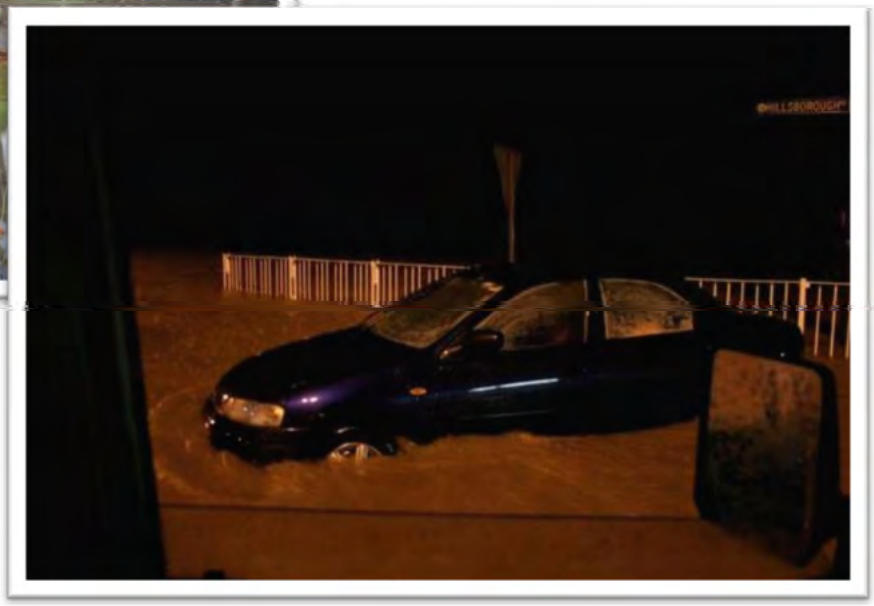
Department of
Environment, Climate Change and Water NSW

Lake Macquarie City Council

CITY OF LAKE MACQUARIE COUNCIL
NORTH CREEK
FLOODPLAIN RISK MANAGEMENT PLAN

June 2007: Debris at Charles Street tennis courts



June 2007: Car stranded near Hillsborough Road

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NOVEMBER 2010

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NORTH CREEK FLOODPLAIN RISK MANAGEMENT PLAN

NOVEMBER, 2010

Project North Creek Floodplain Risk Management Plan	**Project Number** 25080
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NORTH CREEK FLOODPLAIN RISK MANAGEMENT PLAN

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

FOREWORD

The State Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study

- determine the nature and extent of the flood problem.

2. Floodplain Risk Management Study

- evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan

- involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan

- construction of flood mitigation works to protect existing development,
- use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The North Creek Floodplain Risk Management Plan constitutes the third stage of the management process for the North Creek catchment. It has been developed for the City of Lake Macquarie Floodplain Risk Management Committee by WMAwater (formerly Webb, McKeown & Associates) for the future management of flood liable lands in the North Creek catchment.

EXECUTIVE SUMMARY

NORTH CREEK CATCHMENT

North Creek has a catchment area of approximately 5.3 square kilometres and lies within the boundaries of the City of Lake Macquarie local government area. It drains into Lake Macquarie at Warners Bay. Flooding of roads and residential areas within the catchment has occurred on several occasions in living memory. The most notable being June 1949, February 1990 and June 2007.

FLOOD STUDY

The North Creek Flood Study was initiated as a result of flooding of roads and residential areas, most recently in February 1990 and June 2007. The Flood Study was prepared by WMAwater (formerly Webb, McKeown & Associates) on behalf of the City of Lake Macquarie Floodplain Risk Management Committee and details the hydrologic and hydraulic investigations carried out to determine the design flood behaviour (levels, flows and velocities). It represents the technical foundation in the process to provide a formal Floodplain Risk Management Plan for the catchment. All available rainfall, flood and topographic data were collected and analysed as part of the study. As this report was prepared in May 2005 it obviously did not include details of the June 2007 event which caused significant flooding across the catchment.

Outcomes: The main outcomes of the Flood Study were as follows:

- full documentation of the methodology and results,
- preparation of flood contour/hazard and extent maps for the open channel section of the catchment,
- a modelling platform to form the basis for the Floodplain Risk Management Study.

A key recommendation of the Flood Study was to highlight the importance of collecting and maintaining a database of rainfall and flood height data.

REVIEW OF FLOOD STUDY

In the Flood Study a WBNM hydrologic model was set up to cover the entire catchment draining to the lake at Warners Bay with a MIKE11 hydraulic model simulating the main creek channels and overbank areas within the designated study area. The downstream limit of the hydraulic model was Warners Bay within Lake Macquarie.

Due to the limited amount of available historical data the hydrologic and hydraulic models could not be rigorously calibrated during the Flood Study. For both models, parameter values from established texts and those found to be applicable in previous studies were used in determining appropriate values for the present study. The available historical flood level information (only February 1990 event) was then compared to the design flood levels.

The June 2007 event occurred soon after commissioning of the Floodplain Risk Management Study and provided an excellent opportunity to "review" the calibration of the modelling process undertaken in the Flood Study. Immediately following this event a questionnaire was sent to all affected residents (over 200). From this peak flood levels were obtained and subsequently surveyed. Rainfall (pluviometer) data were also obtained from nearby Hunter Water gauges (including one at John Street upstream of the mouth of the creek) and analysed.

The results indicated a rainfall event up to 25% (for a 6 hour duration) greater than the 0.2% AEP (500y ARI) with the peak flood levels up to 0.3 m greater than in February 1990 (the only other event where height data are available). A review of the Flood Study was undertaken, incorporating the recently obtained ALS data was undertaken in the Floodplain Risk Management Study and this means that the modelling process now achieves a higher degree of accuracy for the design flood levels and flood extents than given in the 2005 Flood Study. The updated design flood information is provided in the North Creek Floodplain Risk Management Study.

The accuracy of the design flood levels at any one location is largely dependent on the availability of suitable historical flood data, the survey data, and the reliability of the design rainfall intensities. The relative accuracy of the design flood levels for the North Creek study area and within the area where historical flood data are available likely to be in the order of ±0.3 m after taking account of the June 2007 data. Where no historical data are available the accuracy is likely to be ±0.5 m.

It is recommended that Council install maximum height recorders in the catchment in order to accurately record all future flood events. This would greatly assist in increasing the accuracy of any future flood studies. As with the June 2007 event, it is essential that flood height data is collected immediately following the next flood.

EXISTING FLOOD PROBLEM

A flood damages assessment for existing development was undertaken across a range of design events. This assessment was based on a detailed survey of building floor levels. Table i) indicates the estimated number of building floors which are likely to be inundated for a range of event magnitudes and the corresponding tangible damages. No consideration has been given for damages to public structures or utilities (bridges, roads, pumping stations) or for the complete collapse of structures due to flooding. This information has been updated from that included in the 2005 Flood Study based on recent guidelines on the assessment of flood damages provided by the Department of Environment, Climate Change and Water (DECCW).

Table i: Summary of Flood Damages

Event	Number of Buildings Inundated above Floor Level		Total Tangible Flood Damages ($)*
	Residential	Non-Residential	
PMF	157	27	15,470,000
0.5% AEP	50	11	3,380,000
1% AEP	43	11	2,740,000
2% AEP	35	11	2,190,000
5% AEP	28	10	1,630,000
10% AEP	15	8	1,140,000
20% AEP	8	8	940,000
Average Annual Damages			**$700,000**

Note: * Excludes all damages to public assets. Includes external damages which may or may not occur with building floor inundation.

FUTURE DEVELOPMENT

A large part of the existing residential and commercial/industrial zoned land in the catchment has been developed (apart from isolated infill lots) and combined with a continuing population growth there are increasing pressures to increase the density of developments and/or rezone further land for urban usage.

FLOODPLAIN RISK MANAGEMENT STUDY

A list of all possible floodplain risk management measures which could be applied in the study area were initially developed for consideration. The assessment extended to examination of potential future development and its possible adverse impacts on flows and water quality. The measures were then assessed in terms of their suitability and effectiveness for reducing social, ecological, environmental, cultural and economic impacts. As part of this process a number of measures were identified as not being worthy of further consideration.

The specific outcomes of the study were:

- A review the results from the Flood Study,
- Identification of development and planning controls to regulate redevelopment in the flood affected properties and to ensure that future redevelopment does not significantly add to the overall potential damage,
- Recommendations to adopt Flood Planning Levels (FPL) appropriate for the catchment, and
- An investigation of available floodplain risk management measures along with prioritisation, staging of works and preliminary costings.

A range of floodplain management measures were analysed in the North Creek Floodplain Risk Management Study and from this the proposed measures (Table ii) were developed.

Table ii: Floodplain Management Measures included in the North Creek Floodplain Risk Management Plan

MEASURE/DESCRIPTION	Cost	Funding & Responsibility	Timeframe
High Priority:			
LOCAL DRAINAGE ISSUES- To identify and reduce local drainage problems. Maintain the existing flooding/drainage issues database.	Low	Council	Ongoing
EVACUATION PLANNING – Preparation of a Local Flood Plan which will enable people to evacuate in a safe and efficient manner and reduce actual flood damages.	Low	Council & SES	Within one year
PUBLIC INFORMATION AND RAISING FLOOD AWARENESS - Educate people to minimise flood damages and reduce the flood problem. A cheap effective method but requires continued effort.	Depends on nature of the program	Council & SES	Within one year
DEVELOPMENT CONTROL PLANNING - Reduce potential hazard and losses. Already in place but can be enhanced. A number of suggestions have been made in this Management Plan.	Low	Council	Within one year
Medium Priority:			
CHANNEL MODIFICATIONS - Increase waterway conveyance to reduce flood levels. Most measures not viable except for removal of small bridges or other structures and preventative maintenance. Development of a Creek Management Plan would assist in this regard.	High cost but preventative maintenance is cost effective	Council	Within two years
Low Priority:			
RETARDING BASINS - Reduce flows from upper catchment areas. There are no available suitable sites for a large basin. This measure should be considered as a means of mitigating the effects of urban development.	High	Council	When appropriate
HOUSE RAISING - Prevent flooding of existing buildings by raising habitable floor levels. All flood damages will not be prevented. House raising is unlikely to be cost effective; only suitable for a small number of buildings and is not attractive to all residents. Nevertheless 15 houses inundated in the 10% AEP event should be inspected for their suitability.	$50,000 per building	Council & DECCW	When appropriate
FLOOD PROOFING - Prevents inundation through sealing of entry points. This measure is not suitable for residential buildings but should be promoted for non-residential buildings.	Depends on measure	Building owner	When appropriate
PIT AND PIPE UPGRADE - Increase capacity of sub-surface drainage network. High cost and likely low benefit but should be undertaken at time of any redevelopment within a property.	High cost due to likely service relocation etc.	Council	When appropriate

CLIMATE CHANGE

The only significant outstanding issues for future development are the potential effects of climate change. This may result in increased rainfalls (by up to 30%) and/or increased sea levels (by up to 0.9m) by the year 2090. The world's climate change experts consider that there is a high likelihood that human induced climate change is occurring and it will cause a change in rainfall patterns and/or cause an increase in sea levels. Unfortunately there is no definitive advice regarding the extent of the change and the timeframe.

The implications for the North Creek catchment are significant and are summarised in Table iii.

Table iii: Potential Impacts of Climate Change in the North Creek catchment

Climate Change Scenario	**% Rainfall Increase**			**Sea Level Rise (increase in tailwater in Lake Macquarie in m)**			**Combination**
Impact	10%	20%	30%	0.18	0.55	0.91	10% rainfall increase and 0.91m sea level rise
Maximum increase in flood level in the 1% AEP event	0.1m	0.2m	0.3m	Decreases from the maximum the further upstream from the Lake. Sea level rise only affects the lower reaches downstream of Walker Street.			A combined 10% rainfall increase and 0.91 m sea level rise produces a rise slightly less than the sum of the individual increases.
Additional building floors inundated in the1% AEP event	8	11	23	3	24	42	46
% Increase in flood damages in the1% AEP event	17%	34%	52%	12%	45%	100%	115%

Lake Macquarie City Council is reviewing the Flood Planning Levels around Lake Macquarie to account for the expected increase in flood level due to a climate induced rainfall and sea level rise. This rise would be in addition to the existing 0.5 m freeboard. The outcomes from the Lake Macquarie review of sea level rise should be incorporated into a LGA wide policy on the effect of climate change on flood levels and change to development controls in all contributory catchments.

There are also implications for increased hazard on roads and other infrastructure (sewage pumping stations, electricity sub-stations). However the life of many of these structures is relatively short and most will be upgraded or replaced by the year 2100 and can therefore be modified to account for climate change.

Lake Macquarie has introduced a Draft Policy on climate change and the details are provided in Appendix A. This policy is based on the best current information on climate change including the NSW Government's Draft Guidelines on Climate Change.

FUTURE DEVELOPMENT

Future development within the floodplain has the potential to adversely affect (increase) design flood levels, velocities and flows as well as increase the tangible and intangible damages in future floods.

Other possible adverse consequences (water related) of future development include:

- Increased demand for potable water,
- Degradation of water quality,
- Increased waste water generation,
- Increased runoff.

Council already has appropriate policies for addressing the above issues but must be strictly enforced to ensure that the problems are not worsened through inappropriate development.

1. INTRODUCTION

North Creek is a 5.3 km^2 catchment (Figure 1) which enters Lake Macquarie at Warners Bay. The total catchment area of Lake Macquarie to the Pacific Ocean is 684 km^2 of which 110 km^2 (16%) is the lake itself. The lake extends approximately 22 kilometres in a north-south direction and varies from 2 kilometres to 6 kilometres in an east-west direction.

Lake Macquarie is the largest coastal lake in eastern Australia and has its outlet to the Pacific Ocean at Swansea. The water level in the lake is typically 0.1 mAHD but can rise to 0.4 mAHD following a period of high ocean levels. There is little tidal variation in the lake (±0.1 m).

The catchment area of North Creek is predominantly occupied by residential development (50%), non-residential development (10% - largely schools and commercial/light industrial), open space and forested areas (40%). The creek has two main tributaries, the western and eastern tributaries. Each of these has a sub-branch, the Seaman Avenue branch on the western tributary and the King Street and Lakelands branches on the eastern tributary. Since the late 1980's the main growth area is the Lakelands residential development situated between the western and eastern main tributaries.

In view of the increasing catchment development and the need to accurately define the flood problem, Lake Macquarie City Council has initiated a program of studies to address the flood problem.

1.1. Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the Floodplain Risk Management Process entails four sequential stages:

Stage 1: Flood Study.
Stage 2: Floodplain Risk Management Study.
Stage 3: Floodplain Risk Management Plan.
Stage 4: Implementation of the Plan.

The North Creek Floodplain Risk Management Plan constitutes the third stage in the process and follows the completed North Creek Floodplain Risk Management Study (Reference 2). The Flood Study stage was completed in May 2005 with publication of the North Creek Flood Study (Reference 3).

The fourth and final stage is implementation of the Plan.

1.2. Study Limits

The study area for this investigation (Figure 1) was determined in consultation with Council and the Department of Environment, Climate Change and Water (DECCW). The upstream limits of each stream reach are:

- Eastern tributary, Main Branch – upstream extent of commercial development off Hillsborough Road,
- Eastern tributary, King Street Branch – to Queen Street,
- Eastern tributary, Lakelands Branch – to Lakelands basin upstream of Medcalf Street,
- Western tributary, Main Branch – 630 m upstream of Medcalf Street,
- Western tributary, Seaman Avenue Branch – 75 m downstream of Russwell Avenue.

1.3. History of Development

As noted previously, the catchment has largely been developed for residential or commercial/ light industrial purposes. The only remaining areas of natural bushland are in the south-east corner and a narrow band along the catchment divide in the north. The majority of the urban development has a road system with kerb and gutter and a piped drainage system.

The older residential homes are situated on the lower slopes facing Lake Macquarie. More recent residential development at Lakelands has occurred in the last 20 years to the north of Medcalf Street. There has also been significant commercial/light industrial development east of Macquarie Road on either side of Hillsborough Road.

Redevelopment has extended to the south of Medcalf Street and west of King Street. This started in the early 2000's with construction of buildings on the edge of the floodplain, a road bridge and upgrading of the King Street culverts.

Minor works that affect the floodplain are also continuing. Those noted in 2008 include an earthen bank or a "levee" on the southern bank in the industrial complex at the end of Sweet Street and filling/bridge works immediately upstream of Walker Street. Possibly the "levee" was constructed following inundation in the June 2007 event.

It is also noted that the use of colourbond fencing on the properties adjacent to the open channels significantly restricts the flow width, notably on the King Street, Seaman Avenue and western tributary branches.

2. CATCHMENT DESCRIPTION

North Creek has two main tributaries, the western and eastern tributaries (refer Figure 1). Each of these has a sub-branch, the Seaman Avenue branch on the western tributary and the King Street and Lakelands branches on the eastern tributary. As the natural drainage system has been significantly modified through urban developments it is likely that the extent of natural flora/fauna habitats has been significantly reduced.

The following provides a brief summary of the main features of each branch of North Creek (refer Figure 1).

2.1.1. Eastern Tributary - Main Branch

The lower parts of North Creek are estuarine in character and fringed by native vegetation. Downstream of the weir (located just upstream of Martin Street) the creek is approximately 10 m wide with an invert at -1 mAHD. This reach of the creek has fairly flat banks. Further upstream of the weir the creek narrows and is confined by steeper overbank areas. The first bridge crossing on North Creek is at The Esplanade and there are other pedestrian and road crossings further upstream.

For its entire length from the Lake to where it verges east off Hillsborough Road, North Creek - main branch is in a semi-natural state. Upstream of this point it becomes concrete lined in places. From Walker Street to the start of this lined section, the creek is extremely heavily vegetated to the extent that the main channel is barely identifiable in places. Council has cleared the channel upstream of King Street but in recent years there has been no clearing between Walker and King Streets.

2.1.2. Eastern Tributary - King Street Branch

This branch extends eastwards from the main branch at a point approximately 40 m upstream of Walker Street. The branch is entirely within the yards of the surrounding properties and is crossed by fences and other structures. The creek is unlined but the channel has been significantly modified by the landowners. Upstream of King Street the branch continues along Queen Street but then largely disappears.

The main features of this branch are the dense vegetation in the lower reaches and the fences (at least two) that are significant hydraulic restrictions.

2.1.3. Eastern Tributary - Lakelands Branch

This branch joins the Eastern Tributary - main branch midway between Margaret and Martin Streets. It is concrete lined for its entire length to the Lakelands detention basin.

The main feature of this branch is that there is no defined overland flow path from the detention

basin, thus in an event overtopping the basin wall runoff will cross Medcalf Street over a lateral extent of some 30 m and thus affect the trafficability of the road during a flood.

2.1.4. Western Tributary - Main Branch

This branch connects to the Eastern Tributary through Warner Park and is in a semi-natural state for its entire length. Upstream of Medcalf Street the channel is ill-defined as it passes across semi-rural lands.

Adjacent to the residential developments downstream of Medcalf Street the boundary fencing has severely limited the floodplain.

2.1.5. Western Tributary - Seaman Avenue Branch

This branch joins the Western Tributary - Main Branch in the northern corner of Warner Park and becomes a lined channel upstream of Seaman Avenue. Thereafter the channel is situated within the yards of residential properties. It is crossed by Medcalf Street and becomes part of the urban drainage system downstream of Russwell Avenue.

Between Seaman Avenue and Medcalf Street recent construction of colourbond fencing and housing (2008) has severely limited the extent of the floodplain.

2.2. Preliminary Environmental Assessment

2.2.1. Water Quality

No quantitative information on water quality in the catchment is available.

2.2.2. Flora and Fauna

As the natural drainage system has been significantly modified through urban developments it is likely that the extent of flora/fauna habitats has been significantly reduced. A detailed environmental assessment has not been undertaken as part of this study, however a preliminary review indicates that it is likely that only downstream of Walker Street are there any significant habitats along the creek system. Nevertheless every opportunity in the future should be taken to enhance the quantity and quality of the existing habitats or to promote new habitats.

2.3. Visual Amenity

The visual amenity of the creek system varies significantly. The concrete lined sections would generally be described as of low quality compared to a natural system. However, apart from some graffiti, they are clean, fenced, well-maintained and are typical of creek systems in the Newcastle region urban areas. They have developed in response to development pressures to use all available land in a time when the environmental qualities of natural systems were not considered of high value and could be sacrificed. The semi-natural systems are of much higher visual quality, particularly downstream of Walker Street, upstream of King Street and on the

Western Tributary upstream of Medcalf Street.

2.4. Recreational Amenity

The actual creek system has limited recreational amenity, however the extensive floodplain downstream of Walker Street provides a significant asset which is used for active and passive recreational activities. This is an excellent use of flood prone lands.

3. AVAILABLE DATA

3.1. Flooding Mechanism

Flooding within the North Creek catchment may occur as a result of a combination of factors including:

- An elevated water level in Lake Macquarie due to intense rain over the entire catchment to Swansea. The water level rises when the rate of inflow to the Lake is greater than the outflow to the ocean. The Swansea Channel can act as a significant constriction to outflows.
- Elevated water levels within North Creek and its tributaries as a result of intense rain over the North Creek catchment. The levels in the creeks may also be affected by an elevated water level in Lake Macquarie or by constrictions along their lengths (culverts, blockages, vegetation).
- Local runoff over a small area accumulating in low spots. Generally this occurs in areas which are relatively flat with little ground slope to facilitate drainage. The problem may be compounded by inadequate local drainage provisions and elevated lake levels at the downstream outlet of the urban drainage (pipe, road drainage) system. Flooding as a result of this mechanism is not considered in this study.
- Elevated ocean levels. Generally elevated ocean levels occur as a result of storm surge (from a low pressure system) in combination with increased wave activity. This results in an elevated water level in the lake and has been considered in estimation of the design flood levels in Lake Macquarie.
- Local wind conditions in Lake Macquarie generating waves and setup (wind wave action) across the fetch of Warners Bay.

These factors may occur in isolation or in combination with each other. Generally the peak water level in Lake Macquarie will occur several hours (or days) after the peak levels in North Creek. This is because the peak levels in the majority of the North Creek catchment are as a result of a short duration storm of say up to two hours duration. The peak level in Lake Macquarie results from a longer duration storm (say 24 hours or longer).

Significant flood events in the catchment occurred in February 1990 and June 2007.

The North Creek Floodplain Risk Management Study (Reference 2) provides the most up to date information on flooding (refer Figure 2) and identified the buildings inundated above floor level for each design event (Figure 3). Figures 4 and 5 indicate the Hydraulic and Hazard Classification for the PMF and 1% AEP events respectively.

3.2. Community Consultation

A rigorous public consultation program was carried out as part of this study. This included:

- two resident questionnaires (April 2007 and immediately following the June 2007 flood),
- follow up telephone calls to key respondents,

- floodplain management committee meetings,
- workshop/site inspection and interviews,
- public exhibition of the draft reports during August 2009 and including a Public Meeting.

3.3. Hydraulic and Flood Hazard Classification

The Floodplain Development Manual (Reference 1) defines three hydraulic categorises which can be applied to define different areas of the floodplain. The hydraulic categories of flood prone land include:

> *"Floodways are those areas where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow or a significant increase in flood levels."*
>
> *"Flood storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood."*
>
> *"Flood fringe is the remaining area of flood prone land after floodway and flood storage areas have been defined."*

The above hydraulic classifications have been applied to the North Creek floodplain based on a detailed assessment of the hydraulic parameters and the preliminary maps of hydraulic classification for the PMF and 1% AEP design events are provided on Figures 4 and 5.

Also included on Figures 4 and 5 are the "hydraulic" flood hazard classification (i.e. based on flood depths and velocities). True flood hazard however, is a measure of the overall adverse effects of flooding. It incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production. These factors are not included in the provisional (hydraulic) hazard assessment. In order to determine the true hazard a qualitative assessment based on a number of additional factors (rate of rise, duration, flood access, size of event, warning time, debris issues, evacuation difficulties, awareness of community) was undertaken. At North Creek, however, these additional factors do not significantly alter the provisional hazard classifications.

It should be noted the considerable increase in extent of hazard and floodway definition in the PMF event.

4. FLOODPLAIN RISK MANAGEMENT MEASURES

4.1. Introduction

An assessment of all floodplain risk management measures was undertaken in the Floodplain Risk Management Study (Reference 2). The recommended floodplain management measures for the North Creek catchment are summarised in Table ii) in the summary and discussed in the following sections.

The priority ranking is based upon a combination of reduction in flood risk, ease of implementation and cost/funding implications. There is no particular order of the measures within each priority categorisation.

4.2. High Priority

Local Drainage Issues: Council should maintain a database of reported local drainage issues and review the required actions following each major rainfall event (say an event of magnitude occurring on average once or twice a year).

Evacuation Planning: A Local Flood Plan should be prepared by the SES drawing on their experiences from the June 2007 event.

Public Information and Raising Flood Awareness: Based on feedback and general discussions, the residents of North Creek catchment have a medium level of flood awareness and preparedness (largely because a significant flood recently occurred in June 2007).

A suitable Council wide flood awareness program should be implemented by Council using appropriate elements as discussed in Reference 2. The details of the program and necessary follow up should be properly documented to ensure that they do not lapse with time and to ensure the most cost effective means of communication.

Development Control Planning: Lake Macquarie City Council have specified FPLs, as detailed in its DCP No. 1 Section 2.1.7 Flood Management. The existing FPLs are considered appropriate however consideration should be given to the following upgrades regarding parking:

- commercial spaces or multi residential basement car parking – protection to the PMF or 1% AEP + 0.5 m whichever is the greatest,
- single residential basement car parking – protection to the 1% AEP + 0.5 m.

Consideration should also be given to lowering the FPL building floor requirements for commercial and industrial buildings where appropriate (concrete batching plant, large developer who is aware of the flood risk and has the ability to minimise the risk to life).

A review of Council's current flood related development control planning indicates that they are well documented, appropriate and operate satisfactorily. The controls should be continually reviewed and amended accordingly. However Council should give consideration to:

- allowing a payment in lieu contribution for OSD (on-site stormwater detention) in exceptional cases,
- implementing an OSD inspection policy,
- ensuring all OSDs are included in a GIS database,
- reviewing whether OSD should NOT be applied to properties in the lower reaches of the catchment. In theory retarding flows from these properties may exacerbate the flood problem for downstream properties.

In order to ensure further development does not occur which has the potential to affect flood levels Council must ensure that all Development Applications in the floodplain are supported by an appropriate Flood Study undertaken by suitably qualified professionals.

Council already has a successful policy on the management of overland flows and flood related development controls. However it should be continually reviewed and optimised as appropriate.

Climate Change: Council should continue to monitor the available literature and reassess Council's Flood Policy as appropriate. At a minimum Council should obtain the most current information available from the Bureau of Meteorology and DECCW every two years. Figure 6 provides an indication of the likely change in flood extent in the 1% AEP event if a 10% rainfall increase plus a 0.91m rise in sea level eventuate.

There are no viable measures to decrease the effects of a climate change induced increase in design rainfalls. Existing developments will therefore experience increased flood damages and potentially increased risk to life. Reducing the impact of a climate change induced sea level rise in Lake Macquarie is outside the scope of this study but will be investigated in a proposed review of the Lake Macquarie Floodplain Risk Management Study that will further investigate the effects of climate change. It is not viable to provide mitigation measures (levee) along the foreshores of Warners Bay to prevent inundation of land from elevated levels in Lake Macquarie.

Minimum floor levels and other flood related development controls should be increased to take account of the potential effects of climate change. However this should be undertaken on a LGA basis rather than on an individual catchment basis.

There are also implications for increased hazard on roads and other infrastructure (sewage pumping stations, electricity sub-stations). However the life of many of these structures is relatively short and most will be upgraded or replaced by the year 2100 and can therefore be modified to account for climate change.

Development Intensification: The existing water quality policies of Council are supported. Council policies to manage the adverse effects of development on flooding are to be amended to include the proposed guidelines:

- any development which is proposed within the 1% AEP floodplain must consider the potential impacts of the works on flood levels,
- proposed works greater than 10 m^2 within the 1% AEP floodplain of the open channel

system must have a Flood Study undertaken by a professional engineer experienced in floodplain management. The nature and extent of the Flood Study will be determined by the engineer at the time,

- proposed works within the overland land flow area and outside the 1% AEP floodplain of the open channel system must have a Flood Study undertaken by a professional engineer experienced in floodplain management if the proposed works will block any part of the overland 1% AEP floodplain. The nature and extent of the Flood Study will be determined by the engineer at the time.

Hunter Water should investigate stormwater infiltration of the sewer system.

Water Sensitive Urban Design: The installation of Water Sensitive Urban Design measures is supported.

4.3. Medium Priority

Channel Modifications: Council should consider the removal of small footbridges or other structures over the open channel as, whilst they cause only a minor hydraulic restriction, there is a risk of blockage downstream if they collapse during a flood. Also, Council should consider introducing a maintenance scheme to reduce the likelihood of blockage and identifying inappropriate works through development of a Creek Management Plan. A scheme to ensure all fences are well maintained should be considered.

4.4. Low Priority

Retarding Basins: There are no appropriate sites for construction of a large basin in the catchment. Council should ensure that their planning controls address the effects of urbanisation on water quality and quantity and the appropriate means of addressing the adverse effects. Future development may consider the use of retarding basins as an appropriate measure to mitigate the adverse water quality and quantity effects.

House Raising: House raising should be further investigated for the 15 houses that are inundated in the 10% AEP event. These buildings may not be suitable for raising and further investigations are required to ensure the practicality, structural suitability and to assess the owner's willingness to this measure.

Council should consider undertaking a more detailed study for areas subject to overland flow to identify possible flood liable buildings or if above floor inundation occurs investigate whether house raising is possible for that building.

Flood Proofing: Flood proofing should be promoted as a means available to reduce flood damages for non-residential buildings. This measure is unlikely to receive Government funding however it should still be pursued by Council. Potential owners should be advised that it is an available option.

Pit and Pipe Upgrade: Council has an ongoing program of installing additional inlet pits and upgrading pipes where required. The main difficulty with this program is pipe upgrading within private property. This issue needs to be considered further by Council. Council should initiate a program whereby pipe upgrades (to an agreed ARI) are undertaken when redevelopment on private property occurs.

5. REFERENCES

1. NSW Government
Floodplain Development Manual
April 2005.

2. City of Lake Macquarie
North Creek Floodplain Risk Management Study
WMAwater Pty Ltd, November 2010.

3. City of Lake Macquarie
North Creek Flood Study
Webb, McKeown & Associates Pty Ltd, May 2005.

6. ACKNOWLEDGEMENTS

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- Department of Environment, Climate Change and Water,
- City of Lake Macquarie Floodplain Management Committee,
- residents of the North Creek catchment.

Figures

Appendix A

Sea Level Rise Policy Fact Sheet

How was the prediction for sea level rise of 0.91 metres by 2100 calculated?

Council has decided on this figure based on the best available scientific information and by choosing to "err on the side of reasonable caution". The calculation assumes a high greenhouse gas emissions scenario.

Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) – global average sea level rise (ignoring ice melt) - high emissions scenario	0.59 metres
Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) – allowance for ice melt uncertainty	0.20 metres
CSIRO Technical Report (2007) – calculation for local variation on IPCC global average sea level rise	0.12 metres
Accumulated level	**0.91 metres**

Why does Council have to adopt a prediction for sea level rise?

Council is responsible for planning future development in Lake Macquarie, for managing the natural environment, and for the wellbeing of residents. Planning and development decisions taken now will still be "on the ground" in 50 to 100 years. This places a duty of care on Council to plan for the future based on the best available information. The proposed rate for sea level rise allows Councillors, Council staff, and the community to develop policies, carry out more detailed studies, and make planning and development decisions that are suitable for the changed conditions. Legal advice indicates that Council may be liable for future damages if it does not properly consider the impact of sea level rise and other climate induced changes in its planning and policy decisions.

Will Lake Macquarie rise by the same level as the Pacific Ocean?

The average level of the Lake is currently about 0.1 metres higher than the Pacific Ocean. While it is expected that the Lake will rise roughly in line with sea level rise, the pumping effect of tides through Swansea Channel and other localised factors mean there will be local variations. Council will use the predicted sea level rise of 0.91 metres by 2100 as the basis for further research and modelling to more accurately predict how the Lake will respond, and predict the impacts on the Lake foreshore.

What are the risks from sea level rise?

The table below, prepared by the Sydney Coastal Councils Group, sets out the main impacts from sea level rise on the coastline and along estuarine foreshores. In general, the impacts on estuaries will be less severe than on the coast.

Impact	Description
Coastal and foreshore erosion, retreat, and storm	▪ Increased rates of erosion ▪ Beach realignment ▪ Increased flooding ▪ Saline water intrusion further into creeks and groundwater ▪ Increased storm surges and long term inundation
Ecological Impacts	▪ Threats to ecological communities unable to adapt to change in salinity levels ▪ Changes in wetland and mangrove distribution ▪ Other flora and fauna impacts
Damage to infrastructure	▪ Damage to public and private infrastructure including roads, bridges, houses and other buildings ▪ Damage to utilities including water, sewer and electricity
Public health	▪ Morbidity and mortality associated with adaptation to sea-level rise e.g. community wellbeing
Economic	▪ Increasing insurance premiums ▪ Investment in climate change mitigation measures ▪ Increased depreciation of land and building values ▪ Loss of tourism, recreation and transportation functions

What will Council do to address these risks?

One of the main reasons for adopting a sea level rise prediction for Lake Macquarie is to allow Council to make a considered assessment of risk and response to risk. Except for the risk from increased flood heights (see below), there are as yet no specific proposals for changes in Council's planning and development processes. However, these issues will be addressed over the next few years, once Council adopts a sea level rise prediction.

Hazard Management Options Suggested by Coastline Management Manual	
Category	**Management Option Examples**
Environmental Planning	• Restrictive Zonings • Planned Retreat • Voluntary Purchase
Development Control Conditions	• Building Setbacks • Raised floor levels • Relocatable Buildings • Planned Retreat
Coastal Dune Management	• Dune Reconstruction and revegetation • Dune Protection and/or Maintenance
Protective Works	• Seawalls • Groynes • Beach Nourishment • Offshore Breakwaters

Having a well-informed and prepared community is an essential part of Council's adaptation response to climate change and sea level rise. Your interest and involvement early in this process will assist the community's and Council's preparedness and response.

Will sea level rise make flooding worse?

If sea levels increase, and the Lake rises similarly, then Lake flood levels will also rise. Currently floor levels in low-lying and flood prone areas are set at 0.50 metres above the calculated 100-year flood level (that is, 1.88 metres AHD for most areas around the Lake foreshore). If Council assumes an average house has a life of 50 years before it is renovated or re-built then, based on the proposed sea level rise scenario, flood levels will be up to 0.49 metres higher by the time the house is due for renewal. Taking into account increased rainfall intensity, and discounting for some climate change factors already included in current flood planning levels, Council has calculated that floor height requirements in low-lying areas for a habitable room in a new dwelling, for example, should be 2.27 metres AHD. This level may vary depending on the building type, expected building life, and the proposed use.

Floods will not only be higher, but will probably occur more frequently due to a predicted increase in the frequency and intensity of storms. As Floodplain Management Plans are developed or reviewed for flood-prone areas around the Lake, and along creeks and watercourse, the flood planning level and recurrence interval (the predicted frequency of floods) will be "fine tuned" to fit with variations caused by climate change factors, topography, and other local features.

What is the difference between inundation and flooding?

Some low-lying areas along the coast and around the Lake foreshore may be inundated as sea levels rise. This means they are **permanently** covered by rising water. Other areas may be affected by increased flood levels, where water covers the area **temporarily** due to tides, waves, high rainfall, or storm surge.

What about other changes due to climate change, such as increased storm intensity?

Scientists predict that, as a result of climate change, the east coast of Australia is likely to experience more frequent storms, more intense storms, and more intense rainfall. Added to the increase in sea level, this will make the impact of floods and storms more severe. Council will use the proposed sea level rise scenario as a base to estimate the increase in risk from these hazards, and will incorporate them in Council's planning controls and emergency response plans. Council and other agencies are beginning to address other predicted climate change impacts, not directly related to sea level rise, such as heat waves, environmental health issues, droughts, and wind storms.

What if the scientists have got it wrong?

There is widespread agreement among scientists that human production of greenhouse gases is causing an increase in global temperature. This, in turn, is leading to a rise in sea level through thermal expansion of the oceans and from ice melt. These changes are measurable and documented. Scientists are less certain about how quickly this is happening, how far it will go, and whether we will be able to substantially reduce our production of greenhouse gases over the next 50 years.

Council has adopted a "high emissions" scenario as it fits most closely with the observable changes in temperature and sea level. It is easier to "relax" from an over-pessimistic

prediction than it is to “catch up” with an over-optimistic prediction. Council will regularly review the scientific predictions and the policies developed by Sate and Commonwealth Governments, and adjust the predicted levels in Lake Macquarie in the light of new information.

Does Council’s Sea Level Rise Policy affect what I can and can’t do on my property?

Council has prepared guidelines for development in areas at increased risk from sea level rise and flooding. These guidelines specify higher floor levels and changed construction techniques for buildings in vulnerable areas. There may also be some restriction on creating new lots by subdivision, if the new lots are likely to be substantially within the area affected by sea level rise. All properties around the lake foreshore below 3 metres AHD have the potential to be affected, although local factors will be considered in each case.

The Council may introduce other planning and development changes to cope with sea level rise and other climate change impacts, but these will be the subject of future studies and proposals. Any major changes will include a process of community input and consultation before being decided by Council. Some of the issues and options to be considered are outlined in the table (above) under the heading “**What will Council do to address these risks?**

Schedule of Activities Leading to Preparedness for Sea Level Rise (SLR)

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
1. Lake Sea Level Rise (under still water conditions)	Damage to properties / buildings from permanent inundation.	Medium	**1.1:** Prepare a LM Sea Level Rise Preparedness and Adaptation Policy and guidelines to assist Council with determination of development applications ***Purpose**: To provide clear and consistent direction to the community and to Council staff with respect to a preparedness level for SLR as the basis to proceed with risk assessment, community empowerment, policy development, planning and development decisions.*	**ES** + IP	8/2008
			1.2: Review relevant provisions of Development Control Plan No. 1 (e.g. waterways and foreshores, building lines, building heights, stormwater, etc) and other relevant planning instruments ***Purpose:** To ensure that predicted sea level rise is taken into account when determining new development on affected land.*	**IP** + ES + DAC	6/2009 + Ongoing
			1.3: Undertake internal (Council) training and development programs to build capacity in assessment and compliance ***Purpose:** To ensure that all relevant LMCC staff involved in assessment and compliance work are aware of and take into account predicted sea level rise when assessing new development on affected land.*	**IP** + ES	10/2008 + ongoing
			1.4: Revise 149 Certificates and Flood Certificates to reflect policy changes. ***Purpose:** To ensure that potential purchasers of land are aware of Council's policy relating to predicted climate change induced sea level rise on affected land prior to them purchasing such land.*	**IP** + DAC	10/2008 + ongoing
			1.5: Provide input into Council's Integrated Foreshore Management Plan currently being developed	**IP**	6/2009

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
			Purpose: *To ensure that Council policy, relating to predicted sea level rise, is reflected for affected land within the Integrated Foreshore Management Strategy.*		
			1.6: Review Floodplain Management Plans + Estuary Management Plans (see also action 2.1 re: flooding) ***Purpose****: To ensure that predicted sea level rise is taken into account when planning for estuary and coastal management*	**ES**	2009 – 2011.
			1.7: Engage community in education, awareness, and preparedness programs ***Purpose****: To ensure that community awareness of this emerging issue is developed to allow for engagement as necessary*	**ES** + others	Imed. and ongoing. 2008/09
			1.8: Develop, facilitate, and resource local area community empowerment pilot projects and action plans to address adaptation (Dora Creek – Climate Change and SLR + Swansea – SLR) ***Purpose****: To ensure that local communities are engaged and participate in the development and implementation of adaptation responses.*	**ES**	Imed. and ongoing. 2008/09. Commenced
			1.9: Modelling of tidal dynamics between lake and entrance channel ***Purpose****: To develop understanding of the links between ocean and lake SLR impacts and assist with risk and vulnerability assessments.*	**ES** + cnsltnt	Est. 6/2009 funding dependent (application submitted)
			1.10: Comprehensive risk and vulnerability assessments ***Purpose****: To identify, assess and prioritise hazards and risks (social, environmental and economic) and identify potential control measures (non structural and structural)*	**ES** + cnsltnt	12/2008 – 12/2009.
			1.11: Cost: Benefit Study of Management Options (IP Matrix) ***Purpose:*** *To ensure all main options for managing land, affected by predicted sea level rise, are identified and costed so that a*	**ES** + IP cnsltnt	12/2008 – ongoing to 2010 and

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
			comparative assessment can be made when determining the appropriate option.		beyond.
			1.12: Establish and maintain stakeholder partnerships including with key agencies (DECC, HCCREMS, Universities etc). ***Purpose**: To engage stakeholders in policy development and ensure access to best available information (scientific and policy) to inform Council's research and response measures.*	**ES** + all	Current + ongoing.
			1.13: Review long term urban development and land use planning strategies to ensure town centres, new infrastructure, and residential densities, for example, are suited to future (including up to the year 2100 and beyond) conditions. ***Purpose:** To ensure that the effect of predicted sea level rise is taken into account and reflected in the identification of land for future development.*	**IP**	Ongoing as other actions are completed. 2008 – 2012.
			1.14: Investigate and develop new building and landscape designs that are able to adapt more easily to sea level rise. ***Purpose**: To encourage innovative building, infrastructure, and landscape designs*	**IP**, ES, DAC, City Design	Imed. + ongoing. 2008 – 2012.
	Damage to infrastructure including: - Roads (LiDAR estimate 170 kms of roads below 2.5 metres AHD) - Water and sewerage (HWC) - Communications - Boating, tourism	Medium	**1.15**: Consider actions outlined above including assessment, mapping, and valuing potentially impacted assets ***Purpose:** To ensure that the potential impact from predicted sea level rise is taken into account when assessing the future of Council's infrastructure and other assets.*	**AM** + IP	2008 -2010.
			1.16: Consider management options outlined above including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:** To ensure that the impact on infrastructure from predicted sea level rise is taken into account when developing appropriate*	**ES** + **IP** + AM + others.	2008 - 2010.

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
	and recreational facilities - Industry, retail, and community services		*management options for affected land.*		
			1.17: Specific liaison HWC, RTA, Telstra, and other infrastructure/ utility providers. ***Purpose:*** *To ensure that the infrastructure of all significant utility providers, affected by predicted sea level rise, is taken into consideration when developing/considering and implementing future options for affected land.*	**ES** + IP + others	Imed, 12/2008 + ongoing..
			1.18: Consider options for managing, protecting, or relocating facilities disproportionately affected by SLR such as marinas, surf clubs, caravan parks, sailing clubs, boat ramps, foreshore reserves, swimming beaches ***Purpose:*** *To ensure future planning preserves land uses and activities dependent on proximity to foreshore and costal zones*	**CP** + IP + ES	2009 - 2010
	Morbidity / Mortality – Physical and mental health (rates /10,000)	Low	**1.19:** Consider relevant controls above, particularly community education and empowerment. ***Purpose:*** *To ensure community health and wellbeing is taken into account in preparedness and adaptation measures..*	**ES** + IP + HNE Health + others	12/2009 + ongoing
	Loss or damage to ecosystems including saltmarsh, wetlands, rocky shelves etc. Obtain from LIDAR and other sources.	Medium	**1.20**: Consider actions outlined above including assessment, mapping, and valuing potentially impacted ecosystems ***Purpose: :*** *To ensure all significant ecosystems, affected by predicted sea level rise, is identified and taken into consideration when developing future management options for affected land.*	**ES** + IP	6/2010
			1.21: Consider management options outlined above including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:*** *To ensure that the impact on ecosystems from predicted sea level rise is taken into account when developing and*	**ES** + IP	6/2010

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
			implementing appropriate management options for affected land.		
			1.22: Investigate impact of possible relocation of foreshore and coastal settlements on biodiversity. ***Purpose:*** *To ensure development relocated from vulnerable foreshore areas doesn't cause unacceptable environmental impacts in new locations.*	**ES** + IP	12/2009 + ongoing
	Economic impacts – tourism, business, livelihoods	Medium	**1.23:** Consider relevant investigation, assessment and management options outlined above; including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:*** *To ensure that the economic and social impacts from predicted sea level rise are taken into account when developing and implementing appropriate management options for affected land.*	**ED** + ES + IP + consult.	6/2010 + ongoing
2. Sea Level Rise + flood conditions	Consider ALL risks outlined above, with exacerbated or increased risk. Eg: (LiDAR estimates: 5500 addresses below 2m AHD, 6,500 addresses below 2.5m AHD. Webb McKeown estimate 3,700 buildings affected by 1:100 year flood with 0.91m SLR).	Increased Suggest Medium to High	**2.1** Review the Lake Macquarie Flood Study, Lake Macquarie Floodplain Management Study, and Lake Macquarie Floodplain Management Plan and adjust the Flood Planning Level accordingly. **2.2** Progressively review other Floodplain Management Plans and adjust the Flood Planning Level accordingly **2.3** Include consideration for SLR in all future Floodplain Management Plans **2.4** Revise Emergency Management Planning and Response Plan/s ***Purpose:*** *To establish the impact of SLR on flood behaviour and impact on the City and to consider and cost assessment, and adaptation responses.*	**ES** + IP + consultants **WER**, SES ES + others.	9/2008 – 12/2012
3. Oceanic Sea Level Rise	Coastline recession	Medium	**3.1:** Map, monitor, and assess vulnerable areas **3.2:** Review design, location, and planned longevity of vulnerable coastline infrastructure such as surf clubs	**IP** + **ES** + consultants	12/2008 – 12/2011

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
			3.3: Review Coastline Management Plan **3.4:** Ensure natural barriers such as dune systems are protected and rehabilitated to improve their resilience **3.5:** Consider relevant investigation, assessment and management options outlined above; including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:*** *To establish the ability of the City's coastline to withstand the likely impact from predicted sea level rise, and to identify vulnerable areas requiring particular consideration.*		
4. Effect of Storm Surge on SLR	Consider ALL Risks Outlined above + additional risks related to storm surge impacts.	Increased Suggest Medium to High	**4.1:** Assess storm surge extent and impacts on ocean and lake: model, map and report **4.2:** Consider relevant investigation, assessment and management options outlined above; including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:*** *To establish the ability of the Lake and coastline to withstand the likely impact from predicted storm surge coupled with SLR and to identify vulnerable areas requiring particular consideration.*	**ES** + IP + consultants	12/2008 – 12/2011
5. Effect of increased <u>frequency</u> and <u>intensity</u> of extreme weather events on SLR	Consider ALL risks outlined above + additional risks related to increased frequency and intensity of extreme weather events on SLR.	Increased, possibly Medium to Extreme	**5.1:** Modelling, risk assessment, and mapping of additional risks related to increased frequency and intensity of extreme weather events on coastline and lake foreshores. **5.4:** Revise standard rainfall tables and recurrence intervals **5.3:** Consider relevant investigation, assessment and management options outlined above; including research, modelling, risk and vulnerability assessment; options analysis (structural and non-structural); cost: benefit analysis; community empowerment. ***Purpose:*** *To assess and take account of anticipated increase in*	**ES** + IP + consultants **ES** As above	10/2008 – 12/2010

Hazard Identification	Risk Identification / Source	Risk Analysis (R:L,C,T)	Risk Amelioration Actions Including Further Work/s Required	Dept/s: Resp = Bold	Est. T/Frame
			frequency and intensity of extreme weather events on SLR		