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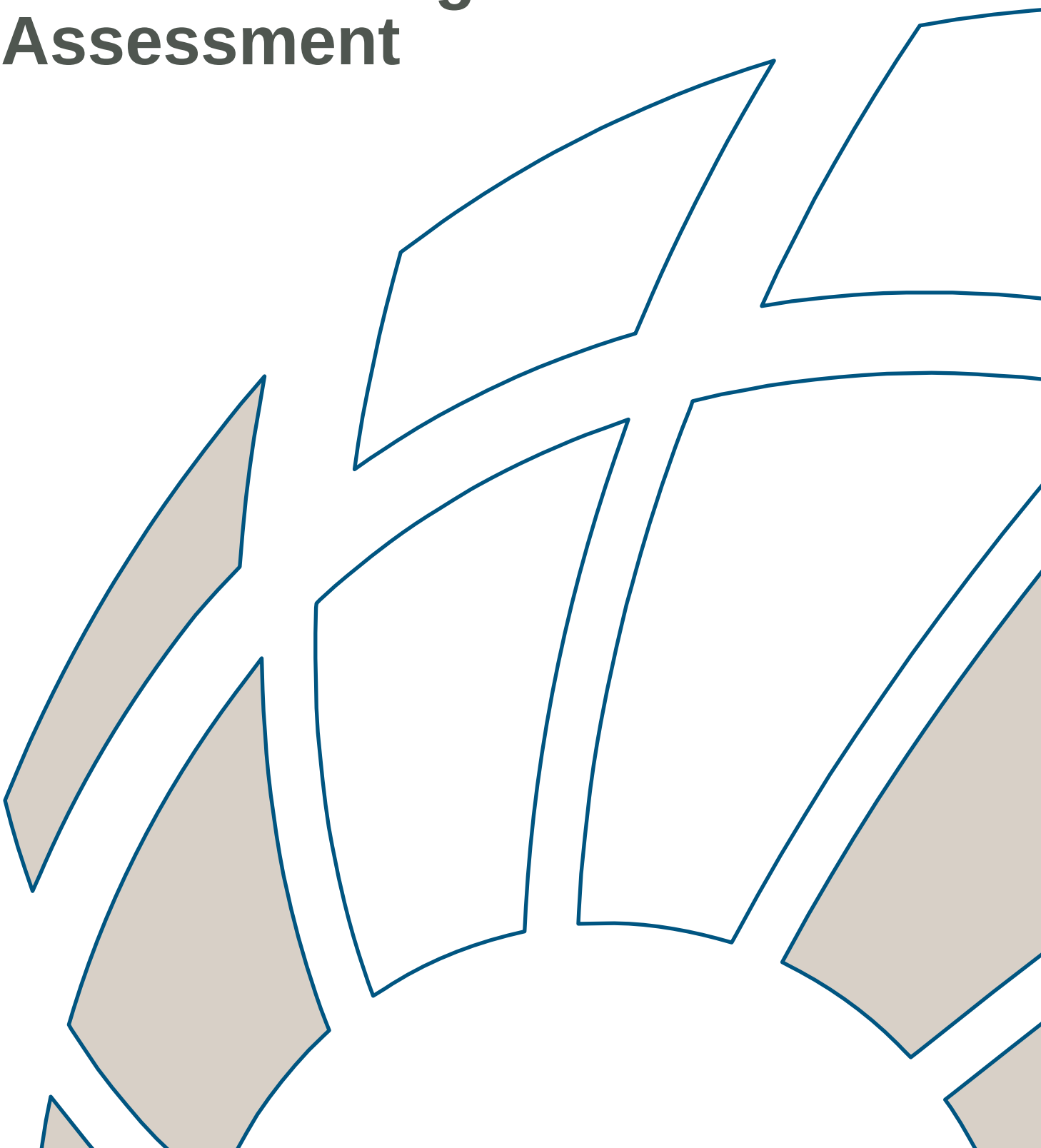
Tallawarra Lands Climate Change Assessment



Tallawarra Lands Climate Change Assessment

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1 INTRODUCTION

This report has been prepared to identify the implications of climate change for the Tallawarra Lands development proposal. The structure of the report aligns with the information requirements of the Director General Requirements (DGR) for the project, namely:

1) An overview of the climate change policy framework that applies to the project;

2) A qualitative risk assessment of the site to various climate change impacts including its potential vulnerability to future impact both in terms of its current condition (pre-development) and proposed re-development based on the latest design and layout; and

3) A summary of demonstrating how climate change has been considered in project planning.

2 CLIMATE CHANGE POLICY FRAMEWORK

The following sections outline the key planning and strategic documents that guide the management of climate change impacts for the Tallawarra site.

Each section gives a brief summary of the relevant document followed by a description of its climate change implications.

Based on the analysis undertaken, there are a range of both explicit and implicit requirements that guide climate change assessment at the State, regional and local level.

2.1 State Requirements

2.1.1 NSW Coastal Policy

The aim of the NSW Coastal Policy is to promote the ecologically sustainable development of the NSW coastline. The implementation and enforcement of the NSW Coastal Policy takes place through a range of other indirect measures. These include:

- A requirement that all local environment plans give effect to it in accordance with a section 117 direction by the Planning Minister
- A requirement that a local council must consider the Coastal Policy when determining a development application in the Coastal Zone
- A requirement that local councils and state agencies address, in their annual reports and state of the environment reports, how they are going to implement the Coastal Policy.

The NSW Coastal Policy states that the principles of ecologically sustainable development (ESD) should be used to guide decision-making in all areas and activities affecting the NSW coast. One of the principles of ESD is the precautionary principle, which requires a risk-averse approach to decision-making, especially where location specific considerations are critical or where environmental impacts are uncertain but potentially significant. The policy notes that this is particularly relevant to the issue of climate change and sea level rise in coastal areas.

The coastal policy further notes that the precautionary principle should be used at the project level, for example in assessing development applications in areas prone to shoreline recession, and at the strategic level, for example in the development of coastline management plans and local environmental plans.

The Implementation of the Coastal Policy is outlined in part (b) of the document. Of particular interest from a climate change perspective are strategic actions under objective 2-2 *To recognise and consider the potential effects of climate change in the planning and management of coastal development.*

This wording is referred to in a number of other documents reviewed below including SEPP (Major Projects) and Wollongong LEP (2009).

2.1.2 NSW Sea Level Rise Policy Statement (NSW Government 2009)

The NSW Sea Level Rise Policy Statement sets out the Government's approach to sea level rise, the risks to property owners from coastal processes and assistance that Government provides to councils to reduce the risks of coastal hazards.

The NSW Sea Level Rise Policy Statement includes sea level planning benchmarks which have been developed to support consistent consideration of sea level rise in land-use planning and coastal investment decision-making. The adopted benchmarks are for a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. These benchmarks represent the Government's guidance on sea level rise projections for use in decision-making. The benchmarks have been used for the present assessment of sea level rise risks to the Tallawarra Lands site (refer to Table 3-1).

The policy statement states that the NSW Government has an objective to see coastal communities adapt to rising sea levels in a manner that minimises the resulting social disruption, economic costs and environmental impacts. To assist in meeting this objective, the Government will support local councils and the community in adapting to sea level rise by:

- Promoting an adaptive risk-based approach to managing the impacts of sea level rise
- Providing guidance to local councils to support their sea level rise adaptation planning
- Encouraging appropriate development on land projected to be at risk from sea level rise
- Continuing to provide emergency management support to coastal communities during times of floods and storms
- Continuing to provide up-to-date information to the public about sea level rise and its impacts

2.1.3 The NSW Coastal Planning Guideline: Adapting to Sea Level Rise

The NSW Coastal Planning Guideline: Adapting to Sea Level Rise (the Planning Guideline), supports the SLR Policy Statement and was finalised by the Department of Planning in August 2010. The Planning Guideline describes how sea level rise should be considered in land use planning and development assessments. The Planning Guideline outlines six coastal planning principles for adapting to climate change, including:

- assessing and evaluating the coastal risks taking into account the sea level rise benchmarks set by the NSW Government (refer the Policy Statement);
- advising the public as to coastal risks to facilitate informed land use planning and development decision making;
- avoiding the intensification of land use in coastal risk areas through appropriate strategic and land use planning;
- considering options to reduce the intensity of land use in coastal risk areas;
- minimising exposure of development to coastal risks; and
- implementing appropriate management responses and adaptation strategies that consider the environmental, social and economic impacts of such responses.

2.1.4 The Coastal Risk Management Guide – Incorporating sea level rise benchmarks in coastal hazards assessments (NSW Government 2010)

The Coastal Risk Management Guide – Incorporating sea level rise benchmarks in coastal hazards assessments (NSW Government, 2010) states that the identified risk area for coastal planning is to include the existing coastal hazards region plus an additional area affected by sea level rise. NSW Government (2010) suggests coastal hazards studies should assess a coastal hazard planning line both with and without sea level rise (at benchmark levels set by the Policy Statement).

These sea level rise benchmarks have been used to assess sea level rise risks for the Tallawarra Lands site in the present assessment.

2.1.5 The Coastal Protection and Other Legislation Amendment Bill 2010

The Coastal Protection and Other Legislation Amendment Bill 2010 (the Bill) forms part of the NSW Government's reforms to coastal erosion management. The bill was introduced into parliament in June 2010, but is still under debate. It is anticipated that the bill will be passed this year. Key provisions in the Bill include:

- definition of emergency temporary coastal protection works that landholders or public authorities (Council) are permitted to carry out under specific scenarios (i.e. when scarp reaches 10 m from property), of specific form (i.e. no higher than 1.5 m AHD, using sand and sand bags placed at toe of erosion scarp only, and only using imported sand) and only on authorised locations, none of which are in the Wollongong LGA;
- amendments to enable Council to levy (as an annual coastal protection service charge) landholders who have funded or part-funded coastal protection works (such as seawalls), to pay for ongoing maintenance of the works and management of offsite impacts;
- improved order powers for Council officers, to order the removal or fine landholders who have placed inappropriate protection works (temporary or otherwise) on public or private land, including 'stop work' orders, increased penalties for such illegal actions, and exemptions from liability for Council officers who place the orders;
- legislative amendments (under SEPP Infrastructure 2007) that permit landholders to submit applications to erect long term coastal protection works, with approval contingent on the landholders demonstrating that potential offsite impacts can be managed, and allowing landholders to fund the works and ongoing works such as beach nourishment (via the levy described above);
- the establishment of a joint state-local body called the NSW Coastal Panel, to act as a consent authority for proposed long term protection works (under SEPP Infrastructure, as above) where a council does not have an adopted CZMP and requires further technical assistance in assessing such development applications, and to assist the Minister when requested, such as for reviewing CZMPs;
- modifying Part 5 of the Environmental Planning and Assessment Act 1979 to include assessment of potential for coastal erosion in conducting environmental impact assessments;
- increasing the exemptions from liability for government agencies such as local councils

2.1.6 Draft Guidelines for Preparing Coastal Zone Management Plans (NSW Government August 2010)

Draft Guidelines for Preparing Coastal Zone Management Plans ('the CZMP Guidelines') were released by DECCW in August, 2010. The CZMP Guidelines specify the requirements for preparing a coastal zone management plan (CZMP) in accordance with the Coastal Protection Act 1979, including requirements additional to those specified in the Act.

The focus of the guidelines is for the preparation of CZMPs particularly in relation to coastal hazard risk management and estuary health management. Coastal access and amenity is to be considered in the context of managing risks from coastal hazards.

The CZMP Guidelines set the use of a risk-based approach as a key principle for coastal zone management. The CZMP Guideline document outlines the ISO 31000:2009 risk process and recommends this be used in managing risks from coastal hazards.

Part B of the CZMP Guidelines outlines components of a CZMP to manage risks from coastal hazards (including coastal hazard impacts on estuaries). The CZMP Guideline prescribes risk management for coastal hazards, where the likelihood and consequence of coastal risks should be analysed and combined to determine the level of risk. This enables highest risks to be treated as a priority over lower risks, as prescribed in the principles above.

A risk management based approach has been undertaken for the present assessment of climate change risks for the Tallawarra Lands Development Concept.

2.1.7 Floodplain Risk Management Guideline - Practical Consideration of Climate Change (2007)

This document gives practical considerations for use in flood studies including indicative data for projected changes in:

- Extreme rainfall 1 day totals and evaporation for 2030 & 2070,
- Flood producing rains,
- Sea level rise (subsequently updated – refer to Section 2.1.2)

It also reiterates the importance of assessing the potential impacts of climate change on a location by location basis.

2.1.8 Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments

This guide has been prepared to assist local councils, the development industry and consultants incorporate the sea level rise benchmarks in floodplain risk management planning and flood risk assessments for new development. The information in this guide updates the sea level rise information in *NSW Floodplain Development Manual* (NSW Government 2005) and can be used in the floodplain risk management planning process described in this manual. This guide also updates the sea level rise section of the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC 2007). The 2007 guideline provides additional advice on dealing with the

impacts of climate change on existing development areas and discusses the consideration of potential changes to flood producing rainfall events caused by climate change.

2.1.9 State Environment Planning Policy 71

SEPP 71 aims to protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast, protect and improve public access, protect and preserve Aboriginal heritage, visual amenity, beach environments and beach amenity, native coastal vegetation, the marine environment, rock platforms, and manage the coastal zone in accordance with the principles of ecologically sustainable development, ensure development is appropriate for the location, and encourage a strategic approach to coastal management. This Policy establishes what development is significant coastal development, identifies the procedure for the determination of significant coastal development in terms of the referral process to the Director-General for comment, and identifies master plan requirements for certain development in the coastal zone.

SEPP 71 does not directly address climate change.

2.1.10 State Environmental Planning Policy 14- Coastal Wetlands

SEPP 14 aims to ensure that the coastal wetlands are preserved and protected in the environmental and economic interests of the State by requiring development consent to be obtained before any clearing, draining, filling or construction of levees can take place on mapped wetlands. These developments will also require an EIS and the concurrence (agreement) of the Director-General of DECCW before consent can be granted.

SEPP 14 does not directly address climate change. However, it is important to note that sea level rise, in particular will influence each of the matters of consideration listed in Regulation 7 (2), namely:

"(*2) In considering whether to grant concurrence under subclause (1), the Director shall take into consideration:*

(a) the environmental effects of the proposed development, including the effect of the proposed development on:

(i) the growth of native plant communities,

(ii) the survival of native wildlife populations,

(iii) the provision and quality of habitats for both indigenous and migratory species,

(iv) the surface and groundwater characteristics of the site on which the development is proposed to be carried out and of the surrounding area, including salinity and water quality,

(b) whether adequate safeguards and rehabilitation measures have been, or will be, made to protect the environment,

(c) whether carrying out the development would be consistent with the aim of this policy,

(d) the objectives and major goals of the "National Conservation Strategy for Australia" (as set forth in the second edition of a paper prepared by the Commonwealth Department of Home Affairs and

Environment for comment at the National Conference on Conservation held in June, 1983, and published in 1984 by the Australian Government Publishing Service) in so far as they relate to wetlands and the conservation of "living resources" generally, copies of which are deposited in the office of the Department,

(e) whether consideration has been given to establish whether any feasible alternatives exist to the carrying out of the proposed development (either on other land or by other methods) and if so, the reasons given for choosing the proposed development,

(f) any representations made by the Director of National Parks and Wildlife in relation to the development application, and

(g) any wetlands surrounding the land to which the development application relates and appropriateness of imposing conditions requiring the carrying out of works to preserve or enhance the value of those surrounding wetlands."

2.1.11 SEPP (Major Projects)

This SEPP identifies, among many other things, the types of coastal development that require the approval of the Planning Minister under Part 3A of the environmental planning and assessment act. The Policy also makes the Planning Minister the approval authority for these developments and for sites of State significance. Such developments include: some subdivisions which are in a 'sensitive coastal location'

A 'sensitive coastal location' has the same definition as under SEPP 71.

The SEPP states that development within the coastal zone should recognise and accommodate coastal processes and climate change. This terminology originates from the NSW Coastal Policy (refer to Section 2.1.1)

2.1.12 The NSW State Groundwater Policy Framework Document

It is the policy of the NSW Government to encourage the ecologically sustainable management of the State's groundwater resources so as to:

- slow and halt, or reverse any degradation in groundwater resources;
- ensure long term sustainability of the systems biophysical characteristics;
- maintain the full range of beneficial uses of these resources; and
- maximise economic benefit to the Region, State and Nation

While the framework does not directly address climate change it do as state that sustainable management of a groundwater system involves management for the maintenance of a number of different aspects of the system, and includes consideration of (amongst other aspects) long term and short term seasonal climatic variation.

2.1.13 The NSW Government's Coastline Hazard Policy (1988)

The NSW Government's Coastline Hazard Policy is aimed at reducing the impact of coastal hazards upon land owners and occupiers in the coastal zone, and to reduce public and private losses which may result from coastal hazards. With respect to sea level rise, the 2009 NSW Sea Level Rise Policy Statement supersedes this policy (refer Section 2.1.2).

2.2 Regional

2.2.1 Riparian Corridor Management Study 2004

DIPNR 2004 mapped the streams of the Wollongong LGA into categorized segments depending on the potential of the riparian habitats to meet ecological objectives. The three categories mapped were:

- Environmental corridor – provide biodiversity linkages ideally between one key destination to another;
- Terrestrial and aquatic habitat – provides basic habitat and preserves the natural features of a watercourse
- Bank stability and water quality – has limited, if any, habitat value but contributes to the overall health of the catchment.

The mapping was based on unspecified digital data from the Land Information Centre and the local knowledge of DIPNR staff (DIPNR 2004). Field verification was also undertaken for some sites, although not quantified. The correlation to the desk top results was reportedly high (DIPNR 2004).

The report does not discuss climate change and implications of rising sea levels and saltwater intrusion further into coastal creeks was presumably not considered.

2.3 Local

2.3.1 Wollongong LEP 2009

The Wollongong Local Environment Plan (LEP) 2009 was approved by the NSW Minister for Planning in February 2010 and now applies to all Development proposals in Wollongong.

The provisions in part 5 (18) refers to the NSW Coastal Policy and the need for determining authorities to recognise and accommodate coastal processes and climate change.

2.3.2 Tallawarra Lands Local Environmental Study

This document has been prepared to support proposed amendments to the Wollongong LEP. It provides an analysis of the capability and suitability of the land for future development with the aim of ensuring that the proposed rezoning is both environmentally sustainable and consistent with relevant planning strategies and community aspirations

The Local Environmental Study process commenced in April 2006, involving a number of specialist studies coordinated by Willana Associates.

Amongst other things, the LES has identified areas of ecological significance and recommended areas for conservation. The recommended ecological conservation areas include a large wetland site to the south of Duck Creek, a wildlife corridor along Duck Creek and riparian zones along some smaller watercourses. The large wetland area and Duck Creek have the potential to form an important link as part of the proposed Yallah-Calderwood Corridor.

The LES does not directly address climate change. The document mentions that the flood study is presently being revised to include consideration of climate change (in particular sea level rise)

2.3.3 Lake Illawarra Estuary Management Study and Strategic Plan

This document is an Estuary Management Study and Plan, developed in accordance with the NSW Government's Estuary Management Program. It outlines key management issues for the Lake, presents management objectives, and considers management options.

While the Estuary Management Plan does not address climate change directly, it does include a number of strategies that may be impacted by climate change. These incude:

- AGL-2 Reduce nutrient loads to the Lake
- WQ-1 Reduce the impacts of stormwater and sewer overflows on the Lake from existing and future urban developments
- ES-2 Reduce sediment loads entering the Lake from both rural and urban catchments to pre-European levels.
- CM-1 Protect estuarine habitats from detrimental impacts resulting from any future urban development within the catchment.
- CM-2 Prevent future development from increasing runoff volumes and pollutant loads.
- EF-1 Protect and enhance existing areas of valuable terrestrial and aquatic habitat, and preserve communities and species of particular significance.
- WU-1 Improve recreational facilities and provide waterway access in and around the Lake.
- RZ-1 Develop, wherever possible, a contiguous riparian zone along streams entering the Lake and around the Lake foreshore. Wherever possible, this riparian zone should exist in conjunction with appropriate facilities for shared pathways and maintenance equipment access.
- FOR-1 Provide suitably designed and operated foreshore access areas and facilities around the Lake.
- FOR-2 Where appropriate, integrate water quality, habitat enhancement opportunities and education activities within the foreshore areas.
- VA-2 Seek to ensure that land usage decisions are made having regard to the quality and amenity of the Lake's environmental and recreational values.
- CI-2 Improve catchment management practices and environmental management in general.
- HER-1 Increase awareness of the significance of Aboriginal cultural heritage sites and local Aboriginal traditions, and conserve these sites in perpetuity.

3 RISK ASSESSMENT – ESTABLISHING THE CONTEXT

The previous section of the report outlines the policy framework for consideration and assessing climate change impacts in New South Wales and at relevant regional and local scales.

In applying this framework to the proposed development, the Director General Requirements (DGR) call for a risk management assessment of climate change impacts to be undertaken using the latest available information from the International Panel on Climate Change (IPCC), Department of Environment and Climate Change (DECCW) and the CSIRO.

The risk assessment methodology used in this report follows that outlined in the Australian Standard (AS/NZS 4360). The stages are shown in Figure 3-1

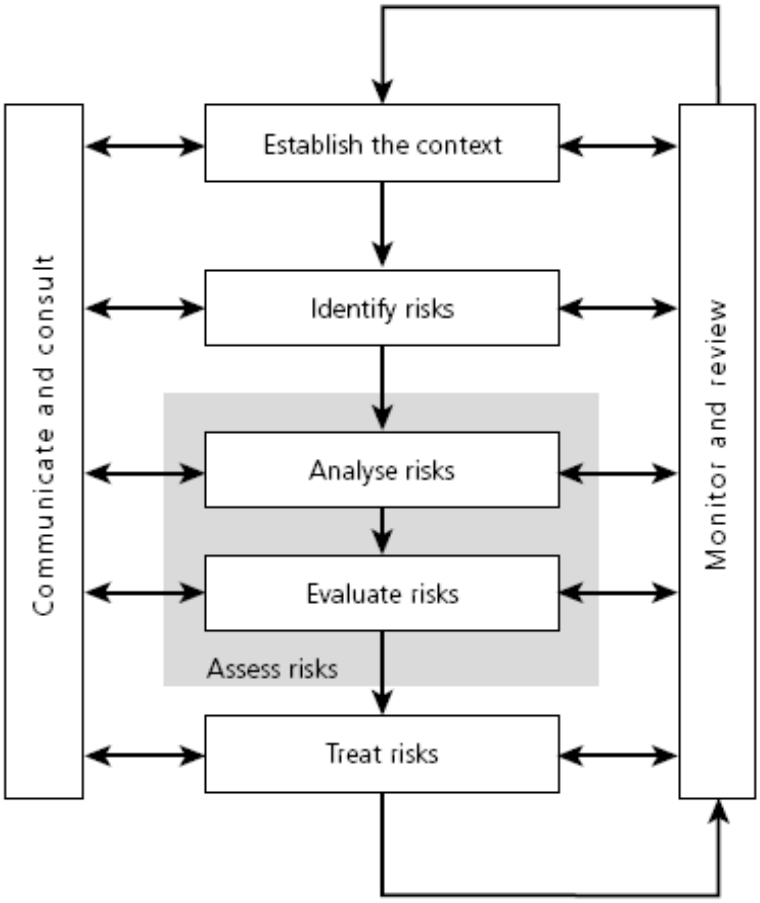


Figure 3-1 Risk Assessment Methodology

Following the process set out in Figure 3-1, this section establishes the context for the risk assessment required by the DGR through:

- An examination of climate change science including scenarios and projections and their application to the site; and
- A broad assessment of the vulnerability of the Tallawarra site to these future impacts

3.1 Climate Change Science

In 2007 the Intergovernmental Panel on Climate Change (IPCC) released their fourth assessment report, concluding that:

- Warming of the climate system is unequivocal;
- Humans are very likely to be causing most of the warming that has been experienced since 1950; and
- It is very likely that changes in the global climate system will continue well into the future, and that they will be larger than those seen in the recent past.

These changes have the potential to have a major impact on human and natural systems throughout the world including Australia.

The IPCC reports provide limited detail on climate change in Australia, particularly when it comes to regional climate change projections. For this reason the Australian Greenhouse Office, through the Australian Climate Change Science Programme, engaged CSIRO and the Bureau of Meteorology to develop climate change projections for Australia. The latest projections are documented in the report *Climate change in Australia* (CSIRO 2008). This is based upon international climate change research including conclusions from the IPCC's fourth assessment report. It also builds on a large body of climate research that has been undertaken for the Australian region in recent years.

The Floodplain Risk Management Guideline - Practical Consideration of Climate change (NSW Govt 2007) gave high mid- and low-range estimates for sea level rise. These have since been superseded by the sea level rise benchmarks in NSW Govt (2009). The benchmarks given in NSW Govt (2009) for sea level rise are a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100.

For the Tallawarra development, consideration of sea level rise will need to take into account the response of Lake Illawarra to changes in mean ocean level. Lake Illawarra now has a fully trained entrance, which maintains a mean lake level approximately the same as the mean ocean level. The tides within Lake Illawarra are highly attenuated through the entrance, meaning that mean high water in the lake is much lower than mean high water on the open coast. With increasing ocean level, the constricting effect of the entrance channel on the tides may ease, essentially leading to larger tides in Lake Illawarra in the future. Therefore, the development will need to consider not only an increase in mean lake level as a result of climate change, but also an increase in the mean tidal range of the lake.

3.1.1 Scenarios and Projections

This section identifies the key climate change parameters and timing for the Illawarra area based on latest science projections and uses this as basis for assessment.

For this assessment, key dates to be used include 2010 (present day – immediate), 2030 and 2050 (medium term) and 2070 and 2100 (long term).

The projections describe a climate which is generally warmer, drier, subject to more frequent and intense storms and a rising sea level. This discussion and assessment is not concerned with the extent to which climate change is an anthropogenic impact. The discussion is based on the

assumption of some level of climate change will occur in the future. The scenarios and projections to be adopted are set out in

Table 3-1

Table 3-1 Scenarios and Projections to be adopted for the risk assessment

Parameter	Medium Term Climate Change Projection		Long Term Climate Change Projections		Source of projection
	2030	2050	2070	2100	
Temperature	0.2-+0.8 °C		+0.7 – +5.6°C		CSIRO (2007)
Rainfall	-13% - + 7%		-40 – +20%		CSIRO (2007)
Sea Level Rise		40cm		90cm	NSW Govt (2009) (based on IPCC & CSIRO)
Increased Storminess	For example: Increase in extreme rainfall of up to 7% (1 day 40year)		For Example: Increase in extreme rainfall of up to 5% (1 day 40year)		DECC 2007
	Up to 5% increase in average annual wind speed		Up to 15% increase in average annual wind speed		McInnes *et al* 2007

3.2 Vulnerability of the Tallawarra Site to Climate Change

Climate change vulnerability refers to the degree to which a system is susceptible to, or unable to cope with, adverse effect of climate change including climate change variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed its sensitivity and its adaptive capacity (or resilience) (Australian Government, 2009).

While progressive sea level rise may introduce new risks to the Tallawarra site, some of the other climate change variables such as changes to rainfall and temperature will increase the frequency or magnitude of existing risks to the Tallawarra site such as flooding or bushfire. An important aspect to consider in managing these risks is whether existing mitigation measures (either designed or on the ground) will be sufficient to manage the existing risks as well as the superimposed climate change risks into the future.

The overall vulnerability of the site is an important part of determining the risk of impact from future climate change discussion in Section 4 of this report. The following sections provide a brief discussion about this sensitivity of the site to each relevant climate change parameter (e.g. temperature, rainfall, sea level rise and storminess) discussed in Table 3-1.

In defining the vulnerability of the site to climate change, consideration has also been given to sensitivity with and without the development, based on the current master plan concept shown in Figure 3-2 (dated May 31 2010).

Figure 3-2 Tallawarra Lands Masterplan

3.2.1 Sensitivity of the Site to Increasing Temperatures

Trend

CSIRO (2008), reports that days are projected to be hotter over all seasons in the Illawarra region. Both minimum and maximum temperatures are projected to rise over time. The increase is projected to be greatest in the winter, spring and autumn months.

Site Implications

- Increasing temperatures are likely to increase bushfire frequency and intensity on the site. The fire season may also be extended as a result of warmer temperatures. This is likely to reduce opportunity for hazard reduction burning. As site development would increase the population of people and infrastructure on the site at any one time (increased exposure), it would increase both the likelihood and consequences of the risk.
- An increase in fire frequency and intensity, high temperatures and dry spells are also likely to affect the biota to varying degrees. It is important that this increased vulnerability is accounted for in the design of mitigation measures such as buffers and protection of corridors.

3.2.2 Sensitivity of the Site to Changes to the Rainfall Regime

Trend

The region is projected to experience a substantial increase in summer rainfall and a slight to moderate increase in spring/autumn rainfall. Rainfall in winter is likely to be similar to current levels, with an increase in evaporation (CSIRO 2008).

Site Implications

- Increases to freshwater inputs to wetlands and to some extent the estuary are likely to have some impact on these ecosystems.
- In the case of a developed site, it will be important that stormwater infrastructure is appropriately designed for projected changes to rainfall. Catchment pollutant loads including sediments and nutrients will be more readily available to be washed into the estuary.
- Increases in mosquito populations due to an increase in the duration of puddles of water are a possibility. Development of the site would increase the human exposure to mosquito borne diseases.

3.2.3 Sensitivity of the Site to Sea Level Rise

Trend

The Tallawarra site is vulnerable to the projected increases in sea level.

As discussed previously, the magnitude of change to water levels within Lake Illawarra will depend upon the response of the entrance channel.

Based on the current footprint of development in the masterplan, the risk of sea level rise inundation on the current and proposed future built environment are considered low.

Impacts on the natural environment could include: saltwater intrusion to wetlands, creeks and groundwater, shoreline recession, and inundation of overbank areas in more upstream locations of Duck Creek.

Saltmarsh habitats are particularly vulnerable to sea level rise. Shoreline recession may mean loss of saltmarsh if habitats are prevented from a natural migration onto higher land. Existing low lying freshwater wetlands may be subject to oceanic inundation (or at least much more frequent inundation than at present), changing the ecological character. For existing saltwater wetlands, more frequent inundation would change habitat structure (eg saltmarsh would become mangroves). A loss of wetlands would result if there is no opportunity for landward migration of species. However the saltmarsh areas on the Tallwarra Lands Site are situated in locations that will limit the impacts of sea level rise.

Site Implications

- Coastal Inundation mapping for projected sea level rise has been undertaken by Worley Parsons. The results are presented in Figure 3-3
- Eco-logical (2010b) identifies saltmarsh in the vegetation mapping for the site shown in Figure 3-4 (source Eco-logical 2010c). Proposed buffers are presented in Ecological 2010c. Buffers are typically 50 metres around SEPP 14 wetlands and 20 metres around artificial wetlands.

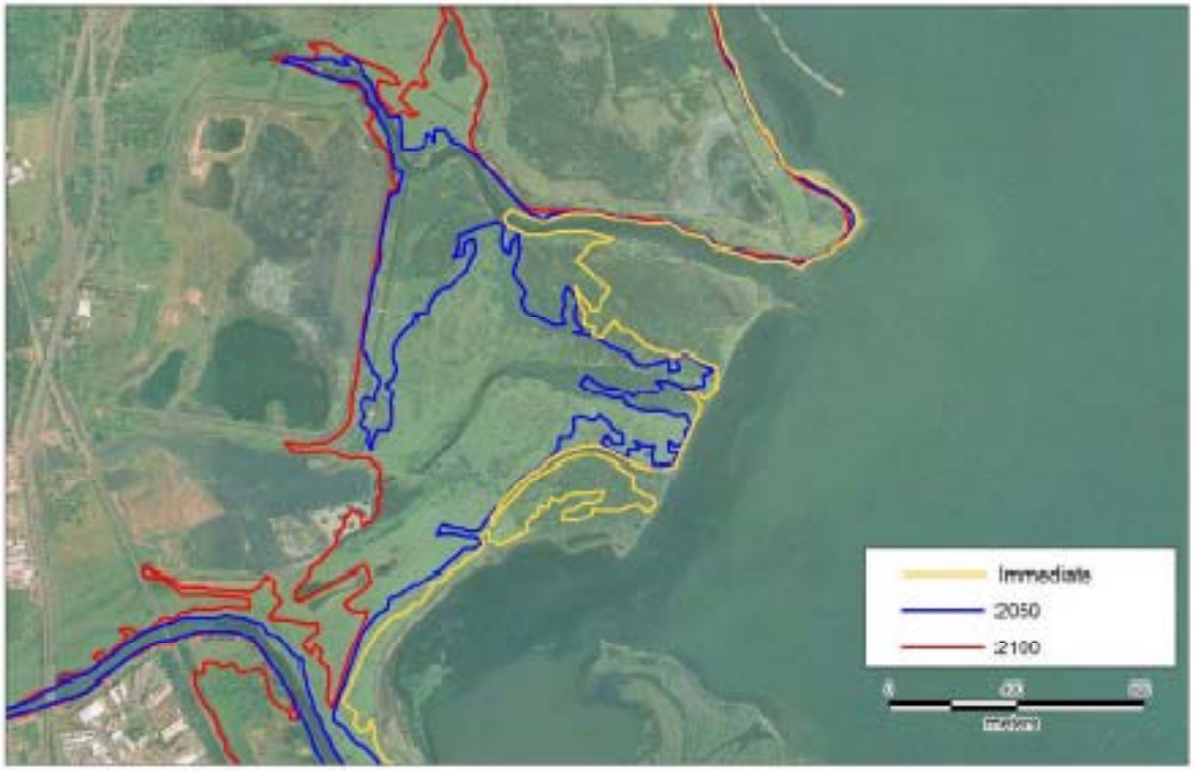


Figure 3-3 Coastal inundation hazard lines for the South part of the Tallawarra Site

- The saltmarsh areas to the north of Duck Creek are in an area of high elevation that is not predicted to be vulnerable to rising sea levels or shoreline recession (refer to Figure 3-3 and Figure 3-4), the saltmarsh areas directly south of Duck Creek will not be impacted by

development. The saltmarsh areas to the south west are on a large flat area at about two metres elevation. Development of the land to the north of these areas will require filling.

- Coastal groundwater aquifers may be adversely affected by rising sea levels and salt water infiltration (CSIRO 2007). Sea level rise will impact upon drainage and groundwater in low lying coastal floodplains leading to potential increases in the duration of floods, water logging of soils and soil salination (CSIRO 2007). Higher tailwater levels in creeks, drains, rivers and receiving waters will also raise groundwater levels.
- An increase in mean sea level is likely to assist in the re-submergence of any existing ASS on the Tallawarra site through a gradual neutralisation of acidity by saline waters (which are dominantly alkaline).

3.2.4 Sensitivity of the Site to Increased Storminess

Trend

Projected increases in the intensity of heavy rainfall events have the potential to lead to increased flash flooding across the site.

Site Implications

- For low-lying parts of the site there will be increased risk of storm surge inundation.
- The severity of consequences from an intense storm event will increase with the introduction of residents and associated infrastructure to the site.
- Key aspects of the site design that may need to be examined in terms of flooding include finished levels and floor levels of proposed development areas and buildings, overland flood controls and stormwater management strategies and devices.
- Other site planning aspects that will need to be examined include flood evacuation and contingency measures.

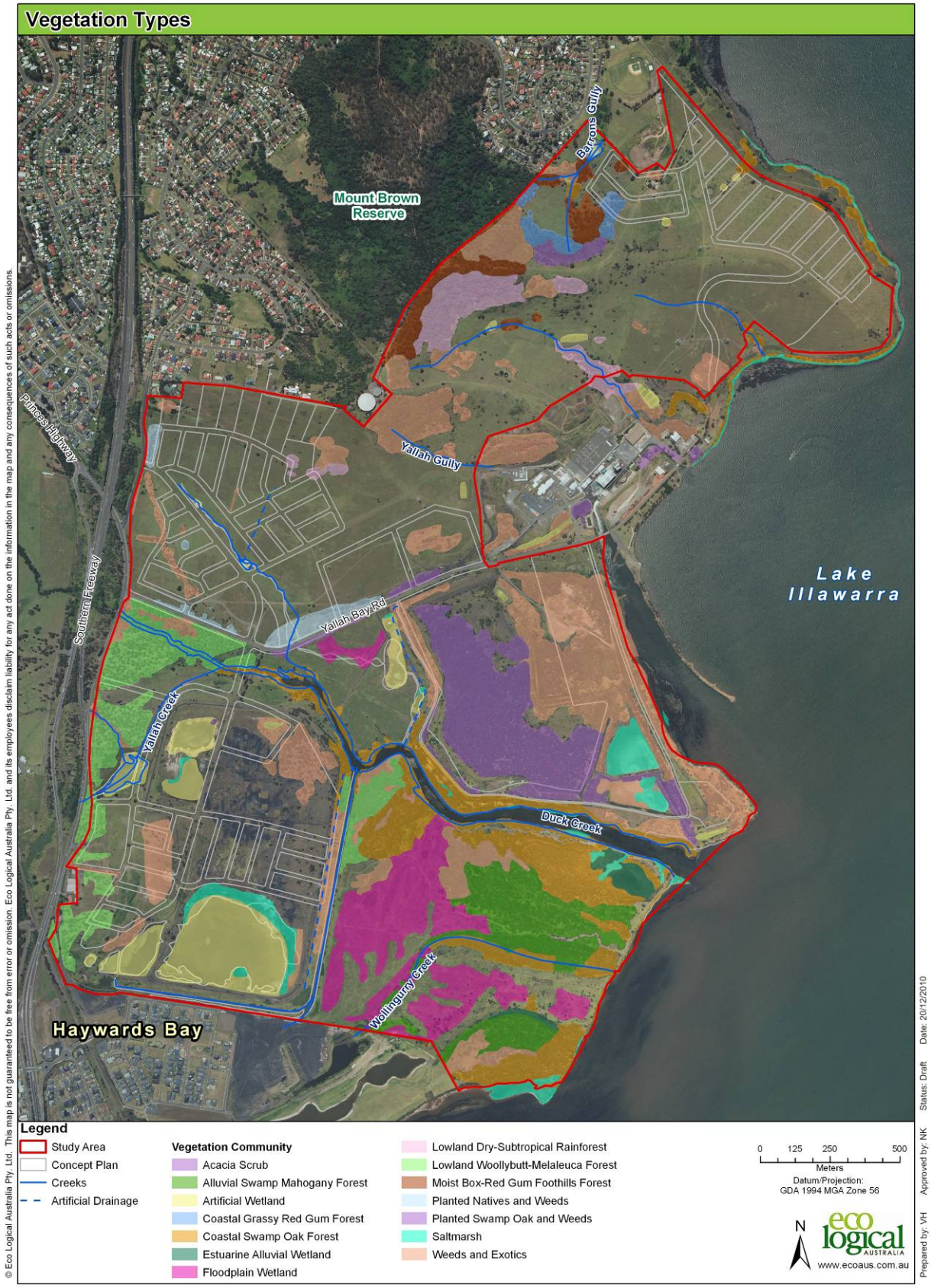


Figure 3-4 Vegetation Community mapping

4 RISK ASSESSMENT – IDENTIFICATION, ANALYSIS AND EVALUATION

With the context for the risk assessment established in Section 3 above, this section outlines the remaining steps of the risk assessment process, namely risk identification, risk analysis and risk evaluation.

4.1 Risk Identification

A list of risk statements for the assessment was developed by BMT WBM using relevant Government guidelines (AGO 2007), approaches used in similar projects, the DGRs and previous reports and other information about the site and neighbouring areas. These risks capture the potential impacts of climate change on key assets and values of the Tallawarra site and have been categorised under headings of Environment, Community or Infrastructure.

In total, 19 risks statements were identified and are summarised in a risk register contained in Appendix A.

4.2 Risk Analysis

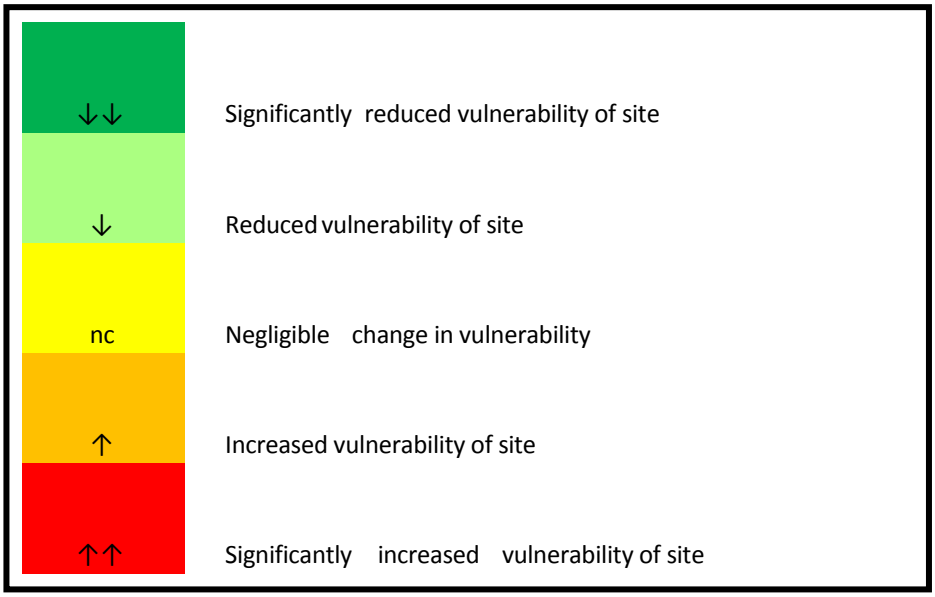
The analysis provides a qualitative assessment of whether the sites vulnerability is reduced, unchanged or increased by the proposed site development and to flag these issues for consideration in the design and layout of the development, specialist technical reports being prepared for other DGRs and in the formulation of mitigation measures. In particular, the assessment identifies where climate change risks have the potential to be exacerbated by the development (e.g. increased likelihood and/or severity).

However, it should be noted that the assessment has not been able to evaluate or otherwise take into account the range of mitigation measures being developed under other DGRs. As such the climate change risks stated in the report should be considered as being unmitigated (e.g. no mitigation is proposed) and conservative. .

4.2.1 Implication scale

The assessment uses a simple visual scale to describe the implications for the sites vulnerability to climate change by site development. This scale is illustrated in Table 4-1

Table 4-1Site Vulnerability Implication Scale



4.2.2 Time Scales

The impacts of climate change to the site were looked at for the medium and long term time scales. Medium term roughly equates to 2050, while long term roughly equates to 2100.

For the development scenario, the present day was also considered due to the potential for cumulative impacts involving the construction phase. All risks are displayed using this proforma -

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term

4.2.3 Environmental Risks

This section outlines and discusses the environmental risks from the risk register in Appendix A.

4.2.3.1 Risk 1: Risk of high pollutant loads as a result of climate change and/or site development, leading to a decline in Lake Environment

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	↑↑	↑	↑

Increased rainfall and storminess have an increased capacity to liberate pollutants such as nutrients and sediments from the site and carry these to the receiving environment. This includes Lake Illawarra and the fringing wetland areas.

In particular there would be a large increase in available nutrients and sediments during the construction stage. This is reflected in the significant increase in the vulnerability of the site for the present day.

By increasing the impervious area and through human occupation, the development would increase the availability of pollutants to be carried by stormwater to wetlands and lake. However, the risk assessment does not indicate that the development will change the risk of high pollutant loads significantly in the medium and long terms. It is important when these aspects are accounted for in the design of stormwater management that climate change impacts are included.

4.2.3.2 Risk 2: Risk of decline in vegetation / habitat connectivity as a result of climate change and/or site development, leading to decline in ecological value and utilisation by fauna populations

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	↑	↑	↑↑

Climate change, and most particularly sea level rise, will impact on vegetation and habitat connectivity. Saltmarsh, for example is particularly vulnerable to sea level rise. It is therefore important to maximise resilience of these habitats by reducing impacts from other potential pressures, such as development. The risk assessment shows the development has the potential to increase the vulnerability of the site during the construction phase and into the medium and long term.

Saltmarsh is listed as an endangered ecological community under the *Threatened Species Conservation Act 1984*. Saltmarsh on the Tallawarra Site is vulnerable to cumulative impacts of habitat loss and fragmentation due to a coastal squeeze between urban development and rising sea levels. Any buffer areas to facilitate adaptation to rising sea levels must be in addition to required

buffers from development this will help build the resilience of the saltmarsh by reducing the pressures on the ecosystem by the development.

The development must also allow for landward migration under the incremental sea level rise scenarios.

However the existing saltmarsh areas are located such that they are not susceptible to shoreline recession and sea level rise under the mapped projected scenarios.

4.2.3.3 Risk of declining species diversity as a result of climate change and/or site development leading to local and regional species impacts

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	↑	↑	↑↑

As for above; with specific reference to those species that may be using habitats such as saltmarsh that will be negatively affected by sea level rise.

4.2.3.4 Risk 4: Risk of unnatural catchment runoff volumes as a result of climate change and/or site development, leading to altered eco-hydraulic regime of receiving wetlands

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	↑	↑	↑

As discussed in Section 4.2.3.1, the development will increase impervious areas and therefore runoff volumes. WSUD design will need to consider and accommodate changing rainfall and sea level rise to minimise runoff volumes and subsequent pollutants.

4.2.3.5 Risk 5: Risk of exposure of acid sulfate soils as a result of climate change and/or site development, leading to acid runoff into receiving waterways

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
↓	↓↓	↑	↓	↓↓

Sea level rise may reduce the risk of acid sulfate soil exposure through re-submergence of any existing ASS material on the Tallawarra site and a gradual neutralisation of acidity by saline waters. However, this process will occur over a long period of time.

During the construction stage there may be exposure of ASS through earthworks and filling. This will need to be addressed within the site EMP. Exposure during construction should be avoided or otherwise treated on-site with agricultural lime in accordance with best practice methods.

Medium and long term impacts are comparable for climate change impacts with and without development.

4.2.3.6 Risk 6: Risk of modified groundwater regime as a result of climate change and/or site development, leading to surface soil saturation and potential vegetation change

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
↑	↑↑	nc	↑	↑↑

The groundwater hydrology of the site is not well understood As such, ilt is unclear exactly what the impacts on groundwater from climate change would be without detailed information, so it is important that this is assessed as part of specialist report for the project.

However, the present assessment assumes that changes in rainfall, sea level rise (and hence saltwater intrusion) and changes to evapotranspiration are likely to significantly alter the existing groundwater regime in the long term.

4.2.4 Risks to Community

This section outlines and discusses the community risks from the risk register in Appendix A.

Many of the risks to community are increased as the new population residing and working on the Tallawarra site increases exposure to climate change risks, particularly those related to human health and safety.

4.2.4.1 Risk 7: Risk of restricted foreshore access as a result of climate change and/or site development, leading to loss of public amenity

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	nc	nc	↑

Rising sea levels will encroach on foreshore land, however, development is actually likely to increase access and facilities (including walking trails) to the foreshore in the medium term. Rising sea levels are likely to reduce access for either scenario in the longer term and this could be reduced through mitigation techniques such as increasing the required and designed setbacks to development.

4.2.4.2 Risk 8: Risk of loss or damage to cultural heritage as a result of climate change and/or site development, leading to degradation of cultural significance

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	↑	nc	↑

Cultural items and places are most likely to be in areas that are undeveloped. Construction has the potential to impact on known and unknown sites. In the long term, foreshore erosion associated with sea level rise is likely to impact upon sites in along the foreshore. Generally, there is a higher probability of sites in the foreshore zone.

It is assumed a specialist report on cultural heritage is currently being prepared and any sites, items or places that could be in areas prone to inundation and flooding from future climate change may need to be evaluated in terms of potential mitigation and/or transporting any cultural heritage items.

4.2.4.3 Risk 9: Risk of eroding foreshores as a result of climate change and/or site development, leading to loss of foreshore land and public amenity

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
↑	↑↑	nc	↑	↑↑

Foreshore erosion will be exacerbated by climate change, development will not alter this, however opportunities to stabilise erodable foreshores as part of development should be sought.

4.2.4.4 Risk 10: Risk of enhanced mosquito populations as a result of climate change and/or site development, leading to potential increase in arbovirus

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑	↑	↑

While increasing temperatures and rising sea levels are likely to increase mosquito populations to some extent, this would not be significant for an undeveloped site.

In developing the site, exposure to mosquitos would increase substantially and therefore, the risk increases. Measures can be incorporated as part of the stormwater and flooding strategy to reduce risk levels through reduction in the formation and persistence of breeding habitats (e.g. still, shallow pools and waters) and through maintenance activities (spraying, etc.).

4.2.4.5 Risk 11: Risk of potential for loss of emergency access as a result of climate change and/or site development, leading to inadequate servicing of communities and infrastructure

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	nc	nc	↑

Without development this is unlikely to be an issue, however, by virtue of increasing the population and infrastructure requiring emergency evacuation and/or access, the risk increases for the developed scenarios.

The increasing probability of large storms and the coastal location of Tallawarra are key drivers for ensuring adequate emergency and evacuation management planning processes are developed and then implemented with current and future communities and relevant emergency services authorities.

4.2.4.6 Risk 12: Risk of potential for hazardous situations or events as a result of climate change and/or site development, leading to possible loss of life or limb

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑	↑	↑

This risk associated with increased climate-related hazardous events is increased for the developed scenarios due to increased exposure of people and infrastructure. As per above, this is a key driver

for developing emergency management and evacuation procedures for the site and its various development precincts.

4.2.5 Risk to Infrastructure

This section outlines and discusses the infrastructure risks from the risk register in Appendix A.

4.2.5.1 Risk 13: Risk of increased bushfire potential as a result of climate change and/or site development, leading to potential damage to property, infrastructure and habitat

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
↑	↑	↑	↑↑	↑↑

The risk of damage resulting from bushfire increases with climate change. The risk is further exacerbated by the development due to increased exposure. Similar to the natural hazards risk, measures that can be implemented to further reduce bushfire risk include establishing and maintaining firebreaks between development and forested areas and the development of emergency management and evacuation procedures.

4.2.5.2 Risk 14: Risk of obtrusive built form as a result of climate change and/or site development, leading to loss of visual amenity

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑↑	↑↑	↑↑

This risk is not impacted by climate change, although it is a risk that may need to be considered in the wider development assessment process.

4.2.5.3 Risk 15: Risk of potential for infrastructure damage as a result of climate change and/or site development, leading to loss of services and increased need for maintenance / repairs

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	↑	nc	↑	↑

Climate change is likely to increase this risk by means of increased frequency and intensity of extreme events such as storms. The development will increase the severity of the consequences for these events by increasing the infrastructure exposed on the site. Design standards used for new

infrastructure should take into account higher wind and storm potential as well as evaluation of any current infrastructure that need to be upgraded or retrofitted.

As discussed previously, infrastructure proposed on the site does not appear to be affected by future sea level rise.

4.2.5.4 Risk 16: Risk of inadequate water supply as a result of climate change and/or site development, leading to more frequent water shortages and restrictions

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑	↑	↑

The development will increase the demand for potable water. Given the climate change trend is for less rainfall (particularly in the longer term with projections of up to 40% less rainfall), this increases the vulnerability of the site to climate change.

Measures that can be taken to reduce this risk include water sensitive urban design, re use of stormwater for non-potable uses, and ensuring water efficiency devices are installed in new buildings and structure such as water tanks.

4.2.5.5 Risk 17: Risk of inadequate power supply as a result of climate change and/or site development, leading to more frequent brown-outs or black-outs

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	nc	nc	nc

The development increases electricity demand for the Tallawarra site. This could be compounded by climate change through increased use of air conditioners and other devices during hotter summers. However this risk is not considered to have any significant impact.

4.2.5.6 Risk 18: Risk of inadequate wastewater capacity as a result of climate change and/or site development, leading to more frequent system surcharging and overflows

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑	↑	↑

As with potable water supply and power supply, demand for wastewater capacity is likely to increase significantly for the site should the concept development proceed.

Measures that can be taken to reduce this risk include designing the wastewater infrastructure to deal with peak demand and variable weather patterns. Advice should be sought from the relevant local government authority and/or water corporation about this issue.

4.2.5.7 Risk 19: Risk of increased traffic as a result of climate change and/or site development, leading to local traffic congestion

Climate Change (no development)		Climate Change (with development)		
Medium term	Long Term	Present	Medium Term	Long Term
nc	nc	↑	↑	↑

Increased storminess may need to be considered in terms of designing the transport network and possible emergency evacuation procedures. However, it is not anticipated that climate change will have any significant impact on normal traffic patterns.

5 SUMMARY AND CONCLUSION

The purpose of this report (and the Director General Requirement) is to ensure the proponent has considered the implication of future climate change in project planning and that any 'high' risk climate change issues are identified and addressed through appropriate adaptation measures.

Accordingly, the output of the risk assessment is a series of adaptation considerations that should be considered and addressed in the context of other DGRs and the overall site design and layout.

A brief summary of recommended adaptation considerations are provided below. In general, the recommendations respond to those risks where the risk indicator shows an increase in vulnerability comparing the development to no development scenario.

It is important to reiterate that a conservative approach - assuming largely unmitigated development - was applied. Measures to be implemented as part of the design or otherwise as part of construction or operational phases of the development outlined in other DGR reports and studies may be adequate to address future climate change issues and reduce risks to acceptable levels.

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Table 5-1 Climate change risks flagged as having potential to be exacerbated by the development of Tallawarra Lands

Risk Id	Description	DGR	Adaptation Considerations
1	Risk of high pollutant loads as a result of climate change and/or site development, leading to a decline in lake environment	12 Drainage	WSUD design considers and accommodates increased rainfall and sea level rise to minimise runoff volumes and subsequent pollutants. WSUD elements have been sized considering the potential for increased runoff.
2	Risk of decline in vegetation / habitat connectivity as a result of climate change and/or site development, leading to decline in ecological value and utilisation by fauna populations	3 Flora and Fauna and 4 Riparian impacts	In particular, the design needs to ensure that saltmarsh has the opportunity to adapt to rising sea levels. The present design achieves this.
4	Risk of unnatural catchment runoff volumes as a result of climate change and/or site development, leading to altered ecohydraulic regime of receiving wetlands	12 Drainage	WSUD design considers and accommodates changing rainfall and sea level rise to minimise runoff volumes and subsequent pollutants. This can be achieved by minimising the discharge of additional stormwater from the development to the adjacent wetlands.
5	Risk of exposure of acid sulfate soils as a result of climate change and/or site development, leading to acid runoff into receiving waterways	21 contamination / acid sulphate soils	ASS will need to be managed during construction phase in accordance with best practice. Overall sea level rise will likely result in reduced site vulnerability to this risk.
10	Risk of enhanced mosquito populations as a result of climate change and/or site development, leading to potential increase in arbovirus	16 Environmental and Residential amenity?	WSUD design minimises mosquito habitat through avoiding the potential for shallow, still, ponding water.
13	Risk of increased bushfire potential as a result of climate change and/or site development,	20 Bushfire	This has been addressed in Eco-logical (2010)

	leading to potential damage to property, infrastructure and habitat		
16	Risk of inadequate water supply as a result of climate change and/or site development, leading to more frequent water shortages and restrictions	9 Ecologically Sustainable Development	Design incorporates future climate change projections over the design horizon. Where possible, water efficiency strategies should be included in the detailed design in future stages of the development process to minimise this risk. This can be achieved through integrated water management making the best use of onsite water.
18	Risk of inadequate wastewater capacity as a result of climate change and/or site development, leading to more frequent system surcharging and overflows	9 Ecologically Sustainable Development	Design incorporates future climate change projections over the design horizon. This can be achieved through integrated water management and provision of appropriately sized infrastructure.

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APPENDIX A: RISK ANALYSIS SUMMARY

		Risk of impact from climate change on site values (no development)		Risk of impact on site values from climate change (with development)			
Risk ID	**Risk Register**	2010 - 2050	2050 - 2100	2010	2050	2100	**Relevant DGR**
	Environment						
1	Risk of high pollutant loads as a result of climate change and/or site development, leading to a decline in lake environment	nc	nc	↑	↑	↑	12 Drainage
2	Risk of decline in vegetation / habitat connectivity as a result of climate change and/or site development, leading to decline in ecological value and utilisation by fauna populations	nc	↑	↑	↑	↑↑	3 Flora and Fauna and 4 Riparian impacts
3	Risk of declining species diversity as a result of climate change and/or site development leading to local and regional species impacts	nc	↑	↑	↑	↑↑	3 Flora and Fauna and 4 Riparian impacts
4	Risk of unnatural catchment runoff volumes as a result of climate change and/or site development, leading to altered ecohydraulic regime of receiving wetlands	nc	↑	↑	↑	↑	12 Drainage
5	Risk of exposure of acid sulfate soils as a result of climate change and/or site development, leading to acid runoff into receiving waterways	↓	↓↓	↑	↓	↓↓	21 contamination / acid sulphate soils
6	Risk of modified groundwater regime as a result of climate change and/or site development, leading to surface soil saturation and potential vegetation change	↑	↑↑	nc	↑	↑↑	13 groundwater
	Community						
7	Risk of restricted foreshore access as a result of climate change and/or site development, leading to loss of public amenity	nc	↑	nc	nc	↑	7 public domain/conservation areas/foreshores
8	Risk of loss or damage to cultural heritage as a result of climate change and/or site development, leading to degradation of cultural significance	nc	↑	nc	nc	↑	19 Aboriginal and cultural heritage
9	Risk of eroding foreshores as a result of climate change and/or site development, leading to loss of foreshore land and public amenity	↑	↑↑	nc	↑	↑↑	7 public domain/conservation areas/foreshores and 16 Environmental and Residential Amenity
10	Risk of enhanced mosquito populations as a result of climate change and/or site development, leading to potential increase in arbovirus	nc	nc	↑	↑	↑	16 Environmental and Residential amenity?
11	Risk of potential for loss of emergency access as a result of climate change and/or site development, leading to inadequate servicing of communities and infrastructure	nc	nc	nc	nc	↑	10 Traffic accessibility (construction and operational)
12	Risk of potential for hazardous situations or events as a result of climate change and/or site development, leading to possible loss of life or limb	nc	nc	↑	↑	↑	6 flooding and 20 bushfire
	Infrastructure						
13	Risk of increased bushfire potential as a result of climate change and/or site development, leading to potential damage to property, infrastructure and habitat	↑	↑	↑	↑↑	↑↑	20 Bushfire
14	Risk of obtrusive built form as a result of climate change and/or site development, leading to loss of visual amenity	nc	nc	↑↑	↑↑	↑↑	8 Built form and 16 Environmental and Residential Amenity
15	Risk of potential for infrastructure damage as a result of climate change and/or site development, leading to loss of services and increased need for maintenance / repairs	nc	↑	nc	nc	↑	6 flooding, 20 bushfire and 14 Climate Change
16	Risk of inadequate water supply as a result of climate change and/or site development, leading to more frequent water shortages and restrictions	nc	nc	↑	↑	↑	9 Ecologically Sustainable Development
17	Risk of inadequate power supply as a result of climate change and/or site development, leading to more frequent brown-outs or black-outs	nc	nc	nc	nc	nc	9 Ecologically Sustainable Development
18	Risk of inadequate wastewater capacity as a result of climate change and/or site development, leading to more frequent system surcharging and overflows	nc	nc	↑	↑	↑	9 Ecologically Sustainable Development
19	Risk of increased traffic as a result of climate change and/or site development, leading to local traffic congestion	nc	nc	↑	↑	↑	10 Traffic and accesibility and 11 Car Parking

↓↓	Significantly reduce vulnerability of site
↓	Reduce vulnerability of site
nc	No change in vulnerability
↑	Increased site vulnerability
↑↑	Significantly increased vulnerability

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