Practical Consideration of Climate Change

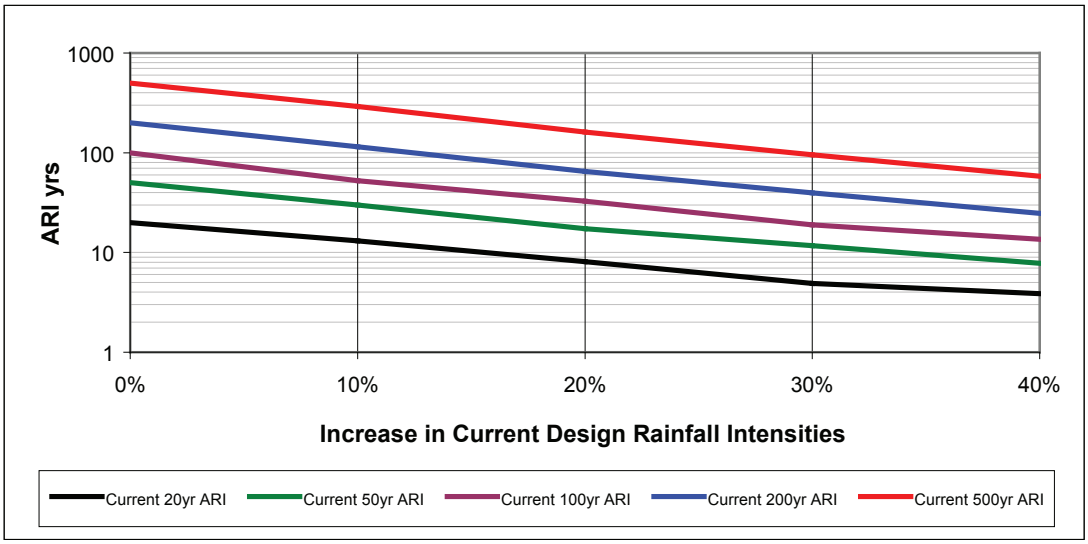
SUMMARY

Climate change is expected to have adverse impacts upon sea levels and rainfall intensities, both of which may have significant influence on flood behaviour at specific locations.

IPCC 2007 trends indicate that average global sea level rise (ignoring ice flow melt) may be between 0.18m to 0.59m by between 2090 and 2100. Add to this the ice flow melt uncertainty of up to 0.2m gives an adjusted global range of 0.18 to 0.79m. IPCC 2007 (0.1m) and recent CSIRO modelling (up to 0.12m) by McInnes et al indicate that mean sea level along the NSW coast is expected to rise by more than the global mean. Combining the relevant global and local information indicates that sea level rise on the NSW coast is expected to be in the range of 0.18 to 0.91m by between 2090 and 2100.

In addition, climate change impacts on flood producing rainfall events show a trend for larger scale storms (rainfall totals for the 40 year average recurrence interval (ARI) 1 day storm events) tend to increase by 2030 and 2070 as shown in **Table 1.** **Figure 1** shows the potential impacts of changes in current design ARIs due to increases in rainfall. CSIRO is currently undertaking further work in the area of shorter duration rainfall events which is expected to lead to further advice in this area in the future.

Figure 1 — Indicative Change in Design ARI as Rainfall Intensities Increase



Source: McLuckie et al, 2005

Climate Change Impacts and their Ramifications

The impacts of climate change and the associated ramifications upon the vulnerability of floodplain risk management (FRM) mitigation options and development decisions can be significant and therefore cannot be ignored in decision making today. The climate change factors affecting flood behaviour and their degree of influence vary with location and therefore it is essential that studies for specific locations consider these impacts and their ramifications. McLuckie et al provides examples of the ramifications of potential impacts including:

- Sea level rise. For example, annual average damage (AAD) to a house built at the flood planning level (FPL) in an area where flood levels are directly controlled by ocean levels could increase by more than 1000% due to a high sea level rise scenario by 2090 to 2100.
- Increased frequencies of events due to increased rainfall intensities (**Figure 1**). For example, in a particular town not influenced by sea level rise, a 30% increase in rainfall could increase AAD by 300%.

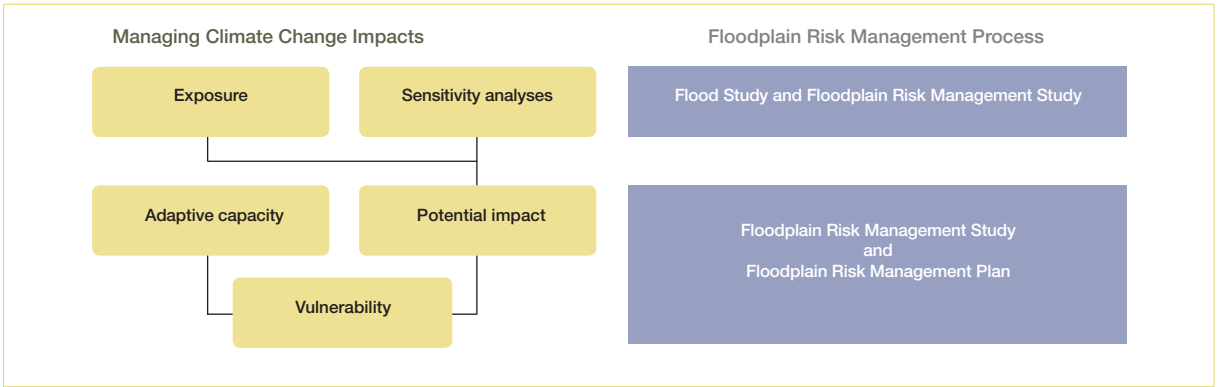
Therefore the 2005 Floodplain Development Manual (the Manual) requires flood studies and FRM studies to consider and where necessary manage climate change implications and associated vulnerabilities as part of strategic management of flood risk **(Figure 2)**. Adaptation may involve consideration of more robust management options now or management options that enable effective adaptation to climate change in the future, i.e. adaptive capacity built into management options.

Table 1 — Indicative Change in Extreme Rainfall 1 day Totals and Evaporation for 2030 & 2070

Source: CSIRO, reports prepared for the NSW Government, 2007. Climate Change in NSW Catchments Series

Catchment	Extreme Rainfall (40 Year 1 day rainfall total) Projected Change 2030	Extreme Rainfall (40 Year 1 day rainfall total) Projected Change 2070	Evaporation Projected Change 2030	Evaporation Projected Change 2070
Border Rivers-Gwydir	+3% to +7%	+10% to +15%	+2% to +13%	+4% to +40%
Central West	-3% to +20%	-3% to +15%	+2% to +13%	+4% to +40%
Hawkesbury-Nepean	-3% to +12%	-7% to +10%	+1% to +8%	+2% to +24%
Hunter-Central Rivers	-10% to +12%	-7% to +10%	+1% to +13%	+2% to +40%
Lachlan	-3% to +25%	-7% to +29%	+2% to +13%	+4% to +40%
Lower Murray-Darling	+0% to +25%	+0% to +29%	+2% to +13%	+4% to +40%
Murray	-3% to +25%	-7% to +29%	+2% to +13%	+4% to +40%
Murrumbidgee	+7%	+5%	+1% to +13%	+2% to +40%
Namoi	+3%	+10%	+2% to +13%	+4% to +40%
Northern Rivers	-10% to +5%	+5% to +10%	+1% to +13%	+4% to +40%
Southern Rivers	+7%	+5%	+1% to +13%	+2% to +40%
Sydney Metropolitan Catchments	-3% to +12%	-7% to +10%	+1% to +8%	+2% to +24%
Western Catchment	-10% to +34%	-7% to +16%	+1% to +13%	+4% to +40%
Maxima	-10% to +34%	-7% to +29%	+1% to +13%	+2% to +40%
Average	-2% to +15%	-1% to +15%	+1% to +12%	+3% to +38%

Figure 2 - Managing Climate Change Impacts (adapted from Allen Consulting Group 2005)



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This guideline provides the following advice to assist in considering climate change in managing flood risk:

Section 1. Assessing climate change impacts through modelling sensitivity analyses.

Section 2. Determining whether climate change is a key issue at a particular location. This depends upon the impacts on flood damages and increased frequency of exposure of people to flood hazard.

Section 3. Incorporating climate change in floodplain risk management plan development considerations, and in new and current works projects and planning strategies.

Section 4. Outlining some potential climate change management strategies for existing and future development and associated practical issues.

Recommendation

It is recommended that this guideline be used as the basis for examining climate change in projects undertaken under the State Floodplain Management Program and the 2005 Floodplain Development Manual.

All associated reports are to have a section that specifically addresses climate change. The scope of reporting should reflect the scope of the particular study and as a minimum include an outline of the modelling and analyses undertaken and their limitations, discuss the impacts of climate change on flood behaviour and outline any associated conclusions and recommendations. Where the study also looks at ramifications of flooding and examine management options these issues should also be addressed in the climate change section of the report.

References

McLuckie D, Lord D, Gibbs J. "Climate Change — The Future is Uncertain. Practical Consideration of Climate Change in Flood Risk Management in NSW". 46th Annual NSW FMA Conference, Lismore, March 2006.

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IPCC 2001 "Climate Change 2001". Comprising the third assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

Abbs D., Aryal S., Campbell E., McGregor J., Nguyen K., Palmer M., Rafter T., Watterson I., Bates B., October 2005. "Projections of Extreme Rainfall and Cyclones." Draft Final Report to the Australian Greenhouse Office.

CSIRO, prepared for the NSW Government, 2007. Climate Change in NSW Catchments Series. Individual reports cover the following areas of NSW: Border Rivers-Gwydir, Central West, Hawkesbury-Nepean, Hunter-Central Rivers, Lachlan, Lower Murray-Darling, Murray, Murrumbidgee, Namoi, Northern Rivers, Southern Rivers, Sydney Metropolitan, Western.

CSIRO and Bureau of Meteorology, Climate Change in Australia, Observed Changes and Projections. October 2007.

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

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Section 1 Sensitivity Analysis — Timeframe and Scenario Selection

The Summary and **Figure 1** outline the potential climate change impacts on sea levels and on flood producing rain.

Whatever climate change scenario is adopted may be exceeded in the future as climate change continues. Therefore the precautionary principle suggests consideration of the full range of scenarios.

The 2090-2100 (ocean) and 2070 (rainfall) timeframes have been selected as the basis for current decisions for development and management options unless it can be shown to the satisfaction of the relevant Council or DECC that the associated decisions or options will not be relevant by this timeframe. Longer timeframes could also be considered, particularly for critical infrastructure.

The following sensitivity analyses are recommended:

- for sea level where relevant to the study area:
  - 0.18m (Low Level Ocean Impacts
  - 0.55m (Mid Range Ocean Impacts
  - 0.91m (High Level Ocean Impacts

In addition until more work is completed in relation to the climate change impacts on rainfall intensities the following sensitivity analyses are recommended:

- Rainfall Intensities. Increases of:
  - 10% in peak rainfall and storm volume
  - 20% in peak rainfall and storm volume
  - 30% in peak rainfall and storm volume

Note that the combination of ocean event ARI with flood event ARI should be discussed with DECC floodplain risk management (FRM) staff due to joint probability issues. Sensitivity analyses should also consider combined sea level rise and rainfall factors where applicable.

Climate change related sensitivity analyses should be in addition to the usual sensitivity analyses involved in flood and FRM studies undertaken in accordance with the Manual.

Section 2 Is Climate Change a Significant Issue for the Location?

The potential impacts of climate change and the associated ramifications will vary significantly with location. Therefore the Manual highlights the need for climate change to be considered in both the flood study and the FRM study to assess the location specific impacts and ramifications and consider associated adaptive FRM strategies.

Any management measures relating to a specific ARI flood event are more susceptible to climate change than those relating to an extreme or probable maximum flood (PMF) event as the associated emergency response management decisions are inherently more robust.

Whilst climate change impacts and ramifications may vary within and between study areas, the following questions will assist in assessing the sensitivity of the study area or specific portions of it to the impacts of climate change.

1. Will climate change result in new floodways developing in the key design events? If so are the associated ramifications to existing or proposed future development or management options significant?
2. Will climate change have significant implications for flood hazard in the study area? If so can this be managed through changes to existing measures or by using new mitigation measures or development controls?
3. Will climate change result in a significant increase in the frequency of inundation? If so is this acceptable, ie is the land still viable or does this increased frequency need to be mitigated? **Figure 3** indicates that the current 100 year ARI design ocean level may occur monthly with the high climate change sea level rise scenario by 2090 to 2100. The frequency of this occurrence and its chance of coinciding with flood producing rainfall events will therefore increase significantly.
4. Will climate change result in a significant increase in frequency of exposure to hazard? If so can this be managed?
5. Will climate change significantly impact upon flood damages? If so, can the community cope with the increased damage or is it necessary to mitigate impacts to reduce the ramifications? Do conditions for new development need to change to reduce the potential growth in damages?

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6. Is the effectiveness of existing or proposed management options vulnerable to climate change? If so are they still appropriate? Do new options need to be considered? Can existing or proposed management options be altered to build in adaptive capacity now or in the future? Section 4 provides some advice on building in adaptive capacity.

7. Are existing or proposed development options or controls vulnerable to climate change? If so are they still appropriate with climate change? If not, can they be altered to allow for climate change? Is the opportunity cost of the alteration significant for the location? Do we need to allow for structural measures to protect new areas in the event of significant levels of climate change? Section 4 provides some advice on building in adaptive capacity.

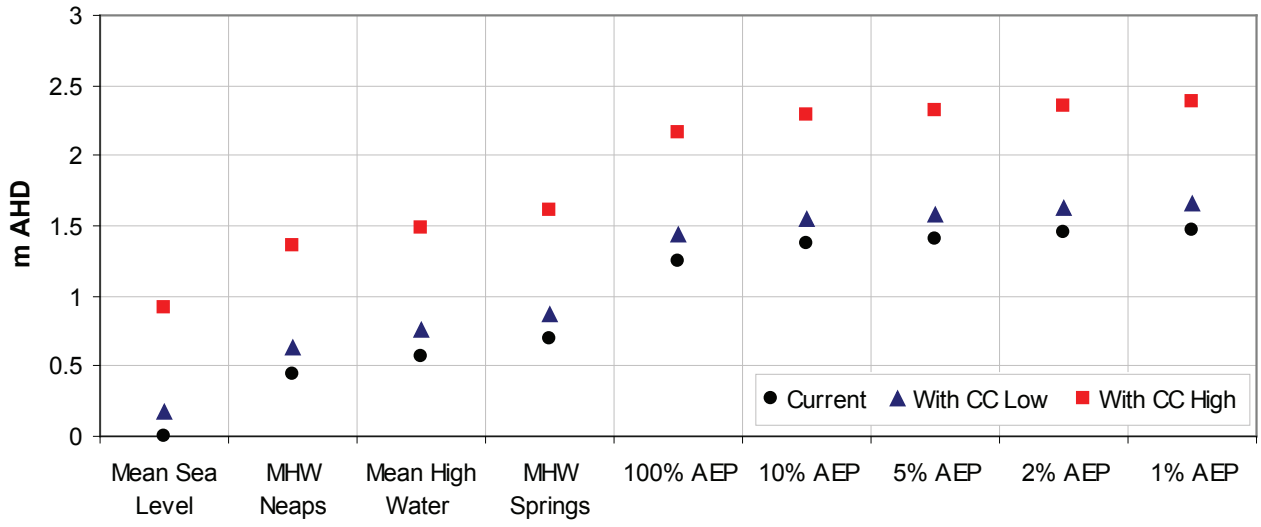
Section 3 Considerations of Climate Change in FRM Projects

The Manual highlights the need for climate change to be considered in both the flood and FRM study to determine the potential impacts on flood behaviour and to enable robust and informed decisions on appropriate adaptive strategies for managing flood risk into the future. These strategies need to be documented in the FRM Plan.

Where the project or decision making has progressed beyond this stage and climate change has not been considered, it is recommended that it now be considered to ensure that decisions and options are robust and adaptive enough to deal with relevant climate change impacts for the locality. This may be undertaken as part of a review to the FRM plan (required at least every 5 years, under Section 2.7 of the Manual), as part of the preliminary concept design for a works project or as part of a review of works or development strategies that have been implemented.

Table 2 provides an indicative scope of works to ensure that relevant climate change impacts for the locality are adequately understood and considered in informed decision making. The documentation of decisions in the FRM Plan and their incorporation into associated implementation strategies must also be ensured.

Figure 3 - Differences in Key Ocean Levels — 2090-2100 (IPCC 2007 + CSIRO McInnes et al)



Source: Mcluckie et al (2005)

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Table 2 - Consideration of Climate Change in FRM Projects

Number and Description of Issue		Flood Study	FRM Study & Plan	FRM Plan Review	Review of New Works Projects & new Planning Strategies	Review of Completed Mitigation Works & Current Planning Strategies
1	Incorporate climate change sensitivity analyses into modelling of current & fully developed catchment model behaviour, flood damage assessments and management option modelling & assessment. Synopsis in main report with detail in appendices.	Yes	Only if not dealt with in Flood Study	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
2	Assess and report on the potential impacts of climate change on flood behaviour and associated ramifications for flood damages, exposure of people to flood hazard and regularity of inundation. Summarise in main report with more detail provided in appendices.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
3	Examine and report on the appropriateness of current or proposed management strategies for existing and future development to deal with long term climate change impacts (ie is the type of option robust enough to deal with climate change implications). Consideration needs to be given to whether climate change impacts will mean that current management strategies are not viable.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
4	For viable options, examine the vulnerability of current or proposed management options to climate change. Consider items in Section 4.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
5	For viable options, examine the vulnerability of current or proposed development strategies and associated conditions to climate change. Consider items in Section 4.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
6	Examine the practicality of building adaptive capacity into management options either now or in the future. Need to consider viability and how issues raised in Section 4 can be addressed.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
7	Examine the practicality of building adaptive capacity into development strategies/conditions either now or in the future. Need to consider viability and how issues raised in Section 4 can be addressed.	n/a	Yes	Only if not dealt with earlier	Only if not dealt with earlier	Only if not dealt with earlier
8	Make informed decisions on managing vulnerability to climate change through either building adaptive capacity into management options and development strategies and controls or accepting the additional risk after considering the associated ramifications.	n/a	Yes	Yes	Yes	Yes
9	Incorporate synopsis of climate change impacts, ramifications and associated decisions, including any associated implementation timetable, into the FRM Plan.	n/a	Yes	Yes	Yes	Yes

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