.

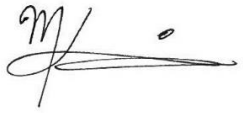
The revised water quality model confirms that the proposed development will have a neutral or beneficial effect on stormwater quality at the boundary of the development at the 7(a) zone, and therefore on the downslope receiving environments. This performance objective is achieved using the treatment train as outlined in Section 4.0. Further refinement of the model at the detailed design stage may alter the sizes of the proposed treatment structures and may allow substitution of elements of the treatment train

provided the final treatment train achieves water quality performance objectives as specified in this document.

If you have any queries please contact the undersigned.

For and on behalf of

MARTENS & ASSOCIATES PTY LTD



MEGAN KOVELIS
Environmental Scientist/Planner

APPENDIX 8

West Culburra Aquatic Ecology Impact Assessment; Proposed Mixed Use Subdivision. Ecological Australia, May 2017.

West Culburra Aquatic Ecology Impact Assessment: Proposed Mixed Use Subdivision

Aquatic Ecology Assessment

Prepared for
The Halloran Trust

04 May 2017

DOCUMENT TRACKING

Item	Detail
Project Name	West Culburra Aquatic Ecology Impact Assessment: Proposed Mixed Use Subdivision
Project Number	16WOL-5719
Project Manager	Ian Dixon 02 4201 2208 Suite 204, Level 2, 62 Moore Street, Austinmer NSW 2515
Prepared by	Ian Dixon
Reviewed by	Miles Yeates (v1 and v3) and Peter Hancock (v2)
Approved by	Miles Yeates (v1 and v3) and Peter Hancock (v2)
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Cover photo	Waterside edge of mangrove forest. Photo by Ian Dixon, December 2016

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ACKNOWLEDGEMENTS

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Abbreviations

Abbreviation	Description
Council	Shoalhaven City Council
DPI	NSW Department of Primary Industries
ELA	Eco Logical Australia Pty Ltd
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FM Act	NSW *Fisheries Management Act 1994*
TSC Act	NSW *Threatened Species Conservation Act 1995*

Executive summary

This assessment provides an overview of the existing health and predicted impacts to estuarine habitats near a proposed subdivision at West Culburra.

In response to stakeholder consultation on the project, Martens and Associates (Consulting Engineers) assessed the estuarine hydrodynamics and changes in water quality variables in the Crookhaven River using a Tuflow Advection Dispersion (TAD) model. The TAD model was used to evaluate the estuarine impacts of the development using the outputs of the surface water quality impact assessment (MUSIC modelling) undertaken for the project. Target variables considered in the TAD model include:

- Salinity
- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids

The independent peer reviewed model is well calibrated and has been used to assess estuarine hydrodynamics and pollutant transport in 32 scenarios, as documented in the *Estuarine Processes Modelling Report.* The 32 model scenarios address two development scenarios for pre- and post-development, two infiltration scenarios (with and without vegetated buffer uptake), four meteorological scenarios (rainfall) and three dispersion sensitivity scenarios (fate of discharged water).

Eco Logical Australia (ELA) conducted a review of environmental tolerances for dominant key fish habitat in the estuary (seagrass, mangroves and saltmarsh). To assess development impacts on these habitats, data was extracted from the MUSIC and TAD models.

On review of these modelling results we conclude that:

- Salinity concentrations at each seagrass sample point and for each assessed scenario match very closely and the proposed development does not increase the duration of salinity concentrations being below 20 g/L and 10 g/L at any seagrass location.
- There are no annual increases in total suspended solids concentrations at the seagrass sample points due to the proposed development.
- Changes to nutrient concentrations at seagrass sample points due to the proposed development throughout the year are negligible.
- Processes favouring mangrove survival would be maintained.
- The development would not have any direct or indirect impact to saltmarsh patches near the development.

In summary, we conclude there is **not** likely to be a significant impact on threatened species, populations, ecological communities or their habitats; and a Species Impact Statement is **not** required, nor is a referral to a Commonwealth body.

The healthy condition of marine vegetation indicates it is tolerant of numerous existing catchment pressures (e.g. dairy farming, residential use). Modelled changes in salinity, nutrients and suspended solids demonstrate an insignificant change between existing and proposed land use. This is the case irrespective of the inclusion of infiltration in the MUSIC model. Our review of the ecology of the estuary and of the model outputs concludes that the proposed subdivision would not alter the health, extent or values of the estuarine ecology.

1 Introduction

The Halloran Trust has engaged Eco Logical Australia (ELA) Pty Ltd to provide an aquatic ecology impact assessment for the proposed development at Culburra Road, West Culburra (Lot 61 DP 755971, Part Lot 5 DP 1065111, Part Lot 6 DP 1065111 and Part Lot 7 DP 1065111) (herein referred to as the site). The aquatic assessment addresses potential impacts to any threatened or protected aquatic species listed under the NSW *Fisheries Management Act 1994* (FM Act), NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It also addresses broader impacts to estuarine ecology, especially to 'key fish habitat' defined by DPI Fisheries.

1.1 Description of works

The proposed works involve the subdivision and subsequent development of predominantly forested land in the Crookhaven River catchment. The site is located on the northern side of Culburra Road, West Culburra. The proposed development consists of numerous allotments across 93 ha. The proposed land uses include (**Figure 1**):

- residential
- commercial
- industrial
- tourist facilities
- conservation areas of ecological and cultural significance

1.2 Previous studies

In response to stakeholder consultation on the project, Martens and Associates (Consulting Engineers) assessed the estuarine hydrodynamics and changes in water quality variables in the Crookhaven River using a Tuflow Advection Dispersion (TAD) model. The TAD model was used to evaluate the estuarine impacts of the development using the outputs of the surface water quality impact assessment (MUSIC modelling) undertaken for the project. Target variables considered in the TAD model include:

- Salinity
- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids

A comprehensive monitoring regime was undertaken to collect data on water level, flow and salinity in the Crookhaven River to calibrate the model. The independent peer reviewed model is well calibrated and has been used to assess estuarine hydrodynamics and pollutant transport in 32 scenarios, as documented in the *Estuarine Processes Modelling Report.* The 32 model scenarios address two development scenarios for pre and post-development, two infiltration scenarios (with and without vegetated buffer uptake), four meteorological scenarios (rainfall) and three dispersion sensitivity scenarios (fate of discharged water) (**Table 1**).

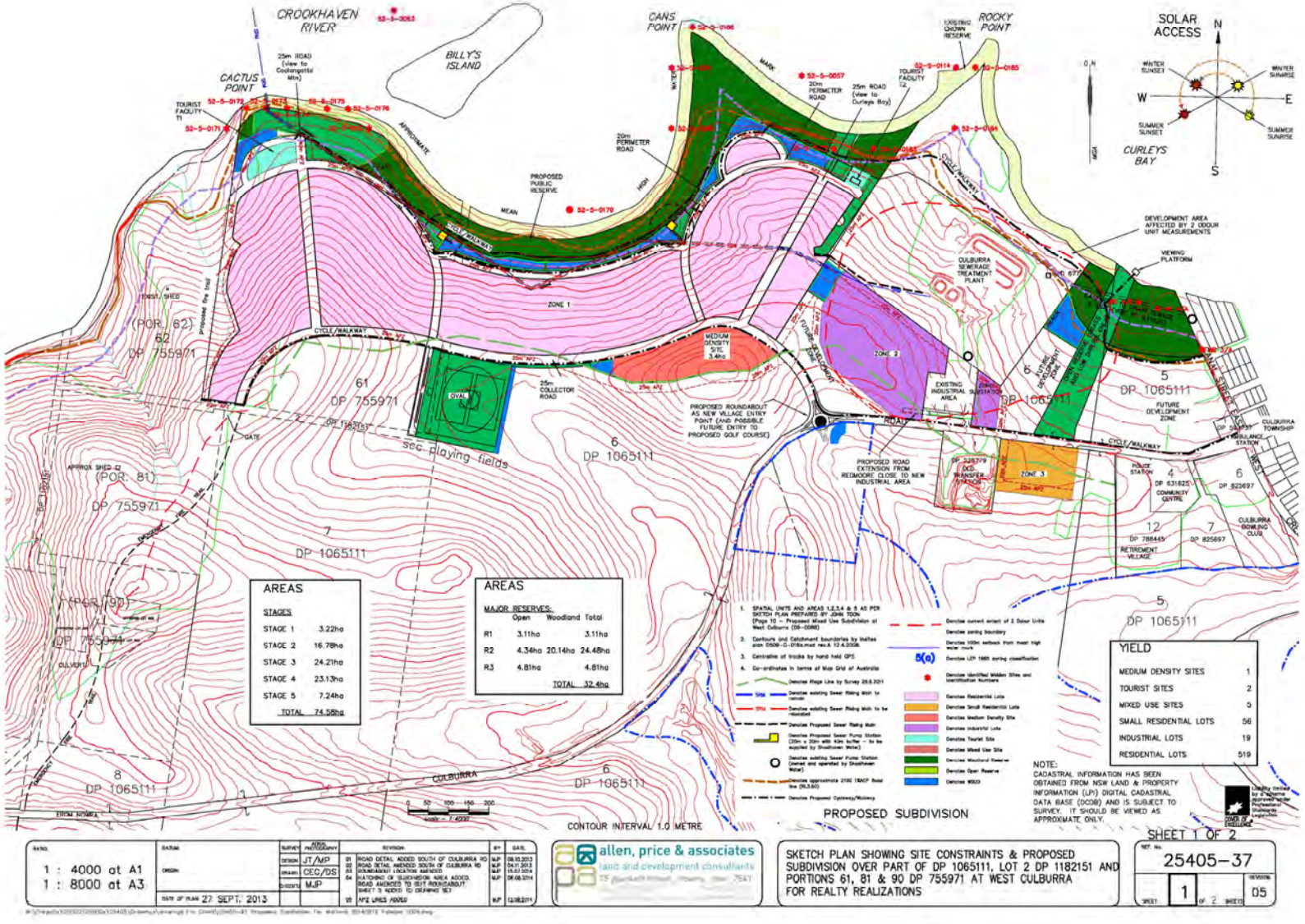

Figure 1: Concept design of proposed development (Water Sensitive Urban Design (WSUD) in blue shade)

Table 1: Development scenarios and Tuflow model naming (provided by Martens & Associates).

		Meteorological Scenario [3]											
		Average Year 1967			Dry Year 1968			Wet Year 1969			Local Wet Month 20 Oct – 20 Nov 1969		
Infiltration Scenario [1]	Development Scenarios [2]	Dispersion Sensitivity Scenario [4]											
		D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
With Infiltration	Pre Dev	M01	M02	M03	M04	–	–	M05	–	–	M06	M07	M08
	Post Dev	M09	M10	M11	M12	–	–	M13	–	–	M14	M15	M16
Without Infiltration	Pre Dev	M17	M18	M19	M20	–	–	M21	–	–	M22	M23	M24
	Post Dev	M25	M26	M27	M28	–	–	M29	–	–	M30	M31	M32

Notes

1. Infiltration scenarios defined in Section 2 of the EPMR (2016).
2. Development scenarios defined in Section 12.5.2 of the EPMR (2016).
3. Meteorological scenarios defined in Section 12.5.3 of the EPMR (2016).
4. Dispersion sensitivity scenarios defined in Section 12.5.4 of the EPMR (2016).

1.3 Study aims

The aims of this aquatic assessment are to:

- gain an understanding of the biota and habitat occurring near the proposed development
- evaluate the predicted changes to environmental conditions due to the development
- assess if the development is likely to cause a significant impact to threatened species, communities or populations and the general estuarine fish habitat.

This report does not consider impacts to oyster farming, as this is addressed by a separate monitoring program (Martens and Associates 2016b, *Water Quality Monitoring Plan*). The following tasks were undertaken to address the project aims:

- a desktop review of species and habitats likely to occur on or adjacent to the site
- literature review of environmental tolerances of key fish habitat, especially seagrass, mangroves and saltmarsh
- an aquatic survey during optimum conditions (high tide with calm swells and high water clarity) to verify and photograph aquatic flora and key fish habitats
- develop criteria for the estuary model to predict environmental changes that have the potential to impact seagrass, mangroves, and saltmarsh
- interpret water quality and estuary model results to allow an assessment of potential aquatic flora and fauna impacts.

2 Legislative context

2.1 NSW Fisheries Management Act 1994 (FM Act)

Under s205, Part 7 of the FM Act, a permit is required to harm (cut, remove, damage, destroy, shade etc.) marine vegetation (saltmarsh, mangroves, seagrass and macroalgae) on public 'water land' or the foreshore of public 'water land' up to the level of Highest Astronomical Tide. This includes indirect impacts if a development alters tidal movement, shades vegetation or is expected to cause dieback from other means. DPI Fisheries does not support clearing of mangroves to provide vistas, but may approve small areas of pruning or removal for infrastructure that benefits the broader community (e.g. a community jetty compared with numerous private jetties).

Future development stages may require specific Part 7 permits, such as and *dredging and/or reclamation* for foreshore structures (e.g. viewing platform). This report only addresses the broader concept plan and does not cover future Development Applications lodged with Council, which may require separate Aquatic Ecology Impact Assessments for foreshore structures (e.g. construction of the viewing platform or other proposed activities that may cause harm to key fish habitat).

Species, communities or populations that are listed as threatened under the FM Act require assessment according to Section 5A of the NSW *Environmental Planning and Assessment Act 1979*, which lists factors that must be taken into account through the preparation of an Assessment of Significance (7-Part Test).

2.2 NSW Threatened Species Conservation Act 1995 (TSC Act)

The TSC Act aims to protect and encourage the recovery of threatened species, populations and communities. The interactions between the TSC Act and the *Environmental Planning and Assessment Act 1979* (EP&A Act) require consideration of whether a development (Part 4 of the EP&A Act) is likely to significantly affect threatened species, populations, ecological communities or their habitats. This is achieved through the preparation of an Assessment of Significance (7-Part Test).

2.3 NSW Water Management Act 2000 (WM Act)

A controlled activity approval under the WM Act is required for certain types of developments and activities that are carried out in or near a river, lake or estuary. The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 meters of the river banks, lake shore or estuary mean high water mark.

2.4 Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Under the EPBC Act, the Commonwealth Environment Minister needs to approve any development that is likely to have a significant impact on Matters of National Environmental Significance (MNES). Should such an impact be likely, the preparation and submission of a referral is required. MNES relevant to this study include threatened ecological communities, flora and fauna species and migratory species listed under The Act.

3 Methods

3.1 Desktop study

Publicly available databases and reports were reviewed for potential impacts resulting from the proposed development. This included a literature review to determine if marine vegetation has specific condition thresholds, such as tolerance limits to freshwater inflows or excessive nutrients causing severe epiphyte growth. The outcomes of the literature review are provided in **Appendix A**. Online databases were accessed to determine if threatened species, communities and populations were likely to occur in the region. The search covered a 10 km radius from the point -34.920755, 150.739165 in the Crookhaven River (central point just east of Billys Island). Only aquatic species known to use estuarine/marine water were considered in this assessment. Databases include:

- Commonwealth EPBC Act – Protected Matters Search Tool
- NSW TSC Act – Threatened Species Search Tool (BioNet)
- NSW FM Act – Listed protected and threatened species and populations, including species profiles, 'Primefact' publications and expected distribution maps (Riches et al 2016)
- Online Zoological Collections of Australian Museums (OZCAM) – individual species searches to determine likelihood of occurrence of threatened species.

3.2 Field survey

The site was visited between 7:00 am and 2:30 pm on 13th December 2016 by two ELA aquatic ecologists. The survey targeted seagrass, mangrove and saltmarsh habitat at eight locations, with additional general observations of environmental condition made between locations (**Figure 2**). The survey was conducted using a canoe mounted with a colour / infrared underwater video camera linked by a 30 m cable to an on-board monitor. This method allows viewing and recording of substrate and sub-tidal flora in shallow and deep water (even in low light conditions by switching to infrared spectrum) without the risks associated with snorkelling or diving. Conditions were reasonably calm leading up to and during the survey (**Table 2**).

Table 2: Weather conditions leading up to the aquatic survey on 13th Dec 2016

Date	Min temperature (°C)	Max temperature (°C)	Rainfall (mm)	Wind Direction	Wind speed (km/h)
6/12/2016	17.4	23	18.8	SW	7
7/12/2016	17.1	22.2	4.8	NNE	7
8/12/2016	16.8	26.1	3	NNE	30
9/12/2016	16.5	21	0	SSE	13
10/12/2016	15.9	21	0	NE	6
11/12/2016	17.2	22.3	1	SSE	13
12/12/2016	17.9	28.2	0.2	NNE	17
13/12/2016	19.2	35.3	0	NNE	13

Observations from BOM – Jervis Bay (Station 068151)

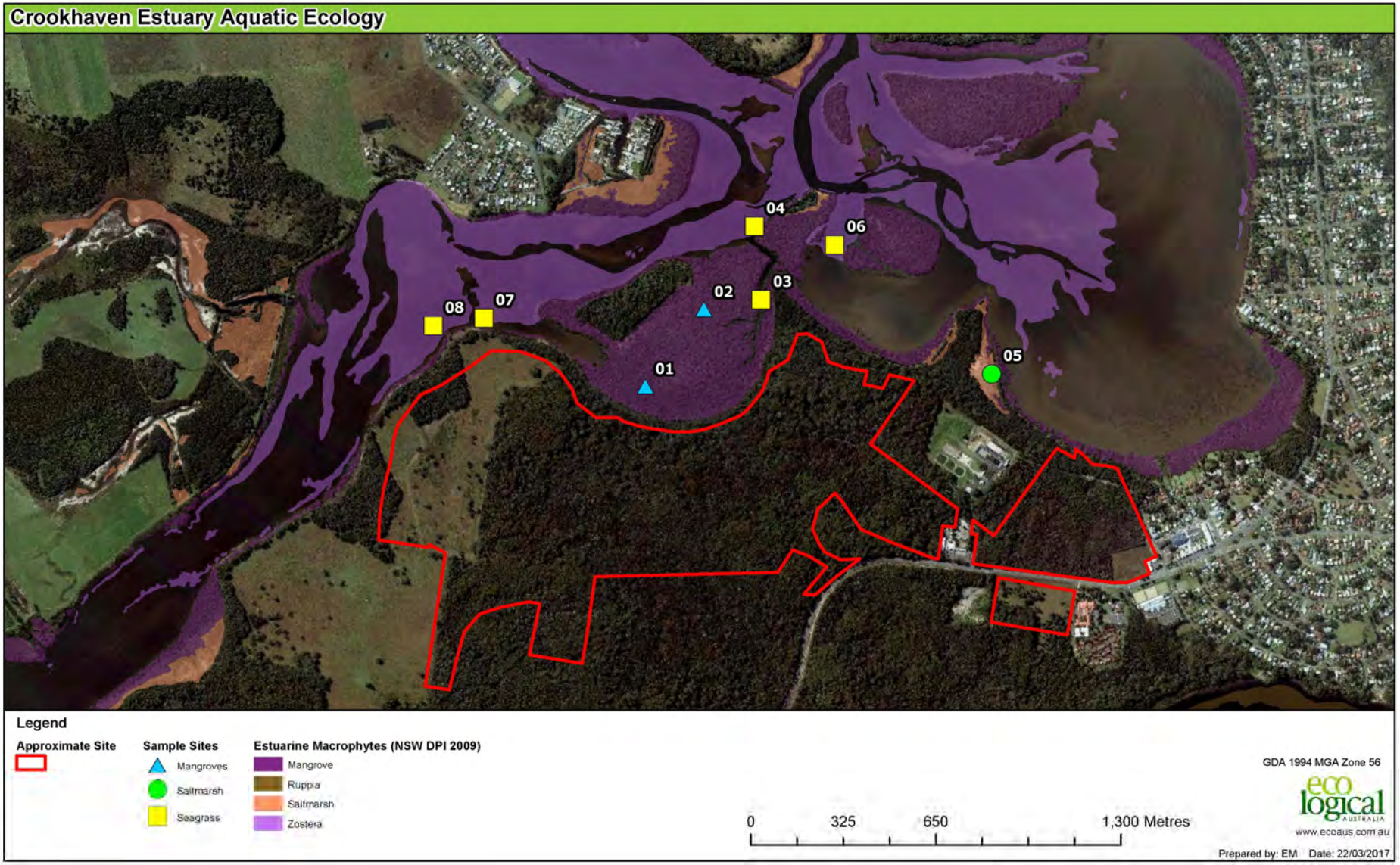

Figure 2: Sample locations during aquatic ecology survey

3.3 Water Quality Sampling

Water samples were taken near the base of the water column to compliment the field observations. Samples were either measured in-situ using a Horiba U-50 multi-parameter meter, or collected using appropriate protocols, and sent to a registered NATA laboratory (ALS) for analysis. Parameters measured include:

Field measurement

- Dissolved oxygen
- Temperature
- Oxygen-reduction (redox) potential
- Salinity
- Total suspended solids

Lab measurement

- Biological oxygen demand (BOD)
- Nutrients (nitrogen and phosphorus: NO_3, NO_2, Total N, Total P, Filtered Reactive P, Ammonia).

Water quality results are provided in **Appendix B**.

3.4 Modelling impacts using habitat thresholds

Condition thresholds of marine vegetation were derived from a review of publicly accessible literature (**Appendix A**). Our review identified several hypothetical issues that could impact the estuary, which led to a series of questions that could be answered by reviewing the estuary model results (Martens and Associates). Potential sources of impacts to each habitat and recommended tests are:

Seagrass

- stormwater discharged on or adjacent to seagrass
  - **TEST → Is a stormwater outlet/channel proposed in or adjacent to the seagrass?**
- prolonged discharge of freshwater in a concentrated area near seagrass
  - **TEST → will salinity near seagrass fall below 10 and 20 ppt, and for what duration?**
- increased suspended solids discharged into the estuary
  - **TEST → will suspended solids increase during rain events, especially in spring-summer?**
- erosion leading to sediment deposits in the estuary, especially during construction
  - **TEST → will suspended solids increase during construction and operation?**
- increased nutrients discharged into the estuary
  - **TEST → will nutrient concentrations be higher than normal, especially in spring-summer, and for how long?**

Mangroves

- foreshore earthworks or structures that effect tidal movement
  - **TEST → Does the proposal inhibit tidal movement to the mangroves?**
- sedimentation of the estuary during construction and operation, including suspended solids such as fine sediment released during earthworks (if mitigation measures fail)
  - **TEST → Does the proposal result in an increase in suspended solids and/or sediment and would this be deposited in the mangroves?**
- diversion of overland flows that currently diffuse water across the bushland to the mangroves

  - **TEST → Is the natural overland flow to the mangroves across a vegetated surface, or otherwise treated to avoid impacts from runoff?**
- stormwater discharged on mangroves
  - **TEST → Is a stormwater outlet/channel proposed in the mangroves?**
- roads, earthworks and development that prevents mangrove retreat over decades
  - **TEST → Will predicted sea level rise reach artificially raised areas of development (http://coastalrisk.com.au/viewer)?**

Saltmarsh

- foreshore earthworks or structures that effect tidal movement
  - **TEST → Does the proposal inhibit any tidal movement to the saltmarsh?**
- diversion of overland flows that currently diffuse water across the bushland to the saltmarsh
  - **TEST → Is the natural overland flow to the saltmarsh across a vegetated surface, or otherwise treated to avoid impacts from runoff?**
- stormwater discharged on or adjacent to the saltmarsh
  - **TEST → Is a stormwater outlet/channel proposed in or adjacent to the saltmarsh?**
- roads, earthworks and development that prevents saltmarsh retreat over decades
  - **TEST → Will predicted sea level rise reach artificially raised areas of development (http://coastalrisk.com.au/viewer)?**

4 Results and impact assessment

4.1 Aquatic habitat

The Crookhaven River estuary is a disturbed ecosystem in a mixed use catchment, but is abundant in healthy marine vegetation comprised of saltmarsh, mangroves and seagrass. These habitats are protected under the FM Act. Additionally, saltmarsh is listed as a threatened ecological community under the TSC Act and EPBC Act. Other marine vegetation (macroalgae and seaweeds) may occur, but was not an abundant habitat type in the surveyed area.

Seagrass

The estuary has an extensive seagrass community, dominated by *Zostera capricorni* (Ribbonweed). A survey at **Sites 03, 04, 06, 07 and 08** (**Figure 2**) showed that meadows appear reasonably healthy, due to high density (cover), large extent, long leaf length, and minor-moderate epiphyte cover. Bioturbation from benthic infauna was evident at all sites, indicating sediment quality suitable to support aquatic organisms. Seagrass is dynamic in its seasonal growth and adaption to sediment movement. Mapping by DPI Fisheries (**Figure 2**) was correct at the time of survey, but meadows may contract or expand over years. For example, the estuary arm surrounding **Site 03** is currently a healthy seagrass bed, but was not evident in the 2009 mapping by DPI Fisheries. In other estuaries ELA has observed disappearance of seagrass beds due to sand deposition after large storms (e.g. between Holts Point and Tom Uglys Bridge, Sylvania).

The seagrass beds at **Sites 03, 04, 07 and 08** (**Figure 2**) were similar in appearance:

- leaf length typically 40+ cm
- dense cover (50-70%)
- minor to moderate epiphyte cover across entire leaf blade

The seagrass at **Site 06** was notably different to other sites:

- leaf length typically 20-30 cm
- sparse cover (10 %)
- minor to moderate epiphyte cover across entire leaf blade

Water quality tests in the seagrass were taken at high tide, mostly in calm conditions but wind and waves increased throughout the day (**Sites 03, 04, 06, 07** and **08**, **Figure 2**). Water was sampled from the bottom without disturbing the substrate. Water salinity was high (35-36 ppt) and similar to sea water. Biological Oxygen Demand (BOD) was low (<2 mg/L), indicating little organic matter breakdown on the bottom. Suspended solid concentrations were variable but high (27-139 mg/L), although the high reading at **Site 08** could have been caused by sediment disturbance by strong winds affecting the boat. Ammonia concentration was high at all sites (0.16-0.18 mg/L) and greatly exceeded ANZECC Guideline trigger values for South-east Australian estuaries. Total phosphorus concentration was also above guidelines at three sites, **Sites 04, 07** and **08** (0.12-0.22 mg/L). Complete water quality results are in **Appendix B**.

Site photos for seagrass beds are in **Appendix C**. An impact assessment for seagrass is provided below in **Section 4.5**.

Mangroves

Mangroves are abundant across the entire foreshore of the study area, with forests ranging in width between 10 – 500 m (**Figure 2**). Two sites (**Site 01** and **Site 02**) were selected in the largest mangrove forest (between the proposed development and Billy's Island). Other locations were observed via canoe at high tide. Mangroves in the surveyed area are a monoculture of *Avicennia marina* (Grey Mangrove), although *Aegiceras corniculatum* (River Mangrove) may occupy landward areas. However, River Mangrove may have been historically harvested for 'oyster sticks', resulting in a dominance of Grey Mangrove (Dwyer 2014).

Mangroves observed during the survey are in good condition, because:

- regeneration appears successful, with abundant seedling/juveniles and a variety of trunk girths (diameter at breast height) with no obvious gaps in recruitment events caused by disturbance
- canopy cover is dense and extensive, covering all available habitat.

Water quality tests at mangrove sites were conducted when most of the mangrove forest was tidally inundated (**Site 01 and Site 02**, **Figure 2**). Water salinity was high (35-36 ppt) and similar to sea water. Biological Oxygen Demand (BOD) was low ($\leq$2 mg/L), indicating little organic matter. Suspended solids was variable but high (14-60 mg/L). Ammonia concentration was high at both sites (0.16-0.20 mg/L) and greatly exceeded ANZECC Guideline trigger values for South-east Australian estuaries. Total phosphorus concentration was also above guidelines at Site 01 (0.07 mg/L). Complete water quality results are in **Appendix B**.

Site photos for mangroves are in **Appendix C**. An impact assessment for mangroves is provided below in **Section 4.5**.

Saltmarsh

Saltmarsh is uncommon along the southern shore of the estuary. It occurs in two locations near the Culburra Wastewater Treatment Plant. The larger of the two patches (**Site 05**) is mostly bare sediment with *Sporobolus virginicus* (Saltwater Couch) and scattered *Avicennia marina* (Grey Mangrove) in the tidal inundation zone; and *Juncus kraussii* subsp. *australiensis* (Sea Rush) and *Casuarina glauca* (Swamp Oak) along the fringes. This mix of species forms a 'Low Saltmarsh' community (as described in Sainty et al. 2012). The bare sediment has abundant crab burrows, an indicator of a healthy environment. 'Low Saltmarsh' depends on a mix of tidal inundation for its competitive advantage, plus freshwater input to promote germination. Saltmarsh communities may be influenced by complex groundwater interaction and local soil chemistry, which is beyond the scope of this study.

Water quality tests at the saltmarsh site were conducted while it was tidally inundated (**Site 05**, **Figure 2**). Water salinity was high (35 ppt) and similar to sea water. Biological Oxygen Demand (BOD) was low (3 mg/L), indicating little organic matter. Suspended solids was high (48 mg/L). Ammonia concentration was high (0.22 mg/L) and greatly exceeded ANZECC Guideline trigger values for South-east Australian estuaries. Total phosphorus concentration was also above guidelines (0.06 mg/L). Unlike the other seven sites in mangroves and seagrass, nitrate (0.04 mg/L) and total nitrogen (0.5 mg/L) concentrations were high and above guidelines. Complete water quality results are in **Appendix B**.

Site photos for saltmarsh are in **Appendix C**. An impact assessment for saltmarsh is provided below in **Section 4.5**.

4.2 Key fish habitat

DPI Fisheries identify three types of 'key fish habitat' in their *Policy and Guidelines for Fish Habitat Conservation and Management* (Fairfull 2013) (**Appendix D**): **TYPE 1** (highly sensitive aquatic habitat); **TYPE 2** (moderately sensitive key fish habitat); and **TYPE 3** (minimally sensitive key fish habitat). All three key fish habitats are present in the study area:

- **TYPE 1**
  - *Zostera seagrass bed (>5 m^2)*
  - *Coastal saltmarsh (>5 m^2)*
  - *SEPP 14 coastal wetland*
- **TYPE 2**
  - *Zostera seagrass bed (<5 m^2)*
  - *Mangroves*
  - *Stable intertidal sand/mud flats with large populations of infauna*
- **TYPE 3**
  - *Unvegetated sand or mud substrate with minimal or no infauna*

4.3 Threatened species, communities and populations

Database searches for threatened species, communities and populations within the study area are listed in **Appendix E**. Of the species known in the region, many are unlikely to use the estuary due to unsuitable habitat (e.g. shallow marine water not suitable for large mammals). While other species may opportunistically and infrequently pass through the study area whilst exploring or grazing (e.g. turtles), their habitat is unlikely to be adversely impacted by the development. Likelihood of the main groups of **threatened** aquatic fauna to occur in the area are:

- Fish – unlikely as no suitable habitat, or no records in catchment
- Sharks & rays – sharks unlikely to come this close to shore in shallow water; rays may pass through, but there is ample foraging habitat throughout the estuary
- Turtles – may briefly explore area, especially in seagrass beds
- Whales & dolphins – too shallow, unlikely this close to shore.

One threatened ecological community occurs in the study area. Two patches of "Subtropical and Temperate Coastal Saltmarsh" occur near the Culburra Wastewater Treatment Plant. Saltmarsh will not be directly impacted by the proposed development.

No threatened plant species were observed in the study area.

4.4 Comments on the 'Estuarine Processes Modelling Report'

Existing conditions

The *Estuarine Processes Modelling Report* (EPMR) (Martens and Associates 2016a) describes the existing conditions in the estuary based on the modelled results:

- For the average rainfall year the Crookhaven River is frequently above ANZECC (2000) trigger criteria for TN and TP in estuaries (0.300 mg/L and 0.030 mg/L respectively), and is therefore considered a disturbed ecosystem with compromised health in existing conditions
- Significant freshening and high nutrient / solids concentrations occur during infrequent storm events. The 1st percentile salinity concentrations and 99th percentile TN, TP and TSS

concentrations (i.e. levels for approximately 3 days per year) in impact assessment scenarios show:

- 1st percentile salinity concentrations falling below 2500 mg/L in an average year and falling as low as 1000 mg/L in a wet year
- 99th percentile TN concentrations of up to 0.70 mg/L in an average year and over 1.00 mg/L in a local wet month
- 99th percentile TP concentrations of up to 0.135 mg/L in an average year
- 99th percentile TSS concentrations of over 40 mg/L in an average year and over 60 mg/L in a local wet month.

- The estuary quickly recovers from stormwater runoff impacts due to tidal flushing and natural concentration fluctuation within the system.

ELA agrees with Martens and Associates' findings and concludes the overarching status is that the Crookhaven River is a disturbed ecosystem with compromised health in existing conditions. ELA's water quality sampling is in line with the modelled findings and confirms the Crookhaven River is above ANZECC trigger criteria at most sample locations. Modelled and observed background concentrations are high, and the model demonstrates extreme short duration runoff events increase estuarine concentrations of nutrients and TSS even further past ANZECC criteria. Despite this, the system still supports commercial aquaculture and reasonably healthy marine vegetation as validated in this study. This demonstrates the resilience of the marine vegetation in surviving despite the pressures of stormwater runoff from the developed catchment, which includes dairy farming and residential use, and can likely be attributed to the large degree of tidal flushing.

Proposed conditions

The EPMR assessed the potential impacts to water quality under 16 developed case scenarios. Statistical analyses and review of maximum spatial concentrations were used by Martens and Associates to develop an impact assessment. Their assessment identified that:

- Changes to estuarine concentrations due to the proposed development are negligible, even in infrequent storm events.
- The magnitudes of changes to estuarine concentrations due to the proposed development are insignificant compared to the large degree of natural concentration fluctuation which occurs under existing conditions.
- The pollutant masses from the proposed development are minor compared to those from the existing Culburra village (suburbs of Culburra Beach and Orient Point), where development often includes seawalls and clearing along the foreshore (unlike the proposed subdivision which aims to protect marine vegetation).
- The vast majority of site impact plumes are limited to foreshore areas immediately adjacent to site outlet locations.
- There are many instances of positive changes to estuarine concentrations which are consequences of the effectiveness of proposed treatment measures and the controlled discharge of stormwater.

Martens and Associates produced impact plots which show the change in minimum / maximum concentration for one hour out of the simulated year / month. Threshold triggers were applied to each variable (100 mg/L change in salinity, 1 µg/L for TN / TP, and 100 µg/L for TSS). The plots represent changes at very low thresholds in extreme, short term events (i.e. one hour out of the year), resulting in a limited assessment over a longer term. It is unlikely such short sporadic changes in water quality

would impact an aquatic ecosystem evolved to respond to dynamic fluctuations in environmental conditions (i.e. tides, temperature, light, salinity and sedimentation). For example, changed discharge regimes due to the proposed development may slightly increase the absolute maximum concentration over a single hour, but the results of the statistical analysis demonstrate developed scenarios have no change to mean / median concentrations, and no material long-term sustained changes in 90th, 95th and 99th percentile conditions.

Given the large range of 'pollutant' concentrations the estuary experiences over the course of a year and even over a single tidal cycle, the magnitude of localised changes to minimum / maximum concentrations in one hour per year is insignificant to the processes supporting a healthy aquatic ecology. In such dynamic systems, persistence of a 'pollutant' in unacceptable concentrations may compound to a negative impact over the long term. Results showing a sporadic spike across a year does not correlate to a threat to ecological health. This is pertinent to estuarine vegetation that has evolved to have a competitive advantage in dynamic environmental conditions, and is somewhat resilient to short-term extreme pressures. The dominant species found in this estuary are typically robust, reasonably healthy and are not likely to be impacted by short-term changes in water quality: *Zostera capricorni* (Ribbonweed), *Avicennia marina* (Grey Mangrove), *Sporobolus virginicus* (Saltwater Couch), *Juncus kraussii* subsp. *australiensis* (Sea Rush) and *Casuarina glauca*.

ELA concludes the minimum / maximum impact plots do not represent a valid assessment of potential impacts to aquatic ecology. Rather, the statistical analysis should be used as the primary impact assessment tool, and for this reason ELA requested Martens and Associates extract additional data from the models to inform a further statistical analysis specific to ELA's study.

The EPMR concludes that there will be no detrimental impacts on estuarine health due to the proposed development. The following section tests that conclusion, specifically addressing environmental tolerances of marine vegetation.

4.5 Model results

ELA has considered the development layout and results of MUSIC and TAD models provided by Martens and Associates. Based on these, ELA has assessed the 'tests' outlined in **Section 3.4** as follows:

Seagrass tests

Is a stormwater outlet/channel proposed in/adjacent to the seagrass?

> There is no direct discharge of stormwater into the estuary. All stormwater discharged from proposed infiltration basins shall be via a level spreader/energy dissipater with outflow into the retained 100 m vegetated buffer zone adjacent to the estuary.

Will salinity near seagrass fall below 10 and 20 ppt, and for what duration?

> Modelled salinity concentrations at the five seagrass sample points (**Figure 2**) have been extracted from the estuarine processes model for each of the 32 scenarios (**Appendix F**). Detailed results from four of the modelled scenarios are presented to address this question:
>
> - [M01] – Existing conditions with infiltration
> - [M09] – Proposed conditions with infiltration
> - [M17] – Existing conditions without infiltration
> - [M25] – Proposed conditions without infiltration

These four scenarios are for an 'average' rainfall year (1967 data) and use calibrated dispersion coefficients (D1), as detailed in the EPMR (Martens and Associates 2016a). **Appendix F** - **Figure 1** plots salinity concentrations for each of the five sample points and each of the four models, and demonstrates that predicted salinity concentrations at each sample point and for each scenario match very closely. Salinity concentrations in all scenarios fall below 20 g/L during seven 'events', and fall below 10 g/L during four 'events'. **Appendix F** - **Figure 2** shows a detailed view of salinity concentrations at one sample point (SG08) for one event ('event 3') and demonstrates there are practically no differences between the four modelled scenario results.

Appendix F - **Table 1** summarises durations below 20 g/L and 10 g/L for each event, using the approximate average duration for all sample points. Durations of salinity concentration <20 g/L range from 6 to 28 days, with a total of 110 days over the modelled average year (i.e. 30% of the year). Durations of salinity concentration <10 g/L range from 1.5 to 12.5 days, with a total of 37 days over the modelled average year (i.e. 10% of the year). The proposed development is not predicted to increase the duration of salinity concentrations being below 20 g/L and 10 g/L at any seagrass location.

Will suspended solids increase during rain events, especially in spring-summer?

Detailed MUSIC modelling indicates average annual load of total suspended solids (TSS) delivered to mapped seagrass areas will be reduced by 14%, from 11,139 kg/year to 9,557 kg/year.

Throughout the consultation process, the Department of Planning's peer reviewer has suggested that water quality modelling should bypass any infiltration, untreated, to the model outlet node – thereby ignoring the natural processes that will occur within the 100 m wide vegetated buffer zone. MUSIC sensitivity analysis indicates that a reduction in suspended solids load to seagrass areas is still achieved under the scenarios suggested by the reviewer, with a reduction from 12,089 kg/year to 11,163 kg/year (8%) when comparing pre and post-development scenarios.

TSS concentrations at the five seagrass sample points have been extracted from each of the 32 models, with statistical analyses summarised in **Appendix F - Table 3 to Table 18**. Results of all 32 model scenarios indicate there are no significant annual increases (<0.5% change) in TSS concentrations at the seagrass sample points due to the proposed development. This annual result does not warrant further tests into variation among months or seasons.

Will suspended solids increase during construction and operation?

Detailed MUSIC modelling indicates that during operation the proposed stormwater management treatment train achieves a 14% reduction of suspended solids discharged to seagrass areas and an 18% reduction (12,319 kg/year to 10,067 kg/year) in suspended solids discharged to the Crookhaven River.

In accordance with industry best practice, Landcom (2004) is the criteria for site management and water quality treatment during the construction phase of development. Sediment and erosion control measures for the site have been designed in accordance with these guidelines. Construction shall be staged and each stage shall include sedimentation basins, energy dissipaters, earth diversion bunds, sediment fences, stabilised site entry and revegetation. Suspended solids will increase during construction within the developed land, however, runoff would be treated by these onsite measures prior to discharge into the vegetated buffer strip and thence to the estuary and seagrass areas.

Regular monitoring and maintenance of construction and operational phase water quality treatment structures would be in accordance with Martens and Associates (2016c) *Water Quality Monitoring Plan*. Monitoring shall assist in mitigating failure and potential impact to seagrass areas

Will nutrient concentrations be higher than normal, especially in spring-summer, and for how long?

Predicted total nitrogen (TN) and total phosphorous (TP) concentrations at each of the five seagrass sample points have been extracted from each of the 32 model scenarios, with statistical analyses summarised in **Appendix F - Table 3 to Ta ble 18**. Results indicate the changes to TN or TP concentrations at the seagrass sample points due to the proposed development throughout the year are negligible (see discussion below). This annual result does not warrant further tests into variation among months or seasons.

Seagrass discussion

For each of the 32 model scenarios tested for change in TSS, TN, TP and salinity at the five seagrass locations, five concentration statistics were used (median, mean and 90th / 95th / 99th percentile concentrations). This gives a total of 1,600 impact statistics. Of the 1,600 impact statistics, the maximum impact due to the proposed development is a 1.5% (0.4 µg/L) increase to the median TP concentration at seagrass Site 03 over the course of a month. This occurs when comparing [M23] and [M31] (**Appendix F - Ta ble 17**), which are modelled 'without infiltration' and with D2 (lower bound) dispersion coefficients, in conjunction with an extreme wet month over Culburra and the site with no other catchment inflows. This is the most unlikely combination of scenarios assessed, and the scenario most likely to 'model' adverse impacts. The EPMR describes the improbability/impracticality of these conditions occurring simultaneously (if ever). Despite this being the most extreme change to model variables assessed, changes to estuarine concentrations due to the proposed development are of immaterial significance and do not push concentrations over ANZECC Guideline triggers for estuarine waters (ANZECC & ARMCANZ 2000).

Of the 1,600 impact statistics for TSS, TN, TP and salinity, there are two instances of concentration impacts between 1 - 2% change, and eight instances of impacts between 0.5 - 1.0% change, which are also considered negligible.

The majority of statistics demonstrate no impact (<0.5% change), with many changes demonstrating improvement of estuarine concentrations (slightly increasing salinity and slightly decreasing TN / TP / TSS) due to:

- The effectiveness of the proposed treatment measures in reducing the concentrations of stormwater pollutants from the development site.
- The reduced peak stormwater runoff flow rates due to discharge control measures incorporated into the proposed treatment train.

There are no significant changes to mean / median concentrations or extreme concentrations (90th / 95th / 99th percentile). The inclusion or exclusion of infiltration in the MUSIC assessment has no significant impact on the estuary water quality outcome predicted by the model. Modelling concludes that the proposed development will not affect long-term concentrations or short-term discharge concentrations near seagrass.

The magnitudes of changes to estuarine concentrations due to the proposed development are considered insignificant compared to the large degree of fluctuation in natural concentrations. Regardless of the combination of scenarios assessed, there would not be any material impacts on seagrass health due to the proposed development, as concentration changes in TSS, TN, TP and salinity are negligible.

Mangrove tests

Does the proposal inhibit tidal movement to the mangroves?

No foreshore earthworks or structures are proposed that would affect tidal movement or exchange. A single viewing platform is proposed in the foreshore area east of the Culburra Sewage Treatment Plant (**Figure 1**), but this is outside the current SEPP 14 wetland areas and is not considered to be a structure that would affect tidal movements.

Does the proposal result in an increase in suspended solids and/or sediment and would this be deposited in the mangrove?

Detailed MUSIC modelling indicates average annual load of suspended solids delivered to the Billys Island inlet (area of SEPP 14 wetlands and mangroves) will be reduced by 57%, from 1,180 kg/year to 510 kg/year. Mangroves often occur in areas where natural sedimentation occurs, and they may be dependent on some sediment deposition. TAD modelling presented in the EPMR shows that mean / median TSS concentrations at the mangroves across the 32 scenarios do not reduce by more than 1% (0.3 mg/L) due to the proposed development, which indicates that changes to sediment deposition from the immediate upslope catchment are negligible compared to the natural estuary depositions. The change in surface runoff loads modelled for the development change is therefore not significant in the context of the requirements of the community.

In accordance with industry best practice, Landcom (2004) is the criteria for site management and water quality treatment during construction phase of development. Sediment and erosion control measures for the site have been designed in accordance with these guidelines. Construction shall be staged and each stage shall include sedimentation basins, energy dissipaters, earth diversion bunds, sediment fences, stabilised site entry and revegetation. Suspended solids will increase during construction, however, overland flows shall be treated by these onsite measures prior to any discharge into the estuary.

Regular monitoring and maintenance of construction and operational phase water quality treatment structures would be in accordance with Martens and Associates (2016c) *Water Quality Monitoring Plan*. Monitoring shall assist in mitigating failure and potential sedimentation of mangrove areas.

Is the natural overland flow to the mangroves across a vegetated surface, or otherwise treated to avoid impacts from runoff?

The development has been designed to ensure pre-development flow rates discharging into the wetlands are maintained. Iterative hydrological modelling has been used to determine the post development catchment area required to achieve this for the 1 in 2, 10, 20 and 100 year ARI storm events. A 100 m wide vegetated buffer zone shall be retained between the development and the estuary (and mangroves) to further maintain natural overland flow.

Is a stormwater outlet/channel proposed in the mangroves?

There is no direct discharge of stormwater into the estuary. All stormwater discharged from proposed end-of-line infiltration basins shall be via a level spreader/energy dissipater into the retained 100 m wide vegetated buffer zone before entering the estuary. In the vicinity of the SEPP 14 wetlands, the infiltration basin has been designed to have an elongated outlet weir to ensure even dispersal of discharged flow.

Will predicted sea level rise reach artificially raised areas of the development?

Using the suggested website (http://coastalrisk.com.au/viewer), the model predicts that maximum sea level rise predictions for 2100 plus highest tide does not reach the development **Figure 3**.

Figure 3: Sea level rise predictions for 2100 plus high tide (http://coastalrisk.com.au/viewer)

Mangrove discussion

The development would continue to allow freshwater flows across a vegetated buffer before entering the mangroves, whilst preventing excessive sedimentation of the mangrove flats. This design feature is preferable to diverting water through centralised outfalls (stormwater channels). As discussed in the seagrass tests, salinity in the estuary will resemble natural fluctuations under any modelled scenario. Therefore, the models produced by Martens and Associates demonstrate that processes favouring mangrove survival would be maintained, and the proposed development would not cause a negative impact to the mangrove forest.

DPI Fisheries commented on a draft planning proposal and raised concerns that sediment plumes may enter the estuary during earthworks. Fine sediment (especially disturbed clay) would pass through sediment fences erected around the construction site, however this is a tertiary treatment measure which would be minimised due to the proposed controlled capture and treatment of all runoff via sedimentation basins and flocculation (if necessary) before being released to the vegetated buffer zone. Assuming the measures detailed in the Water Quality Monitoring Plan (Martens and Associates, 2016c) are implemented, the construction phase works are unlikely to release fine sediments to the estuary. This is especially important for protection of not only mangroves, but the broader aquatic ecology where filter feeders (oysters), benthic biota and fish all rely on clean estuary water.

Saltmarsh tests

Does the proposal inhibit tidal movement to the saltmarsh?

A proposed viewing platform is located in the vicinity of mapped saltmarsh. However, the ramp is unlikely to inhibit tidal movement.

Is the natural overland flow to the saltmarsh across a vegetated surface, or otherwise treated to avoid impacts from runoff?

Given the location of the existing STP, development as part of this project is limited in the vicinity of the mapped saltmarsh. Overland flow from developed areas shall be treated within the proposed stormwater treatment train and the 100 m wide vegetated zone before discharging into the estuary. Modelling indicates a neutral or beneficial effect on water quality is achieved. Overflow from proposed infiltration basins shall be via a level spreader/energy dissipater across the buffer vegetation before entering the estuary.

Is a stormwater outlet/channel proposed in or adjacent to the saltmarsh?

There is no direct discharge of stormwater into the estuary. No stormwater outlets/channels are proposed in or adjacent to the saltmarsh.

Will predicted sea level rise reach artificially raised areas of the development?

As per response under *Mangroves* the model predicts that maximum sea level rise predictions for 2100 plus highest tide does not reach the development (**Figure 3**).

Saltmarsh discussion

The proposed development design and modelling indicates a neutral or beneficial effect on water quality is achieved. No works are proposed in the saltmarsh or influence the natural processes for survival (tidal movement and freshwater inflows). Therefore, the development would not have any direct or indirect impact to saltmarsh patches near the development.

4.6 Legislation compliance

The above impact assessment demonstrates there is unlikely to be a significant impact to threatened species, populations or communities listed under the FM, TSC and EPBC Acts. As such, a Species Impact Statement is not required.

The modelling demonstrates that under any tested scenario, there would be very little change between pre and post-development. Marine vegetation appears reasonably healthy and has established under numerous catchment pressures. The modelled post-development scenarios would not alter essential environmental conditions those species currently depend on, nor would it compound existing catchment pressures regarding TP, TN, TSS and salinity concentrations. As such, there would be no significant harm (directly, indirectly or cumulatively) to marine vegetation or other key fish habitat in the estuary.

Based on the review of applicable legislation and the impact assessment undertaken, we conclude the proposed development meets the legislation criteria and is not expected to cause impacts to estuarine ecology.

5 Conclusion

There is **not** likely to be a significant impact on threatened species, populations, ecological communities or their habitats; and a Species Impact Statement is **not** required, nor is a referral to a Commonwealth body. Future Development Applications to Council would require further assessment if foreshore structures require permits under 7 of the FM Act (e.g. *Harm Marine Vegetation* or *Dredging and/or Reclamation* for the viewing platform).

The water quality and estuary model results provided by Martens and Associates indicate that natural processes supporting marine vegetation will be maintained and would replicate natural conditions under any tested development scenario. By protecting the key fish habitats in the estuary (discussed in **Section 4.2**) there is minimal anticipated impact to aquatic fauna.

The healthy condition of marine vegetation indicates it is tolerant to numerous existing catchment pressures (e.g. dairy farming, residential use). Modelled changes in salinity, nutrients and suspended solids demonstrate an insignificant change between existing and proposed land use. This is the case irrespective of the inclusion of infiltration in the MUSIC model. Our review of the ecology of the estuary and of the model outputs concludes that the proposed subdivision would not alter the health, extent or values of the estuarine aquatic ecology.

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Appendix A: Environmental tolerances

This section outlines a literature review of environmental tolerances for marine vegetation identified in the Crookhaven River and the potential impacts of urban development on these vegetation types. From this review a number of questions were formed in order to assess the impacts of the West Culburra proposed mixed use subdivision. These questions are provided in **Section 3.4** and answers are provided in **Section 4.5**.

Seagrass

Zostera marina (Ribbonweed) is a seagrass common in estuaries because of their ideal conditions for growth, such as nutrient loads, tidal flushing and calm conditions. This species generally grows on soft sediment up to depths of 4 m if adequate light is available (low turbidity). Seagrass is best adapted to seawater salinity (35 ppt) but can tolerate and grow for short periods in brackish (near fresh) or hypersaline (60 ppt) waters (Sainty et al 2012). Most seagrasses cannot withstand long periods of those extreme salinity conditions. *Halophila ovalis* (Paddleweed) is likely to occur in the estuary, and can grow in salinities between 10 to 40 ppt (Hillman et al 1995). This species has been observed to become stressed after four weeks at 10 ppt (Benjamina et al. 1999).

Seagrasses provide many functions in the ecosystem (nutrient cycling, shelter, food, etc) and also support small plants and sessile animals that grow on their leaves and stems, called epiphytes. These epiphytes are also important as a food source for other animal and for uptaking nutrients from the water. However, a higher than normal nutrient load may cause excessive growth of epiphytes, causing dense shade to the leaf they are attached to. Seagrasses are more tolerant to shading in winter than in summer or spring. But, once the shading kills the seagrass leaf, it detaches and decomposes on the sea floor. This decomposition causes an increase in aerobic bacteria, and hence oxygen use. Consequently, when oxygen is depleted, anaerobic bacteria (bacteria that do not require oxygen) take over and kill other benthic animals as the bottom becomes bare with a thick black anaerobic layer containing hydrogen sulphide (Sainty et al. 2012; Lee et al. 2007; Nelson 2017). We have observed this black ooze in other estuaries at stormwater channel outlets, large near-shore areas and where seagrass wrack has sunken if steep banks prevent it from being washed ashore (e.g. Tuggerah Lakes). Excessive leaf litter discharged from the catchment can also cause anoxic conditions, especially if deciduous street trees release a large volume of leaves over a short period.

Impacts to seagrass as a result of urbanisation are commonly attributed to erosion and siltation (smothering beds or causing turbid water), and high nutrient concentrations causing excessive epiphyte growth (especially inorganic nitrogen – sum of nitrate and ammonia). The Simple Estuarine Response Model (CSIRO 2002 - http://www.per.marine.csiro.au/serm/indicators.htm) uses 22 indicators that reflect the state of an estuary. Those indicators relevant to this assessment are shown in **Table 3**.

In an unrelated study in tropical water, Doorn-Groen & Foster (2007) developed impact guidelines based on concentration and duration of suspended sediment and sedimentation in high background environments (i.e. those already with high sediment) (**Table 4**). We have not found similar threshold guidelines for temperate seagrass.

Seagrass requires specific depth and light conditions to survive. *Zostera marina* is tolerant of a range of environmental conditions, but may become stressed under prolonged changes (e.g. weeks at very low salinity, turbid water, or after higher than usual nutrient loads). In regards to impacts of urban development to estuary seagrass, the most foreseeable issues are related to turbidity (suspended solids), polluted water, freshwater inflows and high nutrient concentrations. If development does not increase turbidity, sedimentation and nutrients for extended periods of time, then seagrass quantity and quality within should be retained.

Table 3: Six of the twenty two indicators that define the state of an estuary (CSIRO 2002)

Limits	Dissolved inorganic nitrogen (mg/m^3)	Dissolved inorganic phosphorus (mg/m^3)	Total nitrogen (mg/m^3)	Total phosphorus (mg/m^3)	Total suspended solids (g/m^3)	Salinity (PSU)
Very Low	1-30	3-10	100-200	10-30	0.1-0.5	0-10
Low	30-60	10-20	200-400	30-60	-	10-20
Moderate	60-180	20-60	400-1200	60-180	0.5-10	20-30
High	180-3000	60-1000	1200-3000	180-1000	10-100	30-40

Table 4: Sediment thresholds used in a tropical seagrass monitoring study (Doorn-Groen & Foster 2007)

Table III. Impact severity matrix for suspended sediment impact on Seagrass in high background environments

Severity	Definition (excess concentrations)
No Impact	Excess Suspended Sediment Concentration > 5 mg/l for less than 20% of the time
Slight Impact	Excess Suspended Sediment Concentration > 5 mg/l for more than 20% of the time Excess Suspended Sediment Concentration > 10 mg/l for less than 20% of the time
Minor Impact	Excess Suspended Sediment Concentration > 25 mg/l for less than 5% of the time
Moderate Impact	Excess Suspended Sediment Concentration > 25 mg/l for more than 20% of the time Excess Suspended Sediment Concentration > 75 mg/l for less than 1% of the time
Major Impact	Excess Suspended Sediment Concentration > 75mg/l for more than 20% of the time

Table IV. Impact severity matrix for sedimentation impact on Seagrass in high background environments

Severity	Definition (Excess sedimentation)
No Impact	Sedimentation < 0.1 $kg/m^2/day$ (<0.25 mm/day)
Slight Impact	Sedimentation < 0.25 $kg/m^2/day$ (<0.63 mm/day)
Minor Impact	Sedimentation < 0.5 $kg/m^2/day$ (<1.25 mm/day)
Moderate Impact	Sedimentation < 1.0 $kg/m^2/day$ (<2.5 mm/day)
Major Impact	Sedimentation > 1.0 $kg/m^2/day$ (>2.5 mm/day)

Mangroves

Avicennia marina (Grey Mangrove) is one of the most tolerant mangroves to changes (or temporary extremes) in salinity, aridity, water temperature and frost frequency (Nguyen 2015). Environmental tolerances of *A. marina* and other mangroves are documented in several articles, but with notable variance in some results (possibly due to difference in local environmental character):

- *A. marina* can withstand short periods of inundation by freshwater or hypersaline water (salinity exceeding that of seawater). However, they are susceptible to extended periods of waterlogging, with death occurring within 14 days (DAF Qld 2017).
- Mangrove seedlings were successfully established in experiments at salinities of 0, 5, 15, 25 and 35 ppt for *A. marina*, while salinities over 25 ppt significantly reduced the values of *Aegiceras corniculatum* (River Mangrove) (Ye et al. 2005).
- Growth of established *A. marina* in 0-2 ppt salinity was so poor that plants were unlikely to reach reproductive maturity; and *A. marina* seedlings failed to grow in 0-2 ppt salinity. Growth was maximal in 18-26 ppt saline water (Nguyen et al. 2015).
- *A. marina* growth was similar in freshwater and 100% seawater (35 ppt). *A. corniculatum* growth was significantly lower in 35 ppt seawater than in tap water (Burchett et al. 1989).
- Mangroves are able to withstand gradual sediment accumulation, as part of their natural dynamic state. However, acute increases in sedimentation due to natural or anthropogenic dumping of material can result in burial of pneumatophores (aerial roots), reducing their ability to supply oxygen to the root system. The most sensitive components to sedimentation impacts are seedlings and pneumatophores, as both have a relatively small vertical extent and therefore may be partially or fully buried by high sedimentation rates within a short period of time (Chevron 2010).
- Mangroves with pneumatophore root systems are only likely to be stressed when prolonged sedimentation reaches levels from 10-30 cm (Doorn-Groen & Foster 2007).
- Sedimentation impact on *A. marina* varied from stressed (5 cm sediment deposition) to death (20 cm sediment deposition), with various impacts at greater sediment depths in different locations (Chevron 2010).

In regards to sea level rise, a notable constraint to mangrove survival is whether mangrove assemblages can retreat landwards. Potential retreat is determined by numerous factors, including upslope topography (adjacent low gradient terrain required) and barriers to propagule and tidal movement (such as road batters, houses and fill).

Mangroves occupy a specific niche in the aquatic ecosystem, and are highly dependent on substrate type and grade, and intertidal movement. *A. marina* is tolerant to a range of water conditions, but is susceptible to impacts from sediment deposition and changed hydrology. *A. corniculatum* has a lower tolerance to salinity, and relies on freshwater input from the adjacent land (overland flows and groundwater).

In regards to impacts of urban development to estuary mangroves, the most foreseeable issues are related to hydrology, stormwater, contaminants and litter. If development does not alter the tidal regime or freshwater inflows, or release large volumes of sediment (and suspended solids) during construction and operation, then mangroves are unlikely to be impacted.

Saltmarsh

Saltmarsh consists of many species adapted to micro-topography in the high intertidal zone. Only those species known to occur in the study are included in this review. Environmental tolerances of *Sporobolus virginicus* (Saltwater Couch) are wide ranging, surviving between low-to-high waterlogging and low-to-high salinity (Sainty et al. 2012). The species is also tolerant of waterlogged acidic soils (Naidoo & Naidoo 1992). *Juncus kraussii* subsp. *australiensis* (Sea Rush) is also reported to tolerate low-to-high salinity levels; and waterlogging is rated as low-to-moderate/high (Sainty et al. 2012). However, the species is described in Saintalin (2009) as being able to withstand several months of continuous inundation around margins of lagoons (Adam 1981).

A shift in environmental factors may not directly harm these species (and generally other 'Low Saltmarsh' species), but may favour other wetland plants that outcompete saltmarsh. For example, increased waterlogging from sea level rise or continuous stormwater discharge may increase mangrove establishment in the saltmarsh. Also, increased depth from a constructed discharge channel, along with more regular freshwater inflows may favour brackish species such as *Phragmites australis* (Common Reed) and other reeds and rushes, including invasive species (Saintilan 2009). The resulting shift in species and physical structure can then influence local hydrology and deposition through trapping sediment and organic plant material. If saltmarsh can't establish in the new hydrology/topography and loses its competitive advantage, then the saltmarsh community may not survive.

In regards to sea level rise, a notable constraint to saltmarsh survival is whether it can retreat landwards. Potential retreat is determined by numerous factors, including upslope topography (adjacent low gradient terrain required) and barriers to propagule and tidal movement (such as road batters, houses and fill).

Saltmarsh occupies a specific niche in the aquatic ecosystem, and is the closest marine vegetation to the terrestrial interface. It is tolerant to a range of environmental conditions (salinity, waterlogging) and relies on a mix of tidal inundation and freshwater input. It is, however, susceptible to pressures from landside and waterside. In regards to impacts of urban development to estuary saltmarsh, the most foreseeable issues are related to hydrology, stormwater, contaminants, litter and weeds. If development does not alter the tidal regime of the saltmarsh, and does not intercept the current overland freshwater input, then the saltmarsh will retain its essential processes.

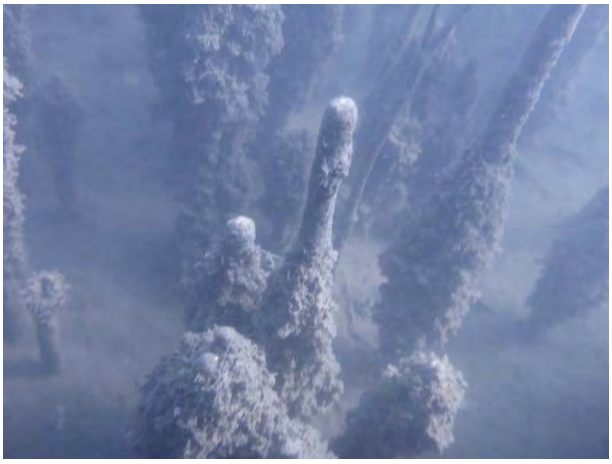
Appendix B: Water quality results

	Unit	Limit of reporting	ANZECC	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 07	Site 08
Date				13/12/16	13/12/16	13/12/16	13/12/16	13/12/16	13/12/16	13/12/16	13/12/16
Time				8:46	9:25	9:43	9:58	10:29	11:08	12:26	12:36
Habitat MG = Mangrove SM = Saltmarsh SG = Seagrass				**MG**	**MG**	**SG**	**SG**	**SM**	**SG**	**SG**	**SG**
Physiochemical											
Temperature	°C			22.72	22.23	22.48	22.07	24	23.48	24.51	24.53
pH	pH		7-8.5	7.59	8.02	8.06	8.08	7.73	7.95	7.93	7.9
Oxidation reduction potential	mV			92	97	110	118	121	170	133	148
pHmV	mV			-58	-83	-85	-87	-66	-79	-78	-77
Conductivity	mS/cm			53.5	54.8	54.5	55.1	53.7	54.1	53.7	53.3
Turbidity	NTU		0.5-10	8.7	5.2	6	9.4	16.5	16.1	21.2	34.8
Dissolved Oxygen	mg/L			3.66	5.58	6.06	6.64	5.45	6.15	5.76	5.71
Dissolved Oxygen	%		80-110	53.6	81.6	88.9	96.9	81.6	91.5	87	86
TDS	g/L			32.1	32.9	32.7	33.1	32.2	32.5	32.2	32
Salinity	ppt			35.3	36.2	36	36.5	35.4	35.8	35.5	35.2
Suspended Solids											
Suspended Solids	mg/L	5		**60**	**14**	**27**	**58**	**48**	**32**	**42**	**139**
Nutrients											
Ammonia as N	mg/L	0.01	0.005	**0.20**	**0.16**	**0.17**	**0.18**	**0.22**	**0.17**	**0.16**	**0.16**
Nitrite as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	**0.04**	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.005	<0.01	<0.01	<0.01	<0.01	**0.04**	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1		<0.5	<0.5	<0.5	<0.5	**0.5**	<0.5	<0.5	<0.5
Total Nitrogen as N	mg/L	0.1	0.3	<0.5	<0.5	<0.5	<0.5	**0.5**	<0.5	<0.5	<0.5
Total Phosphorus as P	mg/L	0.01	0.03	**0.07**	<0.05	<0.05	**0.14**	**0.06**	**0.12**	<0.05	**0.22**
Reactive Phosphorus as P	mg/L	0.01	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Biochemical Oxygen Demand (BOD)											
BOD	mg/L	2		**2**	<2	<2	<2	**3**	<2	<2	<2

Appendix C: Site photos





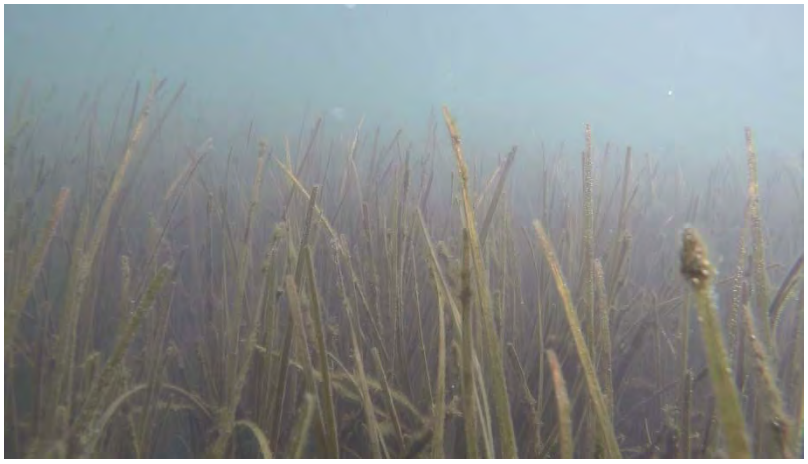



Site 01 - Mangroves






Site 02 - Mangroves



Site 03 – Seagrass

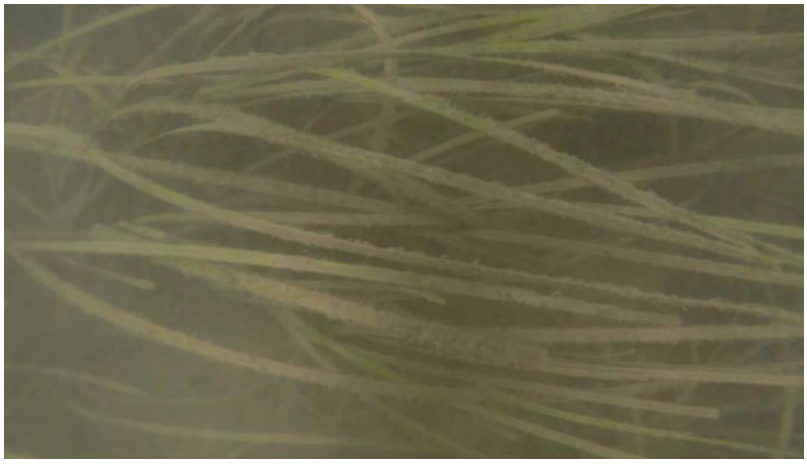
Site 04 – Seagrass

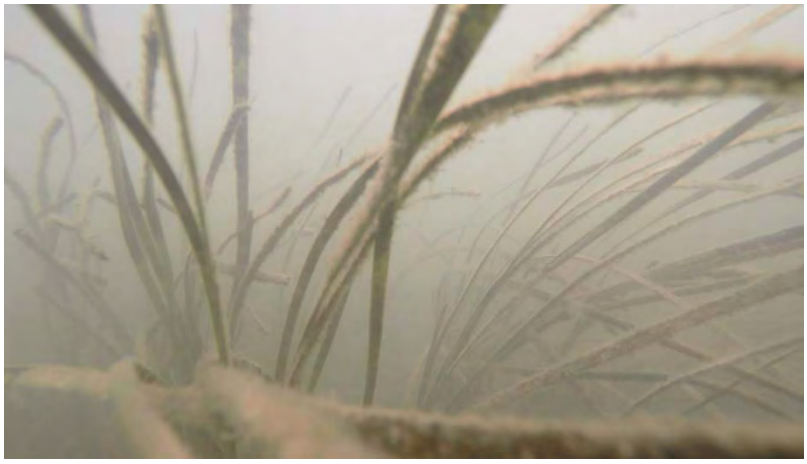


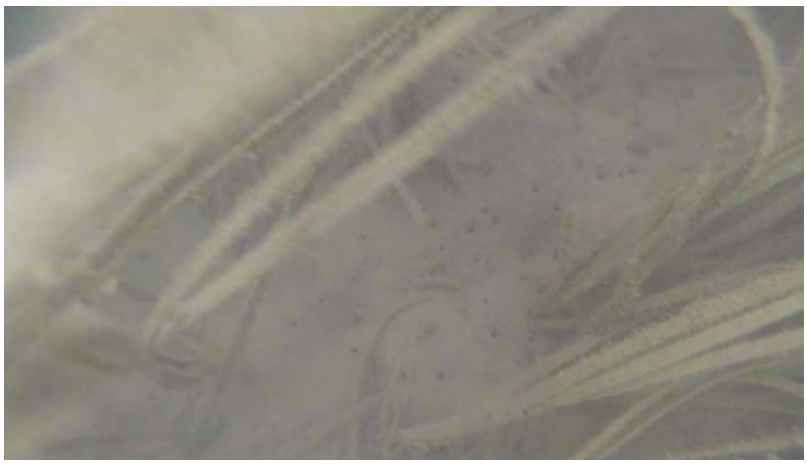



Site 05 – Saltmarsh

Site 06 – Seagrass







Site 07 – Seagrass

Site 08 – Seagrass

Appendix D: Key fish habitat types

TYPE 1 - Highly sensitive key fish habitat:

- *Posidonia australis* (strapweed)
- *Zostera, Heterozostera, Halophila and Ruppia* species of seagrass beds >5m^2 in area
- Coastal saltmarsh >5m^2 in area
- Coral communities
- Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)
- Marine park, an aquatic reserve or intertidal protected area
- SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia[2]
- Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants
- Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act
- Mound springs

TYPE 2 – Moderately sensitive key fish habitat:

- *Zostera*, *Heterozostera, Halophila* and *Ruppia* species of seagrass beds <5m^2 in area
- Mangroves
- Coastal saltmarsh <5m^2 in area
- Marine macroalgae such as *Ecklonia* and *Sargassum* species
- Estuarine and marine rocky reefs
- Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan)
- Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area
- Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna
- Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1
- Weir pools and dams up to full supply level where the weir or dam is across a natural waterway

TYPE 3 – Minimally sensitive key fish habitat may include:

- Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna
- Coastal and freshwater habitats not included in TYPES 1 or 2
- Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation

NSW key fish habitat types and associated sensitivity classification (from Fairfull 2013).

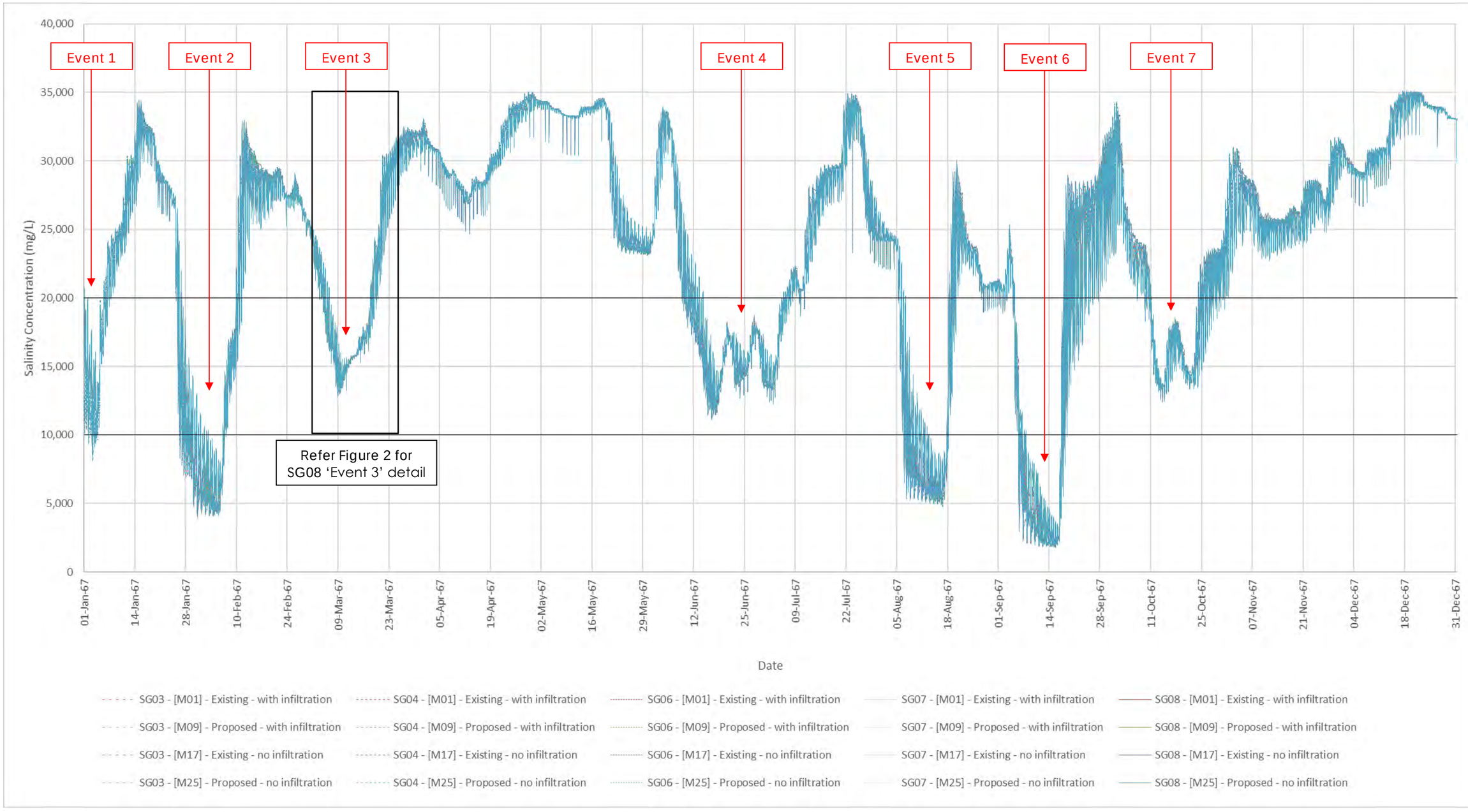
Appendix E: Threatened species likelihood of occurrence and impacts

If a species has suitable habitat present on site **AND** is likely to use this habitat **AND** the species or its habitat will be directly or indirect impacted, **THEN** an Assessment of Significance (7-part test) is required. Such species, if any, are highlighted in the table below. This list excludes terrestrial fauna, such as shorebirds and amphibians.

Species name	Common Name	FM Act Status	EPBC Act Status	Distribution overlaps	Habitat present	Species known to occur in region	Species known to occur on site	Likelihood of occurrence	Habitat on site directly or indirectly impacted	Impact Assessment Required?
Carcharias taurus	Grey Nurse Shark	E4A	CE	Yes	None	No	No	No	No	No
Carcharodon carcharias	Great White Shark	V	V, M	Yes	None	No	No	No	No	No
Epinephelus daemelii	Black Rockcod	V	V	Yes	None	No	No	No	No	No
Macquaria australasica	Macquarie Perch	E1	E	Yes	None	No	No	No	No	No
Prototroctes maraena	Australian Grayling	E1	V	Yes	None	No	No	No	No	No
Rhincodon typus	Whale Shark		V, M	Yes	None	Yes	No	No	No	No
Balaenoptera musculus	Blue Whale	E1	E, M	Yes	None	No	No	No	No	No
Caretta caretta	Loggerhead Turtle	E1	E, M	Yes	None	Yes	No	No	No	No
Chelonia mydas	Green Turtle	V	V, M	Yes	Marginal	Yes	No	Potential	No	No
Dermochelys coriacea	Leatherback Turtle	E1	E, M	Yes	Marginal	Yes	No	Potential	No	No
Eubalaena australis	Southern Right Whale	E1	E, M	Yes	None	Yes	No	No	No	No
Megaptera novaeangliae	Humpback Whale	V	V, M	Yes	None	Yes	No	No	No	No
Coastal saltmarsh	Saltmarsh	E1 (TSC)	V	Yes	Yes	Yes	Yes	Present	No	No

TSC Act: E1 = Endangered, E2 = Endangered Population, E4 = Extinct, E4A = Critically Endangered, V = Vulnerable
FM Act: E1 = Endangered, E2 = Endangered Population, E4 = Extinct, E4A = Critically Endangered, V = Vulnerable
EPBC Act: Bonn = Listed migratory species under Bonn Convention, CD = Conservation Dependent, CE = Critically Endangered, E = Endangered, V = Vulnerable, X = Extinct

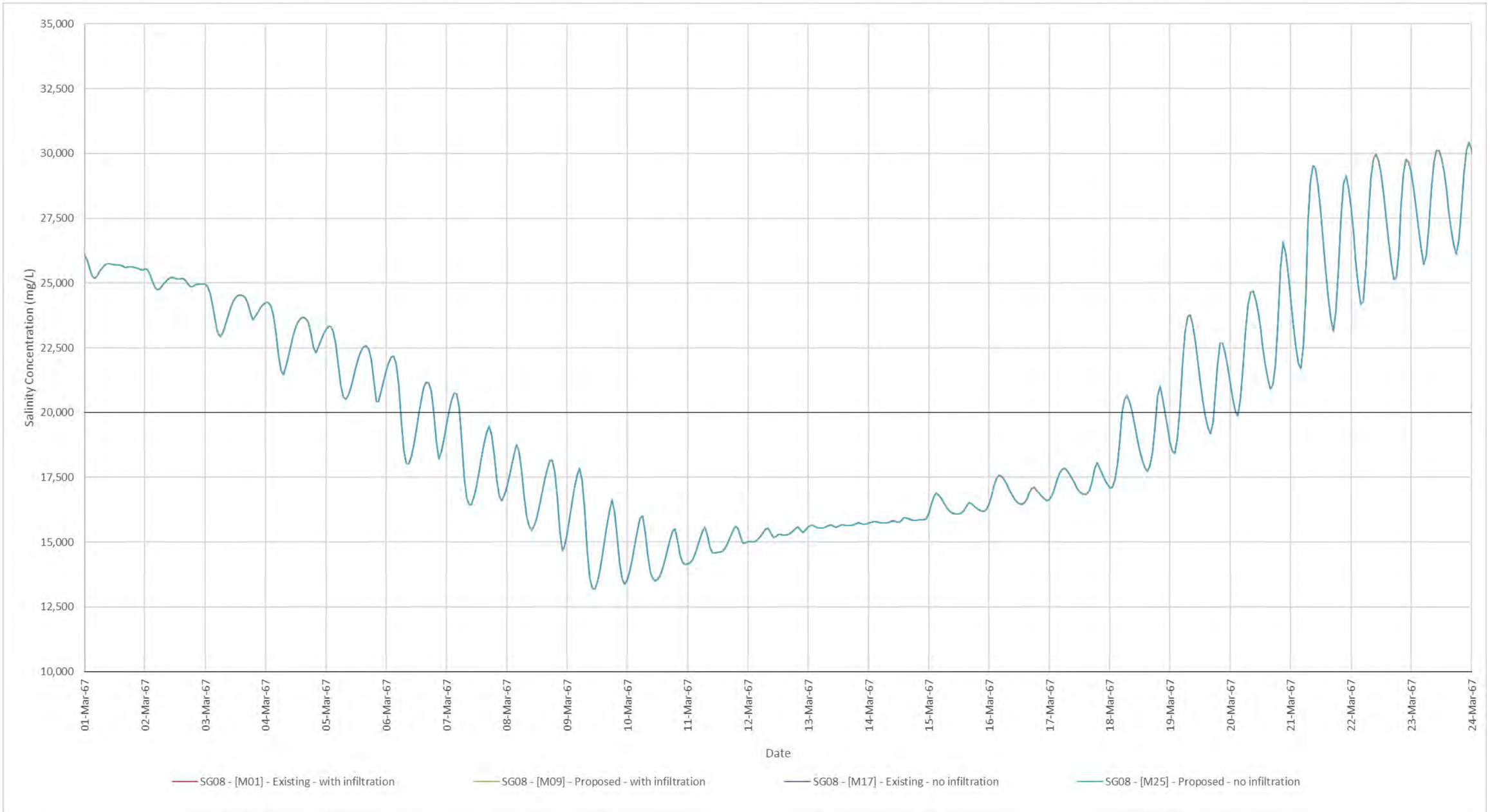
Appendix F: Modelled results



Notes
1. All results shown are for the 'average' year (1967) using calibrated (D1) dispersion coefficients.
2. The 4 models used for this assessment use parameters for existing / proposed conditions and with / without infiltration. Each model is displayed with the same colour.
3. Each Eco Logical seagrass sample point (SG03-SG08) is displayed with the same style.
4. 'Events' are defined by salinity concentrations falling below 20,000 mg/L.

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	DD	MODELLED SALINITY CONCENTRATIONS VS TIME AT ECO LOGICAL SEAGRASS SAMPLE POINTS OVER FULL SIMULATION PERIOD	Drawing No: FIGURE 1
Approved:	AN		
Date:	02.03.2017		
Scale:	NA		Job No: P1203365

martens



martens

Notes
1. All results shown are for the 'average' year (1967) using calibrated (D1) dispersion coefficients.
2. The 4 models used for this assessment use parameters for existing / proposed conditions and with / without infiltration.
3. Only the Eco Logical seagrass sample point SG08 is displayed in this figure.
4. 'Events' are defined by salinity concentrations falling below 20,000 mg/L.

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	DD	MODELLED SALINITY CONCENTRATIONS VS TIME AT ECO LOGICAL SEAGRASS SAMPLE POINT 08 **OVER 'EVENT 3'**	Drawing No: FIGURE 2
Approved:	AN		
Date:	02.03.2017		
Scale:	NA		Job No: P1203365

Table 1: Modelled durations (days) for salinity falling below 20 g/L and 10 g/L at Eco Logical seagrass sample points.

		Threshold											
		Salinity Concentration < 20 g/L						Salinity Concentration < 10 g/L					
		Scenario [1]											
		With Infiltration			Without Infiltration			With Infiltration			Without Infiltration		
		Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
		[M01]	[M09]	[M09] – [M01]	[M17]	[M25]	[M17] – [M25]	[M01]	[M09]	[M09] – [M01]	[M17]	[M25]	[M17] – [M25]
Event [2]	Date	Duration (days) [3]											
1	Jan 1967	6.1	6.1	0.0	6.1	6.1	0.0	1.6	1.6	0.0	1.6	1.6	0.0
2	Feb 1967	16.0	16.0	0.0	16.0	16.0	0.0	11.3	11.3	0.0	11.3	11.3	0.0
3	Mar 1967	13.4	13.4	0.0	13.4	13.4	0.0	– [4]	– [4]	– [4]	– [4]	– [4]	– [4]
4	Jun 1967	28.0	28.0	0.0	28.0	28.0	0.0	– [4]	– [4]	– [4]	– [4]	– [4]	– [4]
5	Aug 1967	14.5	14.5	0.0	14.5	14.5	0.0	11.9	11.9	0.0	11.9	11.9	0.0
6	Sep 1967	16.5	16.5	0.0	16.5	16.5	0.0	12.4	12.4	0.0	12.4	12.4	0.0
7	Oct 1967	15.3	15.3	0.0	15.3	15.3	0.0	– [4]	– [4]	– [4]	– [4]	– [4]	– [4]
	Total	109.8	109.8		109.8	109.8		37.2	37.2		37.2	37.2	

Notes

1. The 4 models used for this assessment use parameters for existing / proposed conditions and with / without infiltration. All 4 models are for the 'average' year (1967) using calibrated (D1) dispersion coefficients.
2. 'Events' are defined by salinity concentrations falling below 20 g/L and are displayed in Figure 2.
3. Approximate average duration for all Eco Logical seagrass sample points having a modelled concentration below 20 g/L and 10 g/L.
4. Salinity concentrations do not fall below 10 g/L for these 'events'.

Table 3: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), with infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M01] Existing Conditions Model Summary (mg/L)	Median	26489	25760	26036	25199	25092	0.272	0.274	0.272	0.279	0.281	0.026	0.027	0.026	0.028	0.028	25.0	25.1	25.1	25.3	25.3
	Mean	24038	23846	23865	23618	23559	0.277	0.290	0.277	0.309	0.314	0.027	0.030	0.028	0.034	0.035	25.2	25.6	25.1	26.2	26.3
	90th Percentile [3]	10344	11311	10946	12533	12789	0.288	0.316	0.291	0.380	0.395	0.030	0.035	0.031	0.048	0.051	25.4	26.2	25.6	27.5	27.9
	95th Percentile [3]	5387	5951	5495	7491	7756	0.301	0.376	0.308	0.482	0.508	0.033	0.048	0.035	0.071	0.078	25.9	27.9	26.1	31.0	31.8
	99th Percentile [3]	2317	2480	2238	3294	3491	0.347	0.535	0.380	0.710	0.751	0.044	0.093	0.052	0.137	0.148	28.0	35.4	29.5	42.6	44.0
[M09] Proposed Conditions Model Summary (mg/L)	Median	26488	25760	26033	25197	25090	0.272	0.274	0.272	0.279	0.281	0.026	0.027	0.026	0.028	0.028	25.0	25.1	25.1	25.3	25.3
	Mean	24034	23846	23861	23618	23559	0.277	0.290	0.277	0.309	0.314	0.027	0.030	0.028	0.034	0.035	25.2	25.6	25.1	26.2	26.3
	90th Percentile [3]	10343	11312	10946	12534	12771	0.288	0.316	0.291	0.380	0.395	0.030	0.035	0.031	0.048	0.051	25.4	26.2	25.6	27.5	27.9
	95th Percentile [3]	5382	5954	5482	7494	7758	0.300	0.376	0.308	0.482	0.507	0.033	0.048	0.035	0.071	0.078	25.9	27.9	26.1	31.0	31.8
	99th Percentile [3]	2319	2477	2237	3294	3491	0.344	0.536	0.380	0.711	0.751	0.044	0.093	0.052	0.138	0.148	27.9	35.4	29.5	42.6	44.0
Change from Existing [M01] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	-0.1%	0.0%	-0.2%	0.0%	0.0%	-0.1%	0.0%	0.1%	0.0%	-0.2%	0.0%	-0.3%	0.0%	0.1%	-0.2%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	99th Percentile [3]	0.1%	-0.1%	-0.1%	0.0%	0.0%	-0.9%	0.2%	0.1%	0.1%	0.0%	-0.2%	0.0%	0.2%	0.2%	0.1%	-0.3%	0.0%	-0.1%	0.2%	0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 4: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), with infiltration, using D2 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M02] Existing Conditions	Median	26205	25348	25679	24315	24103	0.273	0.276	0.274	0.288	0.291	0.027	0.028	0.027	0.031	0.032	25.2	25.3	25.2	26.1	26.3
	Mean	23987	23632	23767	23055	22921	0.283	0.308	0.288	0.354	0.364	0.029	0.034	0.030	0.045	0.047	25.4	26.3	25.5	27.9	28.2
Model Summary (mg/L)	90th Percentile [3]	11113	11556	11657	12388	12391	0.307	0.372	0.323	0.536	0.569	0.034	0.047	0.037	0.081	0.088	26.1	27.8	26.4	31.8	32.8
	95th Percentile [3]	5985	6813	6254	9371	9701	0.328	0.487	0.354	0.727	0.776	0.040	0.072	0.046	0.129	0.140	27.0	31.5	27.8	39.6	41.3
	99th Percentile [3]	2739	2752	2599	4515	4910	0.393	0.727	0.468	0.982	1.034	0.053	0.137	0.073	0.207	0.222	29.6	42.9	33.0	53.7	56.0
[M10] Proposed Conditions	Median	26189	25346	25671	24316	24106	0.274	0.277	0.274	0.288	0.291	0.027	0.028	0.027	0.031	0.032	25.2	25.3	25.2	26.1	26.3
	Mean	23981	23631	23759	23055	22922	0.283	0.308	0.287	0.354	0.364	0.029	0.034	0.030	0.045	0.047	25.4	26.3	25.5	27.9	28.2
Model Summary (mg/L)	90th Percentile [3]	11180	11565	11647	12388	12395	0.307	0.372	0.323	0.534	0.568	0.034	0.047	0.037	0.080	0.088	26.1	27.8	26.4	31.7	32.8
	95th Percentile [3]	6016	6815	6239	9367	9710	0.328	0.486	0.354	0.726	0.774	0.039	0.072	0.046	0.129	0.140	26.9	31.4	27.8	39.6	41.3
	99th Percentile [3]	2751	2751	2597	4513	4912	0.384	0.725	0.468	0.982	1.033	0.052	0.137	0.073	0.207	0.222	29.5	42.8	33.0	53.7	56.1
Change from Existing [M02] (%)	Median	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.6%	0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.1%	-0.1%	-0.1%	0.0%	-0.6%	-0.2%	-0.1%	0.0%	0.0%	-0.1%	-0.1%
	95th Percentile [3]	0.5%	0.0%	-0.2%	0.0%	0.1%	-0.1%	-0.2%	-0.2%	-0.1%	-0.2%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
	99th Percentile [3]	0.4%	0.0%	-0.1%	0.0%	0.0%	-2.3%	-0.3%	-0.1%	0.0%	-0.2%	-1.1%	0.0%	-0.2%	0.2%	0.3%	-0.6%	-0.1%	0.0%	0.0%	0.0%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 5: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), with infiltration, using D3 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M03] Existing Conditions	Median	26591	26435	26197	26211	26180	0.271	0.271	0.271	0.273	0.273	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	24040	24003	23891	23963	23952	0.274	0.276	0.272	0.281	0.282	0.027	0.027	0.027	0.028	0.029	25.1	25.2	25.0	25.3	25.4
Model Summary (mg/L)	90th Percentile [3]	10211	10510	10144	11398	11399	0.276	0.280	0.275	0.287	0.289	0.027	0.027	0.027	0.029	0.029	25.1	25.2	25.1	25.3	25.4
	95th Percentile [3]	5071	5148	5055	5558	5662	0.282	0.289	0.280	0.304	0.307	0.029	0.030	0.028	0.033	0.034	25.3	25.5	25.3	25.9	26.0
	99th Percentile [3]	1961	2074	1942	2283	2336	0.334	0.378	0.334	0.459	0.479	0.044	0.055	0.044	0.078	0.084	27.7	29.5	27.7	32.9	33.9
[M11] Proposed Conditions	Median	26593	26434	26195	26212	26182	0.271	0.271	0.271	0.273	0.273	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	24040	24003	23891	23964	23953	0.274	0.276	0.272	0.281	0.282	0.027	0.027	0.027	0.028	0.029	25.1	25.2	25.0	25.3	25.4
Model Summary (mg/L)	90th Percentile [3]	10211	10511	10144	11405	11400	0.276	0.280	0.275	0.287	0.289	0.027	0.027	0.027	0.029	0.029	25.1	25.2	25.1	25.3	25.4
	95th Percentile [3]	5071	5148	5055	5560	5667	0.282	0.288	0.280	0.303	0.307	0.028	0.030	0.028	0.033	0.034	25.3	25.5	25.3	25.9	26.0
	99th Percentile [3]	1974	2076	1943	2291	2343	0.334	0.378	0.333	0.459	0.478	0.044	0.055	0.044	0.078	0.084	27.7	29.4	27.7	32.8	33.9
Change from Existing [M03] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
	99th Percentile [3]	0.7%	0.1%	0.0%	0.4%	0.3%	0.0%	-0.1%	-0.1%	-0.1%	-0.3%	0.0%	-0.3%	-0.1%	-0.2%	-0.2%	0.0%	-0.1%	0.0%	-0.1%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 6: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – dry year (1968), with infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M04] Existing Conditions	Median	29048	28973	28815	28782	28761	0.270	0.271	0.270	0.272	0.272	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.0	25.1
	Mean	26471	26481	26352	26518	26526	0.271	0.272	0.270	0.274	0.274	0.026	0.026	0.026	0.027	0.027	25.0	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	13861	14068	13895	14831	15023	0.272	0.275	0.272	0.280	0.282	0.026	0.027	0.026	0.028	0.028	25.1	25.1	25.1	25.3	25.3
	95th Percentile [3]	11462	11829	11589	12434	12607	0.273	0.278	0.273	0.286	0.288	0.026	0.027	0.026	0.028	0.029	25.1	25.2	25.1	25.5	25.5
	99th Percentile [3]	3723	4341	3917	5684	5992	0.276	0.287	0.278	0.299	0.302	0.027	0.029	0.027	0.031	0.032	25.3	25.7	25.4	26.3	26.5
[M12] Proposed Conditions	Median	29048	28973	28817	28782	28762	0.270	0.271	0.270	0.272	0.272	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	26470	26481	26351	26519	26526	0.271	0.272	0.270	0.274	0.274	0.026	0.026	0.026	0.027	0.027	25.0	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	13861	14066	13895	14832	15024	0.272	0.275	0.272	0.280	0.282	0.026	0.027	0.026	0.027	0.028	25.1	25.1	25.1	25.3	25.3
	95th Percentile [3]	11462	11829	11589	12434	12605	0.273	0.278	0.273	0.286	0.288	0.026	0.027	0.026	0.028	0.029	25.1	25.2	25.1	25.5	25.5
	99th Percentile [3]	3720	4342	3915	5687	5992	0.276	0.287	0.278	0.299	0.302	0.027	0.029	0.027	0.031	0.032	25.3	25.7	25.4	26.3	26.5
Change from Existing [M04] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	99th Percentile [3]	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 7: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – wet year (1969), with infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M05] Existing Conditions	Median	20801	20610	20678	20167	20091	0.277	0.286	0.278	0.312	0.318	0.027	0.028	0.027	0.032	0.033	25.1	25.3	25.2	25.9	26.0
	Mean	19629	19245	19382	18716	18586	0.283	0.310	0.284	0.349	0.359	0.028	0.032	0.028	0.038	0.040	25.4	26.1	25.3	27.1	27.3
Model Summary (mg/L)	90th Percentile [3]	3298	3739	3371	4869	5158	0.303	0.382	0.310	0.478	0.499	0.031	0.043	0.032	0.059	0.062	26.0	28.0	26.1	30.7	31.4
	95th Percentile [3]	1968	2343	2084	2966	3093	0.317	0.431	0.324	0.549	0.576	0.034	0.051	0.035	0.070	0.075	26.5	29.7	26.8	33.7	34.5
	99th Percentile [3]	947	1386	1009	1884	1982	0.344	0.543	0.362	0.696	0.732	0.039	0.070	0.041	0.095	0.102	28.0	33.7	28.7	39.1	40.2
[M13] Proposed Conditions	Median	20793	20610	20678	20168	20091	0.277	0.286	0.278	0.311	0.318	0.027	0.028	0.027	0.032	0.033	25.1	25.3	25.2	25.9	26.0
	Mean	19623	19245	19379	18717	18588	0.283	0.310	0.284	0.349	0.359	0.028	0.032	0.028	0.038	0.040	25.4	26.1	25.3	27.1	27.3
Model Summary (mg/L)	90th Percentile [3]	3297	3740	3377	4871	5160	0.303	0.382	0.309	0.477	0.497	0.031	0.043	0.032	0.058	0.062	26.0	27.9	26.1	30.7	31.4
	95th Percentile [3]	1974	2347	2084	2973	3099	0.316	0.431	0.324	0.549	0.576	0.034	0.051	0.035	0.070	0.074	26.5	29.7	26.7	33.6	34.5
	99th Percentile [3]	946	1386	1008	1886	1981	0.343	0.542	0.362	0.697	0.731	0.039	0.070	0.041	0.095	0.102	28.0	33.7	28.7	39.1	40.2
Change from Existing [M05] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.2%	-0.2%	-0.1%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	0.0%
	95th Percentile [3]	0.3%	0.1%	0.0%	0.2%	0.2%	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-0.2%	-0.1%	-0.2%	-0.2%	-0.4%	0.0%	0.0%	-0.1%	-0.2%	-0.1%
	99th Percentile [3]	-0.1%	0.0%	-0.1%	0.1%	0.0%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	-0.5%	-0.1%	-0.2%	0.0%	0.1%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 8: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), with infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M06] Existing Conditions Model Summary (mg/L)	Median	28043	28010	28007	27900	27878	0.272	0.274	0.272	0.279	0.280	0.026	0.026	0.026	0.027	0.027	25.0	25.1	25.0	25.1	25.1
	Mean	27964	27972	27688	27885	27866	0.273	0.276	0.273	0.279	0.280	0.026	0.027	0.026	0.027	0.027	25.1	25.2	25.1	25.2	25.2
	90th Percentile [3]	27775	27784	25674	27694	27671	0.278	0.283	0.285	0.287	0.289	0.027	0.028	0.028	0.028	0.028	25.4	25.6	25.9	25.6	25.7
	95th Percentile [3]	27580	27710	25603	27634	27605	0.281	0.285	0.289	0.290	0.292	0.027	0.028	0.029	0.028	0.028	25.6	25.8	26.5	25.8	25.8
	99th Percentile [3]	27107	27586	25359	27522	27501	0.285	0.292	0.303	0.295	0.295	0.028	0.029	0.030	0.029	0.029	25.8	26.3	27.4	25.9	25.9
[M14] Proposed Conditions Model Summary (mg/L)	Median	28030	28011	27991	27904	27882	0.272	0.274	0.272	0.279	0.280	0.026	0.026	0.026	0.027	0.027	25.0	25.1	25.0	25.1	25.1
	Mean	27982	27971	27678	27881	27863	0.273	0.276	0.273	0.279	0.280	0.026	0.027	0.026	0.027	0.027	25.1	25.2	25.0	25.2	25.2
	90th Percentile [3]	27832	27793	25674	27691	27666	0.277	0.283	0.284	0.287	0.289	0.027	0.028	0.028	0.028	0.028	25.4	25.5	25.9	25.6	25.6
	95th Percentile [3]	27703	27713	25583	27599	27581	0.279	0.285	0.289	0.290	0.292	0.027	0.028	0.029	0.028	0.028	25.5	25.8	26.4	25.8	25.8
	99th Percentile [3]	27408	27581	25320	27471	27472	0.282	0.292	0.302	0.294	0.295	0.028	0.029	0.030	0.029	0.029	25.7	26.2	27.3	25.9	25.9
Change from Existing [M06] (%)	Median	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.2%	0.0%	0.0%	0.0%	0.0%	-0.4%	0.0%	-0.1%	-0.1%	0.0%	-0.2%	-0.1%	0.0%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%
	95th Percentile [3]	0.4%	0.0%	-0.1%	-0.1%	-0.1%	-0.5%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.2%	0.0%	-0.1%	-0.1%	-0.3%	-0.1%	-0.1%	-0.1%	-0.1%
	99th Percentile [3]	1.1%	0.0%	-0.2%	-0.2%	-0.1%	-1.0%	-0.1%	-0.2%	-0.1%	0.0%	-1.3%	-0.3%	-0.1%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 9: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), with infiltration, using D2 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M07] Existing Conditions Model Summary (mg/L)	Median	27956	28034	27941	27937	27909	0.272	0.273	0.273	0.280	0.281	0.026	0.026	0.026	0.027	0.027	25.0	25.0	25.0	25.1	25.1
	Mean	27802	27951	27546	27865	27851	0.274	0.276	0.276	0.280	0.281	0.026	0.027	0.027	0.027	0.027	25.1	25.2	25.2	25.3	25.3
	90th Percentile [3]	27380	27661	25683	27551	27541	0.282	0.284	0.296	0.290	0.291	0.028	0.028	0.029	0.028	0.028	25.6	25.6	26.4	25.7	25.7
	95th Percentile [3]	27010	27531	25457	27465	27477	0.287	0.290	0.305	0.293	0.294	0.028	0.028	0.031	0.029	0.029	25.8	25.9	27.3	26.0	26.0
	99th Percentile [3]	26130	27275	24926	27300	27338	0.293	0.301	0.322	0.295	0.296	0.029	0.030	0.033	0.029	0.029	26.0	26.9	28.7	26.4	26.3
[M15] Proposed Conditions Model Summary (mg/L)	Median	27891	28031	27914	27926	27896	0.272	0.273	0.273	0.280	0.281	0.026	0.026	0.026	0.027	0.027	25.0	25.0	25.0	25.1	25.1
	Mean	27823	27944	27506	27838	27831	0.274	0.276	0.276	0.280	0.281	0.026	0.026	0.027	0.027	0.027	25.0	25.2	25.2	25.2	25.2
	90th Percentile [3]	27467	27626	25678	27503	27506	0.281	0.284	0.295	0.290	0.291	0.027	0.028	0.029	0.028	0.028	25.4	25.5	26.3	25.6	25.6
	95th Percentile [3]	27172	27520	25429	27436	27453	0.283	0.290	0.304	0.293	0.294	0.028	0.028	0.031	0.029	0.029	25.6	25.9	27.3	26.0	26.0
	99th Percentile [3]	26669	27225	24775	27058	27335	0.285	0.301	0.321	0.295	0.296	0.028	0.030	0.033	0.029	0.029	25.9	26.8	28.7	26.3	26.3
Change from Existing [M07] (%)	Median	-0.2%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.1%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	Mean	0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%	-0.1%
	90th Percentile [3]	0.3%	-0.1%	0.0%	-0.2%	-0.1%	-0.5%	-0.1%	-0.2%	-0.1%	-0.1%	-0.7%	-0.2%	-0.2%	-0.5%	-0.4%	-0.8%	-0.2%	-0.3%	-0.3%	-0.2%
	95th Percentile [3]	0.6%	0.0%	-0.1%	-0.1%	-0.1%	-1.2%	-0.2%	-0.4%	0.0%	-0.1%	-1.3%	-0.1%	-0.3%	-0.7%	-0.6%	-0.5%	-0.3%	-0.1%	-0.2%	-0.3%
	99th Percentile [3]	2.1%	-0.2%	-0.6%	-0.9%	0.0%	-2.6%	-0.1%	-0.3%	0.0%	-0.1%	-1.8%	-0.3%	-0.5%	-0.6%	-0.7%	-0.4%	-0.4%	-0.2%	-0.3%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 10: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), with infiltration, using D3 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M08] Existing Conditions	Median	28052	28044	28043	28012	28004	0.272	0.272	0.272	0.274	0.274	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	28038	28017	27771	27973	27962	0.272	0.274	0.271	0.275	0.276	0.026	0.026	0.026	0.027	0.027	25.1	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	27976	27906	25664	27812	27785	0.275	0.279	0.277	0.283	0.284	0.027	0.027	0.027	0.027	0.027	25.3	25.3	25.4	25.3	25.3
	95th Percentile [3]	27927	27850	25629	27735	27705	0.277	0.282	0.279	0.287	0.288	0.027	0.027	0.027	0.028	0.028	25.5	25.5	25.7	25.5	25.5
	99th Percentile [3]	27787	27752	25592	27592	27546	0.283	0.288	0.291	0.292	0.294	0.028	0.028	0.029	0.028	0.028	25.7	25.9	26.5	25.7	25.6
[M16] Proposed Conditions	Median	28053	28044	28042	28012	28004	0.272	0.272	0.272	0.274	0.274	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	28042	28017	27770	27972	27962	0.272	0.274	0.271	0.275	0.276	0.026	0.026	0.026	0.027	0.027	25.1	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	27992	27901	25666	27805	27783	0.275	0.279	0.276	0.283	0.284	0.027	0.027	0.027	0.027	0.027	25.2	25.3	25.4	25.3	25.3
	95th Percentile [3]	27941	27854	25629	27722	27705	0.277	0.282	0.279	0.287	0.288	0.027	0.027	0.027	0.028	0.028	25.5	25.5	25.7	25.5	25.5
	99th Percentile [3]	27829	27739	25591	27591	27545	0.282	0.287	0.290	0.292	0.294	0.028	0.028	0.029	0.028	0.028	25.7	25.9	26.5	25.7	25.6
Change from Existing [M08] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	-0.1%	-0.1%
	95th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%	0.0%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
	99th Percentile [3]	0.2%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.1%	-0.2%	0.0%	0.0%	-0.2%	-0.2%	-0.2%	-0.2%	0.0%	-0.3%	-0.1%	-0.1%	-0.1%	0.0%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 11: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), without infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M17] Existing Conditions Model Summary (mg/L)	Median	26490	25762	26038	25199	25094	0.272	0.274	0.272	0.279	0.281	0.026	0.027	0.026	0.028	0.028	25.0	25.1	25.1	25.3	25.3
	Mean	24039	23847	23866	23618	23559	0.277	0.290	0.277	0.309	0.314	0.027	0.030	0.028	0.034	0.035	25.2	25.6	25.1	26.2	26.3
	90th Percentile [3]	10344	11311	10946	12535	12770	0.288	0.316	0.291	0.380	0.395	0.030	0.035	0.031	0.048	0.051	25.4	26.2	25.6	27.5	27.9
	95th Percentile [3]	5389	5950	5493	7490	7758	0.301	0.376	0.308	0.482	0.509	0.033	0.048	0.035	0.071	0.078	25.9	27.9	26.1	31.1	31.8
	99th Percentile [3]	2320	2478	2237	3291	3489	0.348	0.537	0.380	0.712	0.752	0.044	0.093	0.052	0.138	0.149	28.0	35.4	29.6	42.7	44.1
[M25] Proposed Conditions Model Summary (mg/L)	Median	26486	25760	26034	25196	25086	0.272	0.274	0.272	0.279	0.281	0.026	0.027	0.026	0.028	0.028	25.0	25.1	25.1	25.3	25.3
	Mean	24034	23846	23861	23618	23559	0.277	0.290	0.277	0.309	0.314	0.027	0.030	0.028	0.034	0.035	25.2	25.6	25.1	26.2	26.3
	90th Percentile [3]	10343	11311	10946	12534	12761	0.288	0.316	0.291	0.380	0.395	0.030	0.035	0.031	0.048	0.051	25.4	26.2	25.6	27.5	27.9
	95th Percentile [3]	5376	5953	5484	7490	7759	0.301	0.376	0.309	0.482	0.507	0.033	0.048	0.035	0.071	0.078	25.9	27.9	26.1	31.0	31.8
	99th Percentile [3]	2320	2477	2236	3293	3492	0.344	0.536	0.380	0.711	0.750	0.044	0.093	0.052	0.137	0.148	27.9	35.3	29.5	42.5	43.9
Change from Existing [M17] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	-0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	-0.2%	0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	-0.3%	0.2%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.1%	-0.1%	0.0%
	99th Percentile [3]	0.0%	0.0%	0.0%	0.1%	0.1%	-1.3%	-0.2%	0.0%	-0.2%	-0.3%	-0.6%	-0.5%	-0.2%	-0.5%	-0.4%	-0.3%	-0.3%	-0.2%	-0.4%	-0.3%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 12: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), without infiltration, using D2 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M18] Existing Conditions Model Summary (mg/L)	Median	26202	25348	25682	24316	24116	0.274	0.277	0.274	0.288	0.291	0.027	0.028	0.027	0.031	0.032	25.2	25.3	25.2	26.1	26.3
	Mean	23990	23632	23769	23055	22921	0.283	0.308	0.288	0.354	0.364	0.029	0.034	0.030	0.045	0.047	25.5	26.3	25.5	27.9	28.2
	90th Percentile [3]	11182	11564	11659	12380	12387	0.308	0.372	0.323	0.535	0.569	0.034	0.047	0.037	0.080	0.088	26.1	27.8	26.4	31.8	32.8
	95th Percentile [3]	6013	6807	6255	9362	9696	0.328	0.486	0.355	0.727	0.775	0.040	0.073	0.046	0.129	0.140	27.0	31.5	27.8	39.6	41.4
	99th Percentile [3]	2758	2757	2601	4514	4903	0.396	0.726	0.470	0.983	1.035	0.053	0.138	0.073	0.207	0.222	29.7	43.0	33.1	53.7	56.1
[M26] Proposed Conditions Model Summary (mg/L)	Median	26194	25347	25667	24320	24110	0.274	0.277	0.274	0.288	0.291	0.027	0.028	0.027	0.031	0.032	25.2	25.3	25.2	26.1	26.3
	Mean	23981	23631	23759	23055	22921	0.284	0.308	0.288	0.354	0.364	0.029	0.034	0.030	0.045	0.047	25.4	26.3	25.5	27.9	28.2
	90th Percentile [3]	11203	11563	11643	12377	12386	0.308	0.372	0.323	0.535	0.569	0.034	0.047	0.037	0.080	0.088	26.1	27.8	26.4	31.8	32.8
	95th Percentile [3]	6012	6804	6240	9370	9709	0.328	0.487	0.355	0.727	0.775	0.040	0.073	0.046	0.129	0.140	26.9	31.5	27.8	39.5	41.2
	99th Percentile [3]	2752	2752	2599	4515	4903	0.387	0.727	0.471	0.982	1.033	0.053	0.137	0.073	0.207	0.222	29.5	42.8	33.0	53.6	55.9
Change from Existing [M18] (%)	Median	0.0%	0.0%	-0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.2%	0.0%	-0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	-0.4%	-0.2%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	95th Percentile [3]	0.0%	0.0%	-0.2%	0.1%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.0%	0.1%	-0.1%	0.2%	0.2%	0.1%	-0.1%	0.0%	0.0%	0.0%	-0.3%
	99th Percentile [3]	-0.2%	-0.2%	-0.1%	0.0%	0.0%	-2.4%	0.1%	0.1%	-0.1%	-0.2%	-1.0%	-0.7%	-0.2%	-0.2%	-0.2%	-0.8%	-0.4%	-0.1%	-0.2%	-0.3%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 13: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – average year (1967), without infiltration, using D3 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M19] Existing Conditions	Median	26592	26434	26193	26211	26180	0.271	0.271	0.271	0.273	0.273	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	24040	24003	23891	23963	23952	0.274	0.276	0.272	0.281	0.282	0.027	0.027	0.027	0.028	0.029	25.1	25.2	25.0	25.3	25.4
Model Summary (mg/L)	90th Percentile [3]	10211	10511	10144	11392	11395	0.276	0.280	0.275	0.287	0.289	0.027	0.027	0.027	0.029	0.029	25.1	25.2	25.1	25.3	25.4
	95th Percentile [3]	5071	5148	5055	5558	5662	0.282	0.288	0.280	0.304	0.307	0.029	0.030	0.028	0.033	0.034	25.3	25.5	25.3	25.9	26.0
	99th Percentile [3]	1961	2075	1943	2287	2337	0.334	0.378	0.333	0.459	0.479	0.044	0.055	0.044	0.078	0.084	27.7	29.4	27.7	32.9	33.9
[M27] Proposed Conditions	Median	26590	26433	26193	26210	26180	0.271	0.271	0.271	0.273	0.273	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	24040	24003	23891	23963	23952	0.274	0.276	0.272	0.281	0.282	0.027	0.027	0.027	0.028	0.029	25.1	25.2	25.0	25.3	25.4
Model Summary (mg/L)	90th Percentile [3]	10211	10507	10144	11401	11400	0.276	0.280	0.275	0.287	0.289	0.027	0.027	0.027	0.029	0.029	25.1	25.2	25.1	25.3	25.4
	95th Percentile [3]	5071	5148	5056	5560	5662	0.282	0.289	0.280	0.304	0.308	0.029	0.030	0.028	0.033	0.034	25.3	25.5	25.3	25.9	26.0
	99th Percentile [3]	1974	2075	1943	2288	2339	0.334	0.378	0.334	0.460	0.479	0.044	0.055	0.044	0.078	0.084	27.7	29.5	27.7	32.9	33.9
Change from Existing [M19] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	99th Percentile [3]	0.7%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.1%	0.1%	0.3%	0.0%	-0.2%	-0.1%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 14: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – dry year (1968), without infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M20] Existing Conditions	Median	29048	28973	28817	28782	28760	0.270	0.271	0.270	0.272	0.272	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.0	25.1
	Mean	26471	26482	26352	26519	26526	0.271	0.272	0.270	0.274	0.274	0.026	0.026	0.026	0.027	0.027	25.0	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	13861	14068	13895	14831	15024	0.272	0.275	0.272	0.280	0.282	0.026	0.027	0.026	0.028	0.028	25.1	25.1	25.1	25.3	25.3
	95th Percentile [3]	11462	11829	11589	12435	12607	0.273	0.278	0.273	0.286	0.288	0.026	0.027	0.026	0.028	0.029	25.1	25.2	25.1	25.5	25.5
	99th Percentile [3]	3723	4340	3916	5685	5992	0.276	0.287	0.278	0.299	0.302	0.027	0.029	0.027	0.031	0.032	25.3	25.7	25.4	26.3	26.5
[M28] Proposed Conditions	Median	29048	28974	28816	28783	28762	0.270	0.271	0.270	0.272	0.272	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.0	25.1
	Mean	26470	26481	26351	26518	26526	0.271	0.272	0.270	0.274	0.274	0.026	0.026	0.026	0.027	0.027	25.0	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	13861	14067	13895	14831	15023	0.272	0.275	0.272	0.280	0.282	0.026	0.027	0.026	0.027	0.028	25.1	25.1	25.1	25.3	25.3
	95th Percentile [3]	11462	11829	11589	12434	12606	0.273	0.278	0.273	0.286	0.288	0.026	0.027	0.026	0.028	0.029	25.1	25.2	25.1	25.5	25.5
	99th Percentile [3]	3720	4343	3915	5684	5992	0.276	0.287	0.279	0.299	0.302	0.027	0.029	0.027	0.031	0.032	25.3	25.7	25.4	26.3	26.4
Change from Existing [M20] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	99th Percentile [3]	-0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	-0.1%	0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 15: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – wet year (1969), without infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M21] Existing Conditions	Median	20802	20610	20678	20169	20092	0.277	0.286	0.278	0.312	0.318	0.027	0.028	0.027	0.032	0.033	25.1	25.3	25.2	25.9	26.0
	Mean	19628	19245	19383	18716	18587	0.283	0.310	0.285	0.349	0.359	0.028	0.032	0.028	0.038	0.040	25.4	26.1	25.3	27.1	27.3
Model Summary (mg/L)	90th Percentile [3]	3299	3740	3369	4871	5157	0.303	0.382	0.310	0.478	0.498	0.031	0.043	0.032	0.058	0.062	26.0	28.0	26.1	30.7	31.4
	95th Percentile [3]	1968	2345	2084	2972	3096	0.317	0.431	0.324	0.549	0.576	0.034	0.051	0.035	0.070	0.074	26.5	29.7	26.8	33.7	34.5
	99th Percentile [3]	946	1385	1009	1883	1982	0.345	0.543	0.362	0.697	0.731	0.039	0.070	0.041	0.095	0.102	28.0	33.8	28.7	39.1	40.2
[M29] Proposed Conditions	Median	20792	20610	20676	20166	20091	0.278	0.286	0.278	0.312	0.318	0.027	0.028	0.027	0.032	0.033	25.1	25.3	25.2	25.9	26.0
	Mean	19624	19244	19379	18716	18586	0.283	0.310	0.285	0.349	0.359	0.028	0.032	0.028	0.038	0.040	25.4	26.1	25.3	27.1	27.3
Model Summary (mg/L)	90th Percentile [3]	3297	3741	3374	4871	5157	0.303	0.382	0.310	0.477	0.498	0.031	0.043	0.032	0.059	0.062	26.0	28.0	26.1	30.7	31.4
	95th Percentile [3]	1974	2345	2085	2969	3094	0.317	0.431	0.324	0.549	0.575	0.034	0.051	0.035	0.070	0.074	26.5	29.7	26.8	33.6	34.5
	99th Percentile [3]	944	1386	1008	1886	1982	0.344	0.543	0.362	0.698	0.733	0.039	0.070	0.041	0.095	0.102	28.0	33.7	28.7	39.1	40.2
Change from Existing [M21] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	-0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	95th Percentile [3]	0.3%	0.0%	0.1%	-0.1%	-0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
	99th Percentile [3]	-0.2%	0.0%	-0.1%	0.1%	0.0%	-0.2%	0.1%	0.1%	0.1%	0.3%	0.1%	0.0%	-0.1%	-0.2%	0.0%	0.0%	-0.1%	-0.1%	-0.2%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 16: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), without infiltration, using D1 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M22] Existing Conditions Model Summary (mg/L)	Median	28042	28010	28009	27901	27878	0.272	0.274	0.272	0.279	0.280	0.026	0.026	0.026	0.027	0.027	25.0	25.1	25.0	25.1	25.1
	Mean	27962	27971	27688	27885	27866	0.273	0.276	0.273	0.280	0.281	0.026	0.027	0.026	0.027	0.027	25.1	25.2	25.1	25.2	25.2
	90th Percentile [3]	27774	27785	25674	27693	27670	0.279	0.283	0.285	0.288	0.289	0.027	0.028	0.028	0.028	0.028	25.5	25.6	25.9	25.6	25.7
	95th Percentile [3]	27593	27710	25600	27633	27605	0.281	0.286	0.289	0.290	0.292	0.027	0.028	0.029	0.028	0.028	25.6	25.8	26.5	25.8	25.8
	99th Percentile [3]	27083	27585	25365	27521	27501	0.289	0.293	0.303	0.295	0.295	0.028	0.029	0.030	0.029	0.029	25.8	26.3	27.4	26.0	25.9
[M30] Proposed Conditions Model Summary (mg/L)	Median	28032	28011	27991	27903	27880	0.272	0.274	0.272	0.279	0.280	0.026	0.026	0.026	0.027	0.027	25.0	25.1	25.0	25.1	25.1
	Mean	27986	27971	27679	27881	27863	0.274	0.276	0.273	0.280	0.281	0.026	0.027	0.026	0.027	0.027	25.1	25.2	25.1	25.2	25.2
	90th Percentile [3]	27840	27792	25674	27691	27665	0.279	0.283	0.285	0.288	0.289	0.027	0.028	0.028	0.028	0.028	25.4	25.6	25.9	25.6	25.6
	95th Percentile [3]	27712	27711	25582	27598	27581	0.281	0.286	0.290	0.290	0.292	0.027	0.028	0.029	0.028	0.028	25.5	25.8	26.5	25.8	25.8
	99th Percentile [3]	27402	27575	25325	27468	27472	0.285	0.292	0.302	0.294	0.296	0.028	0.029	0.030	0.029	0.029	25.7	26.3	27.4	25.9	25.9
Change from Existing [M22] (%)	Median	0.0%	0.0%	-0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.2%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.1%	-0.1%	-0.1%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%
	95th Percentile [3]	0.4%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.2%	0.0%	0.0%	-0.1%	0.0%	0.2%	-0.1%	-0.1%	-0.3%	-0.1%	-0.2%	-0.1%	-0.1%
	99th Percentile [3]	1.2%	0.0%	-0.2%	-0.2%	-0.1%	-1.1%	-0.1%	-0.1%	-0.1%	0.0%	-0.2%	-0.2%	-0.1%	-0.2%	-0.1%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 17: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), without infiltration, using D2 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M23] Existing Conditions Model Summary (mg/L)	Median	27956	28034	27935	27937	27909	0.272	0.274	0.273	0.280	0.281	0.026	0.026	0.026	0.027	0.027	25.0	25.0	25.0	25.1	25.1
	Mean	27801	27951	27547	27865	27851	0.275	0.276	0.277	0.281	0.282	0.026	0.027	0.027	0.027	0.027	25.1	25.2	25.2	25.3	25.3
	90th Percentile [3]	27375	27661	25683	27551	27542	0.285	0.285	0.298	0.291	0.292	0.028	0.028	0.030	0.028	0.028	25.6	25.6	26.5	25.7	25.7
	95th Percentile [3]	27012	27531	25473	27466	27477	0.290	0.291	0.307	0.294	0.294	0.028	0.029	0.031	0.029	0.029	25.8	26.0	27.3	26.0	26.1
	99th Percentile [3]	26168	27275	24930	27301	27339	0.300	0.303	0.324	0.297	0.297	0.029	0.031	0.033	0.029	0.030	26.0	26.9	28.8	26.4	26.4
[M31] Proposed Conditions Model Summary (mg/L)	Median	27896	28032	27917	27929	27896	0.275	0.274	0.273	0.280	0.281	0.027	0.026	0.026	0.027	0.027	25.0	25.0	25.0	25.1	25.1
	Mean	27825	27945	27512	27838	27832	0.277	0.276	0.277	0.281	0.282	0.027	0.027	0.027	0.027	0.027	25.1	25.2	25.2	25.2	25.3
	90th Percentile [3]	27460	27628	25681	27500	27509	0.285	0.286	0.299	0.291	0.292	0.028	0.028	0.030	0.028	0.028	25.5	25.5	26.4	25.6	25.6
	95th Percentile [3]	27177	27521	25440	27437	27454	0.289	0.291	0.308	0.294	0.295	0.028	0.029	0.031	0.029	0.029	25.7	25.9	27.3	26.0	26.0
	99th Percentile [3]	26630	27228	24821	27055	27337	0.296	0.303	0.324	0.298	0.297	0.029	0.031	0.033	0.029	0.029	26.0	26.8	28.7	26.3	26.3
Change from Existing [M23] (%)	Median	-0.2%	0.0%	-0.1%	0.0%	0.0%	1.0%	0.1%	0.1%	0.1%	0.1%	1.5%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	Mean	0.1%	0.0%	-0.1%	-0.1%	-0.1%	0.5%	0.0%	0.2%	0.1%	0.0%	0.7%	0.1%	0.2%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
	90th Percentile [3]	0.3%	-0.1%	0.0%	-0.2%	-0.1%	0.1%	0.1%	0.3%	0.2%	0.0%	0.4%	0.0%	0.9%	-0.1%	-0.2%	-0.6%	-0.2%	-0.4%	-0.3%	-0.3%
	95th Percentile [3]	0.6%	0.0%	-0.1%	-0.1%	-0.1%	-0.3%	0.2%	0.2%	0.3%	0.2%	0.5%	0.0%	0.5%	-0.1%	-0.2%	-0.4%	-0.3%	-0.1%	-0.2%	-0.3%
	99th Percentile [3]	1.8%	-0.2%	-0.4%	-0.9%	0.0%	-1.4%	0.0%	0.0%	0.3%	0.0%	0.7%	0.0%	-0.1%	0.0%	-0.3%	-0.3%	-0.3%	-0.2%	-0.2%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

Table 18: Modelled concentration statistics and impacts at Eco Logical seagrass sample points – local wet month (20 Oct – 20 Nov 1969), without infiltration, using D3 dispersion coefficients.

		Pollutant																			
		Salinity [1]					Total Nitrogen (TN)					Total Phosphorous (TP)					Total Suspended Solids (TSS)				
		Observation Point [2]																			
Scenario	Statistic	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08	SG03	SG04	SG06	SG07	SG08
[M24] Existing Conditions	Median	28052	28044	28043	28012	28003	0.272	0.272	0.272	0.274	0.274	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	28038	28016	27771	27973	27962	0.273	0.274	0.271	0.275	0.276	0.026	0.026	0.026	0.027	0.027	25.1	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	27976	27905	25663	27812	27785	0.275	0.279	0.277	0.283	0.284	0.027	0.027	0.027	0.027	0.027	25.3	25.3	25.4	25.3	25.3
	95th Percentile [3]	27927	27850	25631	27735	27705	0.277	0.282	0.280	0.287	0.288	0.027	0.027	0.027	0.028	0.028	25.5	25.5	25.7	25.5	25.5
	99th Percentile [3]	27786	27750	25592	27592	27546	0.283	0.288	0.291	0.292	0.294	0.028	0.028	0.029	0.028	0.028	25.8	25.9	26.5	25.7	25.7
[M32] Proposed Conditions	Median	28053	28044	28043	28012	28005	0.272	0.272	0.272	0.274	0.274	0.026	0.026	0.026	0.026	0.026	25.0	25.0	25.0	25.1	25.1
	Mean	28042	28017	27771	27971	27962	0.272	0.274	0.271	0.275	0.276	0.026	0.026	0.026	0.027	0.027	25.1	25.1	24.9	25.1	25.1
Model Summary (mg/L)	90th Percentile [3]	27992	27901	25663	27805	27783	0.275	0.279	0.277	0.283	0.284	0.027	0.027	0.027	0.027	0.027	25.2	25.3	25.4	25.3	25.3
	95th Percentile [3]	27941	27850	25630	27721	27705	0.277	0.282	0.280	0.287	0.288	0.027	0.027	0.027	0.028	0.028	25.5	25.5	25.7	25.5	25.5
	99th Percentile [3]	27833	27739	25591	27591	27545	0.282	0.287	0.290	0.292	0.294	0.028	0.028	0.029	0.028	0.028	25.7	25.9	26.5	25.7	25.6
Change from Existing [M24] (%)	Median	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	90th Percentile [3]	0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	95th Percentile [3]	0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
	99th Percentile [3]	0.2%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%	0.0%	-0.2%	-0.2%	-0.2%	-0.2%	0.0%	-0.3%	-0.1%	-0.1%	-0.1%	-0.1%

Notes

1. Negative changes for salinity represent a freshening effect due to a reduction in salinity concentration. Positive changes represent an increase in salinity concentration.
2. Observation points based on seagrass sample points as per Figure 1 of Eco Logical's *Culburra Estuarine Ecology Preliminary Assessment (Phase 1)* (2017).
3. The 90th, 95th and 99th percentile values are given for TN, TP and TSS. For salinity the 10th, 5th and 1st percentile values are given (respectively) to assess the impact of freshening.

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Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

PERTH
Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 02 9542 5622

DARWIN
16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601
F 08 8941 1220

SYDNEY
Suite 1, Level 1
101 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9542 5622

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 9542 5622

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2685
F 02 9542 5622

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 9542 5622

BRISBANE
Suite 1, Level 3
471 Adelaide Street
Brisbane QLD 4000
T 07 3503 7192
F 07 3854 0310

HUSKISSON
Unit 1, 51 Owen Street
Huskisson NSW 2540
T 02 4201 2264
F 02 9542 5622

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4302 1266
F 02 9542 5622

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1234
F 02 6372 9230

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1221
F 02 9542 5622

1300 646 131
www.ecoaus.com.au

APPENDIX 9

Confirmation that the report by SLR Global Environmental Solutions would apply to the odour buffer zone around Culburra Wastewater Treatment Plant. Email from Ljupco Lazarevski, Shoalhaven Water, 30 June 2017.

From: Ljupco Lazarevski
Sent: Friday, June 30, 2017 10:31 AM
To: evjotoon@bigpond.com.au
Subject: West Culburra Expansion - 3A10/1003 - Odour Buffer Zone

John

Further to our conversation today, I advise that a meeting was held with representatives from Allen Price & Associates (on 24-7-2013) and it was agreed that the report by SLR Global Environmental Solutions (prepared on behalf of the applicant) would apply in relation to the odour buffer zone around the Culburra Wastewater Treatment Plant.

Regards

Ljupčo Lazarevski
Unit Manager – Project/Development
Shoalhaven Water – Shoalhaven City Council

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