

USING PITTWATER'S FLOOD RISK MANAGEMENT STRATEGY AS THE KEY TO ADAPTATION STRATEGIES FOR CLIMATE CHANGE AND SEA LEVEL RISE

Sue Ribbons, Project Leader — Floodplain Management, Pittwater Council

Abstract

The Pittwater Local Government Area is located in Sydney's Northern Beaches. The area is characterised by many small, steep urbanised catchments, and so is highly susceptible to flash flooding. There are also many low-lying properties close to the ocean, lagoons and estuaries that are also affected by flooding from catchment rainfall as well as from tidal and ocean influences. Nearly 2,500 properties have been identified as being affected by 'mainstream flooding', with 1,500 properties affected by tidal inundation. About 1 in 5 properties in the Pittwater LGA have been identified as having some form of flood affectation. Consequently, the impacts of increasing ocean levels and increased rainfall intensities associated with climate change pose a great challenge to the Pittwater community.

Discussion and information about the subject of adaptation strategies for climate change and sea level rise have been evolving rapidly over the last year or so. Pittwater Council has guidance on adaptation strategies from international scientific opinion, Australia's CSIRO and the New South Wales State Government, but no definitive methodology is yet available. Just like all other local councils, Pittwater has the dilemma of deciding whether to launch into adopting the highest level predictions of climate change and sea level rise for all new development now, ignoring the current scientific opinion (at least for now) until more certainty of information is assured, or finding some middle ground that will safeguard the local community both in the short and long term.

Pittwater is currently using its existing Floodplain Management Strategy and the existing framework of the NSW Government Floodplain Management Process as the key to developing, assessing, recommending, implementing and reviewing its adaptation strategies for climate change in floodplain, tidal and coastal areas.

Key Words: Pittwater, floodplain, coast, tidal, adaptation, climate, change, sea, level, rise

1. Introduction

1.1 Location

The Pittwater Local Government Area (LGA) is located in Sydney's Northern Beaches, about 30 kilometres north of the Sydney Central Business District. The LGA extends from Narrabeen Lagoon in the south, to the Pittwater Estuary and Broken Bay at the mouth of the Hawkesbury–Nepean River in the north, to Ku-ring-gai Chase National Park in the west and the Pacific Ocean in the east. Pittwater includes the Sydney suburbs of North Narrabeen, Elanora Heights,

Warriewood, Ingleside, Mona Vale, Newport, Avalon and Palm Beach. Pittwater also includes several communities with boat-only access, including Scotland Island, Elvina Bay and Great Mackerel Beach. Pittwater LGA has a population of about 57,000 people and about 25,000 properties. A locality plan is provided in **Figure 1**.

1.2 The Existing Flood Problem

Pittwater LGA is characterised by many small, steep urbanised catchments, and so is highly susceptible to flash flooding. There are also many low-lying properties close to

the ocean, lagoons and estuaries that are also affected by flooding from catchment rainfall as well as from tidal and ocean influences. Nearly 2,500 properties have been identified as being affected by 'mainstream flooding', with 1,500 properties affected by tidal inundation. In addition, about 300 properties are affected by coastal inundation and 3,000–4,000 affected by overland flooding.

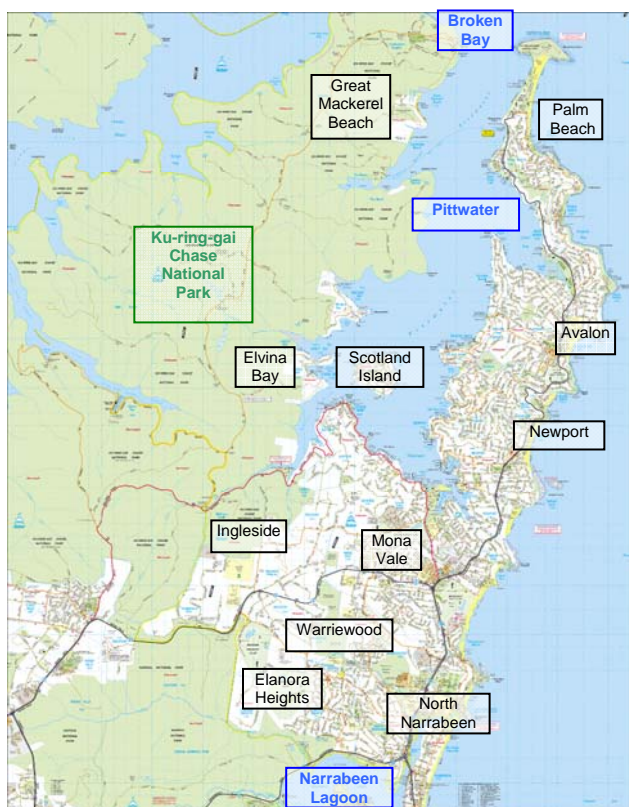


Figure 1— Locality Plan

Source of base mapping: Sydway Copyright Melway Publishing 2003

1.3 The Challenge of Climate Change and Sea Level Rise — “Where to Start?”

With about 1 in 5 properties in the Pittwater LGA having been identified as having some form of flood affectation, the impacts of increasing ocean levels and increased rainfall intensities associated with climate change pose a great challenge to the Pittwater community.

While many communities like Pittwater have made good progress with strategies to try to reduce the impacts of climate change,

discussion and information about adapting to the impacts of climate change, particularly sea level rise, have only start to evolve in the last year or so.

The greatest challenge for Pittwater has been ‘where to start?’ to develop an Adaptation Strategy for climate change and sea level rise, with no definitive methodology yet available.

Just like all other local councils, Pittwater has the dilemma of deciding whether to launch into adopting the highest level predictions of climate change and sea level rise for all new development now, ignoring the current scientific opinion (at least for now) until more certainty of information is assured, or finding some middle ground that will safeguard the local community both in the short and long term.

This paper presents the first rapidly evolving stages of Pittwater’s Adaptation Strategy for Climate Change and Sea Level Rise.

The first step in the process was to identify where to look for ‘good guidance’. This included:

- international scientific opinion, through the Intergovernmental Panel on Climate Change (IPCC);
- Australia’s CSIRO, who could provide a more local perspective to the work of the IPCC;
- the New South Wales (NSW) Department of Environment and Climate Change (DECC) who could provide practical guidance on how to consider the impacts and ramifications of climate change and sea level rise as part of the NSW Government Flood Prone Land Policy;
- the regional group of 15 councils, known as the Sydney Coastal Councils Group, who could provide a regional perspective to the same challenges that face all the member councils.

The second step in the process was to look for a logical framework to develop, assess, recommend, implement and review adaptation strategies for climate change and sea level rise. The Floodplain Management

Process as required by the NSW Government Flood Prone Land Policy, and already used by Pittwater Council in its current Flood Risk Management Strategy, provides the ideal framework and methodology for an Adaptation Strategy for Climate Change and Sea Level Rise.

With a framework identified, the next step was to get a preliminary indication of the areas most vulnerable to the impacts of climate change and sea level rise in the Pittwater LGA using existing and available information.

In conjunction with this preliminary assessment, a more detailed analysis of climate change and sea level rise is currently being undertaken as part of three Floodplain Risk Management Studies in Pittwater. These studies were already being carried out as part of Pittwater's Flood Risk Management Strategy and so it was considered timely to incorporate a detailed consideration of climate change and sea level rise into the studies.

The outcomes of these Floodplain Risk Management Studies, known as Floodplain Risk Management Plans, will provide Pittwater Council with the first building blocks to a Council-wide strategy for adapting to the impacts of climate change and sea level rise.

2. How will Climate Change and Sea Level Rise affect my Local Government Area?

The Intergovernmental Panel on Climate Change (IPCC), originally established by the United Nations in 1988, released its Fourth Assessment Report in 2007, known as *Climate Change 2007* (IPCC, 2007). *Climate Change 2007* "describes the progress in understanding of the human and natural drivers of climate change, observed climate change, climate process and attribution, and estimates projected future climate change".

Climate Change 2007, together with Australia's CSIRO document entitled "*Climate Change in Australia. Technical Report 2007*" (CSIRO, 2007) are the principal references currently available that provide 'good guidance' on how climate change and sea

level change are likely to impact a particular region of Australia

The following summarises the likely impacts of climate change and sea level rise from these documents:

- the ocean level along NSW coast projected to rise by 18cm — 91cm by 2100 (including ice flow melt);
- the temperature across globe projected to rise by 1.1°C — 6.4°C by 2100;
- it is 'virtually certain' there will be warmer and fewer cold days and nights over most land areas;
- it is 'virtually certain' there will be warmer and more frequent hot days and nights over most land areas;
- it is 'very likely' there will be more warm spells and heat waves;
- it is 'very likely' there will be more intense rainfall events and these will form a higher proportion of total annual rainfall;
- it is 'likely' that area affected by droughts will increase;
- it is 'likely' there will be more intense tropical cyclones;
- it is 'likely' there will be more events causing extreme high sea levels (excluding tsunamis).

3. What are the Implications for Floodplain and Stormwater Managers?

The impacts of climate change and sea level rise identified in *Climate Change 2007* and CSIRO (2007) can be translated into the following challenges for floodplain and stormwater managers now and in the future:

- higher mean sea levels will mean larger areas of low lying land in tidal and estuarine areas will be permanently inundated, leading to larger areas of public and private land that may become unusable and/or uninhabitable;
- higher levels of storm surge and wave run-up will mean further increases in the area of land under tidal influence;

- with increases in rainfall intensities this will increase the frequency of flood-producing rainfall events, for example, a 30% increase in rainfall intensity would mean that the current 1-in-100 year flood will occur once every 20 years, i.e. the 1-in-100 flood could occur 5 times as often;
- with increases in rainfall intensities there will be areas above tidal influence that will be subject to increased catchment flooding and hence:
 - there will be larger areas of both public and private land subject to inundation;
 - already flood-prone areas will flood more often;
 - there will be a possibility that there will be an increase in high flood hazard areas and floodways.
- the impacts in tidal and flood-prone areas will be further exacerbated with an increased likelihood of a coincidence of flood producing rain events, high wind events and associated ocean effects;
- the capacity of stormwater drainage systems will continue to decline due to:
 - increased flows;
 - higher tailwater levels;
 - increased siltation.
- the environmental management and biodiversity issues of floodplains and estuaries will continue to change as intertidal zones try to move inland into often already urbanised areas.

4. “Practical Consideration of Climate Change”

In October 2007, the NSW Department of Environment and Climate Change (DECC), through its Floodplain Management Program, released a guideline entitled “Practical Consideration of Climate Change” (DECC, 2007). This document provides practical guidance on how to consider the impacts and ramifications of climate change and sea level rise as part of the NSW Government Flood Prone Land Policy.

Importantly, the DECC Guideline provides good guidance for practitioners as to the

‘numbers’ to use, as translated from the best available international and national advice. The DECC Guideline suggests that the following three levels of climate change scenarios be considered for rises in ocean level together with increases in rainfall intensities and storm volume up to the year 2100:

- ocean level rise:
 - low-level ocean rise = 0.18m;
 - medium-level ocean rise = 0.55m;
 - high-level ocean rise = 0.91m;
- increase in peak rainfall and storm volume:
 - low-level rainfall increase = 10%;
 - medium-level rainfall increase = 20%;
 - high-level rainfall increase = 30%.

5. NSW Floodplain Risk Management Process

5.1 The Process and Climate Change and Sea Level Rise

With ‘good guidance’ from international, national and state government sources, the next step towards an adaptation strategy for Pittwater was to identify a logical framework by which strategies could be developed, assessed, recommended, implemented and progressively reviewed.

Unlike many other aspects of climate change adaptation, floodplain and stormwater managers already have an existing framework and methodology to undertake all the components of an Adaptation Strategy for Climate Change and Sea Level Rise. This framework is known as the ‘Floodplain Risk Management Process’, is required by the NSW Government Flood Prone Land Policy and is described in detail in the NSW Government’s Floodplain Development Manual (NSW Government, 2005). The Floodplain Risk Management Process forms the basis of Pittwater Council’s Flood Risk Management Strategy.

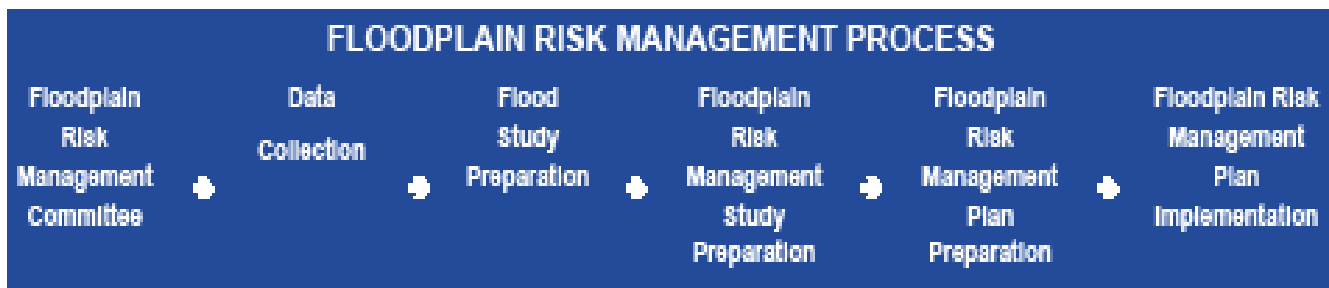


Figure 2— Floodplain Risk Management Process

Source: NSW Floodplain Development Manual (NSW Government, 2005)

Figure 2 shows the key elements of the Floodplain Risk Management Process. These elements are summarised as follows:

- **Floodplain Risk Management Committee** — this Committee, established by the Local Council, ensures that the local community is informed and engaged throughout the process. The Committee comprises Council staff, elected representatives, local community groups and specialists from state agencies;
- **Data Collection** — this exercise, often in the form of a community survey, collects and compiles all available information about historical floods;
- **Flood Study** — The Flood Study defines the nature and extent of the flood problem, including flow rates, extents of inundation, depths of inundation, speed of floodwaters and flood hazard (based on combination of depth and speed of floodwaters);
- **Floodplain Risk Management Study** — using the information from the Flood Study, the Floodplain Risk Management Study determines, analyses and recommends a range of options to reduce the flood risk to the community;
- **Floodplain Risk Management Plan** — the Floodplain Risk Management Plan provides the recommended list of works and measures for reducing flood risk, and includes priorities, costs and staging of any projects. It is adopted by Council following input from the wider community during a public exhibition process;

- **Plan Implementation** — Implementation of the adopted Floodplain Risk Management Plan sees the undertaking of the works and measures.

The NSW Government Flood Prone Land Policy, through the 2005 Floodplain Development Manual requires that the impacts and ramifications of climate change and sea level rise must be considered as part of the Floodplain Risk Management Process.

5.2 The Definition of “Flood”

An added incentive for utilising the framework provided by the Floodplain Risk Management Process is the fact that its definition of ‘flood’ covers all types of inundation. In the 2005 Floodplain Development Manual (NSW Government, 2005), the glossary of terms defines “flood” as:

- *“relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam and/or local overland flooding associated with major drainage before entering a water course and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences, excluding tsunami”.*

5.3 Section 733 of NSW Local Government Act, 1993

Even further incentive for utilising the framework provided by the Floodplain Risk Management Process is Section 733 of the NSW Local Government Act, 1993, which:

- *“provides Councils, statutory authorities and their staff with indemnity for decisions made and information provided in good faith from the outcome of the floodplain*

management process (NSW Government, 2005).

Therefore, by considering the impacts of climate change and sea level rise through the Floodplain Risk Management Process, Council's can provide themselves with indemnity provided they act in good faith. However, this also begs the question of the how Councils can indemnify themselves when considering climate change and sea level rise, if they do not utilise the Floodplain Risk Management Process.

6. "Where do I start?"

6.1 Getting an Idea of the Impacts

With 'good guidance', a framework and some 'numbers' to use, the 'first step' in developing an Adaptation Strategy for Climate Change and Sea Level Rise in the Pittwater Local Government Area was to get a preliminary indication of those area that would be most vulnerable using existing and readily available information.

Two principal sources of information were used for this analysis:

- completed Flood Studies;
- best available ground level data.

6.2 Using Completed Flood Studies

Flood Studies determine where flooding will occur, including depth and speed of floodwaters.

The Floodplain Development Manual (NSW Government, 2005) requires that all Flood Studies include a sensitivity analysis of the results of the computer modelling. A sensitivity analysis generally poses the following questions:

- what happen to the results of the computer modelling if there is a change in rainfall intensities?
- what happens to the results of the computer modelling if there is a change in the level of the stream, lake or sea downstream of the modelling?

These are both questions that need to be posed to determine the impacts of climate change and sea level rise.

Therefore, the information provided in existing flood studies can often be interpreted to get an idea of the impacts of climate change and sea level rise, such as:

- additional extents of inundation;
- additional number of properties affected;
- additional infrastructure affected;
- if new or worse floodways or high hazard areas could occur.

6.3 Using Best Available Ground Level Data

Many Councils, including Pittwater, now have Airborne Laser Scanning (ALS) or LiDar data, which provides digital topographical information of the entire Local Government Area. Often this information provides ground level information with 0.5m contours which is readily available on a Graphical Information System (GIS).

The ground level information available on Council's GIS can be readily used to get an idea of the low lying land in the LGA that may be affected by tidal inundation with sea level rise. This can be done by comparing the ground levels to different predicted tide levels shown in **Figure 3**.

6.4 Vulnerable areas in Pittwater

Using Pittwater's completed Flood Studies and digital topographical data, the following conclusions were made about the vulnerability of the Pittwater LGA to climate change and sea level rise:

- **'everyday' high tide** is likely to rise from 0.6 mAHD to up to 1.5 mAHD by 2100. The impacts of this daily occurrence will be generally limited to parkland and foreshore areas, which primarily consists of Council infrastructure. It is likely these areas will not be able to maintain their current use without some form of mitigation works;

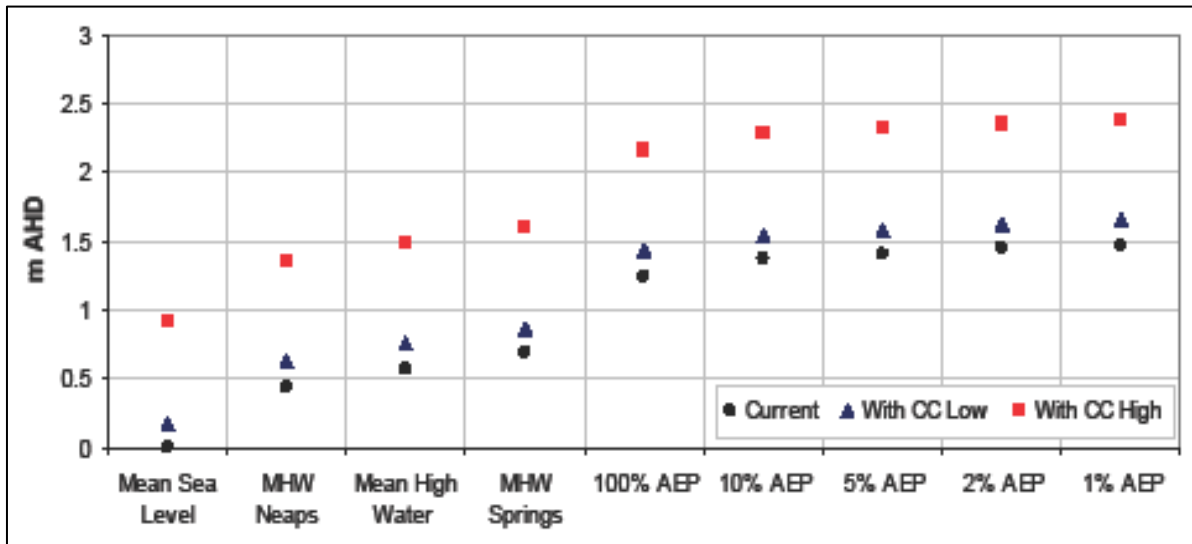


Figure 3— Changes in Key Ocean Levels with Low-Level and High-Level Sea Level Rise

Source: Practical Consideration of Climate Change (DECC, 2007)

Notes: mAHd = metres Australian Height Datum
 MHW = Mean High Water
 CC Low = Ocean level with low-level climate change scenario
 CC High = Ocean level with high-level climate change scenario
 AEP = Annual Exceedance Probability
 for example: 100% AEP refers to a 'average once a year tide' while a 1% AEP refers to an 'average once every 100 year tide'

- **'once a year high tide'** is likely to rise from 1.3 mAHd to up to 2.2 mAHd by 2100. It is these 'king tides' that will start to impact 'developed' areas such as private property, roads and other infrastructure. These king tides will impact the lowermost areas of all Pittwater's floodplain and estuarine areas;
- **sea level rise combined with large rainfall events** — the most vulnerable areas of Pittwater to climate change and sea level rise are those areas already affected by flooding. Climate change and sea level rise will cause flooding to be worse in all flood-prone areas.

7. Incorporating Climate Change and Sea level Rise into current Floodplain Risk Management Studies

A primary aim of an Adaptation Strategy for Climate Change and Sea Level Rise in Pittwater is to update all Flood Studies and Floodplain Risk Management Studies over the next five years to include a consideration of climate change and sea level rise.

In conjunction with the preliminary assessment of Pittwater's most vulnerable areas, the other 'first step' in developing an Adaptation Strategy for Climate Change and Sea Level Rise in the Pittwater LGA has been to incorporate a more detailed consideration of climate change and sea level rise into three current Floodplain Risk Management Studies. These studies were already being carried out as part of Pittwater's Flood Risk Management Strategy.

The detailed consideration of climate change and sea level rise has involved the following key components in the Floodplain Risk Management Studies:

- **Use of DECC Guideline** — 'Practical Consideration of Climate Change' (DECC, 2007) will be used to determine the three level of climate change scenarios to be considered for sea level rise and increase in rainfall intensities and storm volume;
- **Consideration of wide range of impacts** — a range of impacts will be considered for low, medium and high level rise

scenarios together with a possible time frame for these impacts, for example:

- low-level rise scenarios can be considered as short-term impacts, with a time frame of say 20 years;
- medium-level rise scenarios can be considered as medium-term impacts, with a time frame of say 50 years;
- high-level rise scenarios can be considered as long-term impacts, with a time frame of say 100 years.
- **Use of existing flood models** — existing computer models of the flood behaviour will be used to assess a range of combinations of increases in sea level and increases in rainfall volumes for a range of flood sizes. The results will include:
 - maps that show changes in flood depths, flood extents and flood velocities;
 - changes in the number of properties affected;
 - an indication of the range of private property and public infrastructure that will be affected.
- **Long-term viability of communities** — a preliminary investigation will be undertaken to examine the long-term viability of community impact by climate change and sea level rise, for example:
 - will the land surrounding homes become uninhabitable because of too frequent tidal inundation?
 - will roads become undriveable from too frequent tidal inundation?
 - are there any strategies where implementation can be commenced in the short-term?
- **Development controls** — in terms of development controls, the type and scale of development may determine type of adaptation strategy, for example:
 - the low-level or short-term climate change scenario could be used to determine minimum floor levels and other development controls for infill

residential and commercial development;

- the high-level or long-term climate change scenario could be used to determine minimum floor levels and other development controls for critical infrastructure (such as hospitals, main roads etc), large residential subdivisions and large commercial developments.
- adaptation strategies recommended and adopted as part of Floodplain Risk Management Plan — this is an integral part of starting to implement and review the adaptation strategies identified in the Floodplain Risk Management Studies because:
 - it provides a planning pool for developing short and long-term strategies for dealing with climate change and sea level rise;
 - it provides time frame for when action should be taken;
 - it provides for a review of climate change impacts and strategies every 5 to 10 years, (this is also the same time frame as required by Floodplain Development Manual for the review of Flood Studies and Floodplain Risk Management Studies and Plans)
 - it allows for gradual implementation of changes and changes in scientific opinion over time. For example, in next review in 5 years time, medium-rise (or even high-rise) climate change scenario MAY be recommended as a minimum floor level control for infill residential and commercial development.

8. Conclusion

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report of 2007 (known as '*Climate Change 2007*') concludes that climate change and sea level rise are inevitable.

With about 1 in 5 properties in the Pittwater LGA having been identified as having some form of flood affectation, the impacts of increasing ocean levels and increased rainfall intensities associated with climate change

pose a great challenge to the Pittwater community.

Discussion and information about the subject of adaptation strategies for climate change and sea level rise have been evolving rapidly over the last year or so.

Pittwater Council has 'good guidance' from international scientific opinion, Australia's CSIRO and the New South Wales State Government, but no definitive methodology is yet available. This paper has presented the first rapidly evolving stages of Pittwater's Adaptation Strategy for Climate Change and Sea Level Rise.

Unlike many other aspects of climate change adaptation, floodplain and stormwater managers already have an existing framework and methodology to undertake all the components of an Adaptation Strategy for Climate Change and Sea Level Rise. This framework is known as the 'Floodplain Risk Management Process', is required by the NSW Government Flood Prone Land Policy and is described in detail in the NSW Government's Floodplain Development Manual (NSW Government, 2005). The 2005 Floodplain Development Manual requires that the impacts and ramifications of climate change and sea level rise be considered as part of the Floodplain Risk Management Process.

This Floodplain Risk Management Process already forms the basis of Pittwater Council's Flood Risk Management Strategy.

Pittwater is currently using its existing Floodplain Management Strategy and the existing framework of the NSW Government Floodplain Management Process as the key to developing, assessing, recommending, implementing and reviewing its adaptation strategies for climate change in floodplain, tidal and coastal areas.

A primary aim of an Adaptation Strategy for Climate Change and Sea Level Rise in Pittwater is to update all Flood Studies and Floodplain Risk Management Studies over the next five years to include a consideration of climate change and sea level rise.

In conjunction with the preliminary assessment of Pittwater's most vulnerable areas, Pittwater Council is currently incorporating a detailed consideration of climate change and sea level rise into three current Floodplain Risk Management Studies. The outcomes of these Floodplain Risk Management Studies, known as Floodplain Risk Management Plans, will provide Pittwater Council with the first building blocks for a Council-wide strategy for adapting to the impacts of climate change and sea level rise.

9. References

CSIRO and Bureau of Meteorology, 2007. Climate Change in Australia. Technical Report 2007. Released October 2007. Various Authors

Intergovernmental Panel on Climate Change, 2007. Climate Change 2007: The Physical Science Basis. Summary for Policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 5 February 2007.

New South Wales Department of Environment and Climate Change, 2007. Practical Consideration of Climate Change. Floodplain Risk Management Guideline. Version 1.0. Issued 25 October 2007.

New South Wales Government, 2005. Floodplain Development Manual: The Management of Flood Liable Land. Gazetted May 2005.