SEA-ING CHANGE – LAND USE AND EMERGENCY PLANNING FOR EXISTING AND FUTURE FLOOD RISK DUE TO SEA LEVEL RISE

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Abstract

This paper discusses the challenges of managing existing and future flood risks for low level settlements nearby Intermittently Closed and Open Lakes or Lagoons (ICOLLs). It will draw on the findings of Floodplain Risk Management Studies and Plans (FRMSPs) at Conjola, Burrill and Tabourie Lakes in the Shoalhaven Local Government Area (LGA).

ICOLLs can be flooded by three different mechanisms: catchment rainfall, oceanic inundation and low-level persistent flooding when the entrance is closed.

The FRMSPs show that the main risk to life and property from flooding is currently attributed to catchment rain events. However, with rising sea levels, the dominant flood mechanism will become ocean driven, and flood damages will increase by up to ten-fold in some areas for frequent flood events.

The FRMSPs have also shown that engineered/structural flood mitigation options are limited, if available at all. Flood management options are therefore reduced to emergency management, development controls and strategic land use and post disaster recovery planning.

Emergency management options are hampered by quick catchment responses with minimal warning time, limited flood warning systems, wide distribution of flood affected villages and limited local SES resources. Development controls can address existing risk, but in future without further adaptation, land will be regularly affected by floods, tides and high lake levels. How liveable and serviceable will these areas be in the future?

Additional studies to identify appropriate land use transition strategies including rolling easements, land swap strategies and alternate land use zonings are required. At Conjola, the community is working with Griffith University to develop a resilience plan. These actions aim to ensure future generations are not displaced by the legacy of current planning and development decisions. But can any of these options be implemented now or will support only be gained following a major disaster?

Introduction

Available literature and data records show that historically, significant flooding in NSW coastal catchments has occurred both from intense rainfall events over coastal river and lake catchments, and also from elevated ocean levels pushing landward through estuary entrances to inundate the lower lying foreshores and floodplain areas (McLuckie et al. 2014). In addition, ICOLLs are also subject to low level persistent flooding when the entrance is closed.

While climate change will have impacts on all types of flooding, this paper focuses on the impacts of sea level rise on ocean and low-level persistent flooding in coastal communities. Shoalhaven City Council (Council) has completed climate change assessments for most of its coastal catchments, which include the Shoalhaven River and St Georges Basin waterways, as well as the Conjola, Burrill and Tabourie Lake ICOLLs. These climate change assessments have investigated the impacts of a 0.4m and a 0.9m sea level rise.

This paper will outline the findings of these assessments, implications on engineered/structural flood mitigation options, emergency management options and land use management options.

Modelling of sea level rise

Guidance to councils for considering the impacts of climate change (sea level rise and rainfall increase) on flood risk is mainly provided by the following State Government guidelines:

- Floodplain Risk Management Guideline: Practical Consideration of Climate Change, NSW Department of Environment and Climate Change, October 2007;
- Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, and Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments, published by the NSW Department of Environment, Climate Change and Water, August 2010.

For sea level rise, the guidance stipulated an increase of 0.4m by the year 2050 and an increase of 0.9m by the year 2100. To assess the effects of sea level rise on flood events, each ordinate of the ocean level hydrographs was increased by the assumed sea level rise.

A comparison of the adopted peak ocean levels is provided in Table 1 for the Shoalhaven River and Crookhaven River. Table 1 shows that the current 100 year Annual Recurrence Interval (ARI) peak ocean flood level will have a greater occurrence with the impact of sea level rise; that is, the future 10 year ARI event will have an even greater level than the current 100 year ARI event.

At St Georges Basin, a sea level rise of 0.4m equates to four times the difference between the 20 year and the 100 year ARI design flood levels at the entrance to the basin. For example, the current (2012) seven year sea level is estimated at 1.7m AHD, by the year 2050 this will have increased to 2.1m Australian Height Datum (AHD). This level (2.1m AHD) is the current 100 year ARI ocean level, thus in the year 2050, the current 100 year ARI ocean flood levels are likely to be exceeded approximately 14 times more regularly than under existing conditions. Similarly, a sea level rise of 0.9m represents a significant increase in the design sea levels with the current 100 year ARI level expected to be exceeded every year (WMA Water, 2011).

Table 1: Comparison of peak oceanic flood water levels (in m AHD) from varied starting sea level conditions (WMAwater, 2011)

Flood (ARI)	100y/200y 500y/Extreme	50y	20y	10y
Existing sea level				
Shoalhaven River	2.40	2.20	2.10	2.10
Crookhaven River	1.98	1.90	1.80	1.80
+0.4m sea level rise				
Shoalhaven River	2.80	2.60	2.50	2.50
Crookhaven River	2.38	2.30	2.20	2.20
+0.9m sea level rise				
Shoalhaven River	3.30	3.10	3.00	3.00
Crookhaven River	2.88	2.80	2.70	2.70

Note: in the absence of any other data the 100y ARI ocean conditions have been adopted for all events greater than the 100y ARI event.

In the absence of a detailed guideline, the envelope approach (outlined in Table 2) was adopted for modelling the combined effect of catchment and oceanic flooding. It should be noted that the adopted approach varies from the now recommended approach by McLuckie et al. (2014).

Table 2: Adopted combinations of ocean and catchment flood events (WMAwater, 2013)

Ocean Envelope		**Design Flood Event (AEP)**	**Catchment Envelope**	
Peak Design Ocean Event (AEP)	Co-incident Catchment event (AEP)		Catchment flood event (AEP)	Co-incident Ocean flood event (AEP)
PMF	1%	**PMF**	PMF	1%
1%	5%	**1%**	1%	5%
2%	5%	**2%**	2%	5%
5%	5%	**5%**	5%	5%
10%	10%	**10%**	10%	10%
20%	20%	**20%**	20%	20%
50%	50%	**50%**	50%	50%

For ICOLLs, there are no current government guidelines covering the impact of future climatic change on entrance berm geometries. Wainwright et al. (2012) states that the effect of sea level rise on entrance conditions are likely to be complex and cannot be accurately determined. However, research suggests that barrier berm height is expected to rise at a similar rate to mean sea level.

For the purpose of modelling the sea level rise impact on entrance berms it was assumed that a net upward shift in typical berm heights at the entrance may be proportionate with sea level rise projections. It was also acknowledged that apart from increasing berm heights, one of the other potential effects of sea level rise is the impact on the opening/closure regime of entrances however these could not be evaluated and therefore were not considered as part of these studies.

Effect of sea level rise on flood levels

The modelling results generally showed that:

- the effect of sea level rise varies with distance upstream from the ocean. This was expected, however the effects reduce within a shorter distance upstream in the smaller events (10 year) than in the larger events (100 year).

- the effect of sea level rise reduces with the magnitude of the catchment flood. That is, the larger the catchment flood, the less impact sea level rise will have on flood levels. For larger events the greater catchment peak flow means that the ocean level is a lesser factor in determining the peak water levels. This is to be expected as in larger events the greater catchment peak flow means that the sea level is a lesser factor in determining the peak water levels

- For Conjola and Burrill Lakes, current catchment flooding presents the most risk and generates higher flood levels than ocean floods. As can be seen in Table 3 with sea level rise the flood risk from either catchment flooding or ocean derived flooding is relatively similar. Therefore consideration of both flooding mechanisms is required in determination and assessment of appropriate floodplain risk management options.

Table 3: Comparison of peak flood levels at Conjola Lake under existing and sea level rise conditions (in m AHD) (BMT WBM, 2013)

Event conditions	Planning Horizon		
	Existing	2050	2100
5% AEP Catchment Event	2.8	3.0	3.2
5% AEP Ocean Event	1.9	2.4	2.9
1% AEP Catchment Event	3.2	3.4	3.5
1% AEP Ocean Event	2.2	2.7	3.3

- The increase in the range of normal water levels in non-flood times will result in more frequent flooding of low lying areas. A 0.9m sea level rise would result in a King Tide level of 1.5m AHD. Figure 1 shows the extent of inundation under Highest High Water Spring (HHWS) with a 0.9m AHD sea level rise.

- The 1% Annual Exceedance Probability (AEP) flood extents incorporating a 0.4m and 0.9m sea level rise are very similar to flood extents under current conditions. This is due to the floodplains having defined boundaries, leading to an increased depth rather than increased extent. As a result of sea level rise more high hazard flood storage areas will be present in the catchment. This is due to a general increase in flood levels and therefore flood depths across the catchment.

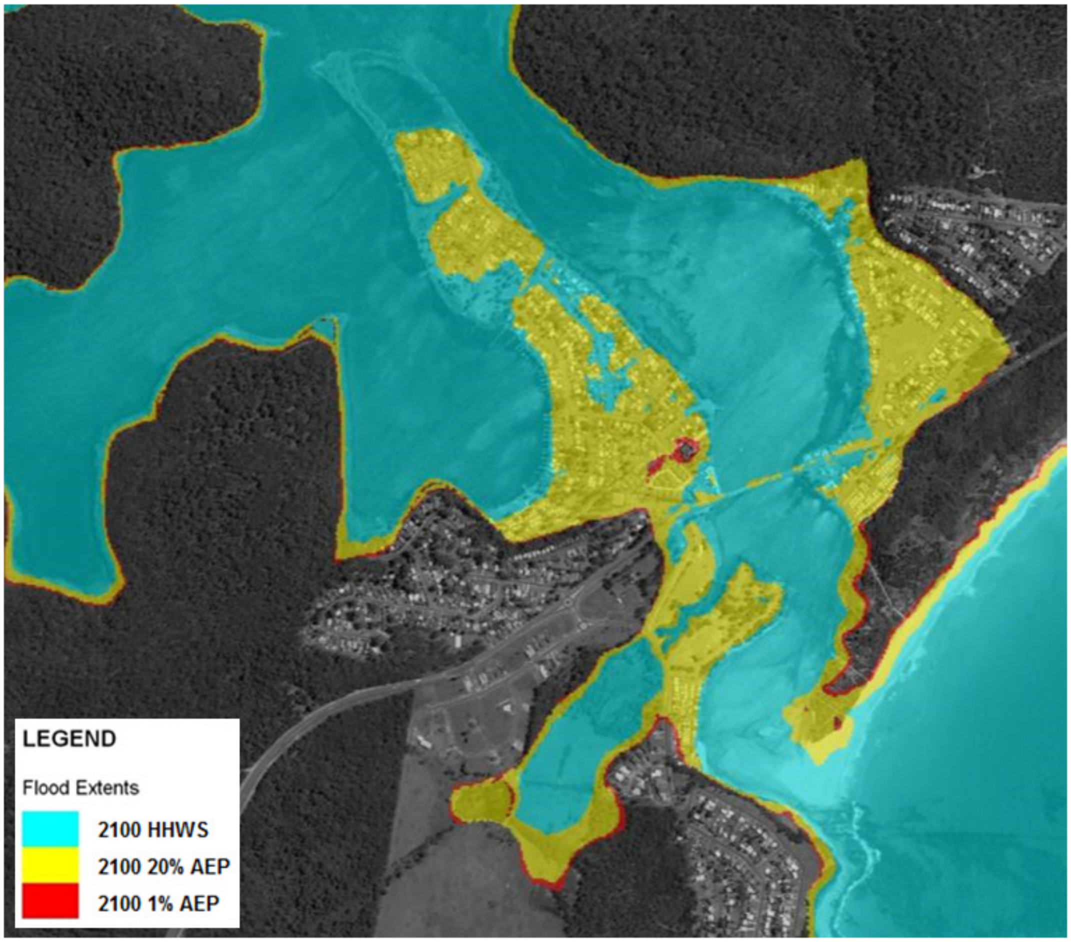

Figure 1: Flood extents with a 0.9m sea level rise at Burrill Lake (BMT WBM, 2013)

Effect of sea level rise on flood damages

Table 4 shows that the number of properties affected by the 1% AEP flood event increases with an increase in sea level. It can be seen that for the Burrill Lake catchment, with a 0.4m sea level increase, there is a 42% increase in the number of properties affected by overfloor flooding. For the St Georges Basin catchment, with a 0.9m sea level increase, there is a 78% increase in the number of properties affected by overfloor flooding.

Table 4: comparison of the number of buildings with overfloor flooding for the 1% AEP flood event under existing and sea level rise conditions

Number of buildings with overfloor flooding - 1% AEP flood event	Current sea level condition. No. affected properties	With 0.4m sea level rise		With 0.9m sea level rise	
		Affected buildings	Percentage increase	Affected buildings	Percentage increase
Shoalhaven River	737	810	10%	839	14%
St Georges Basin	597	749	25%	1065	78%
Lake Conjola	183	225	23%	280	53%
Burrill lake	318	450	42%	470	47%
TOTAL	**1835**	**2234**	**22%**	**2654**	**44%**

Table 4 highlights the extent of low lying development in the smaller catchments, with larger increases in flood affectation being felt in St Georges Basin, Conjola Lake and Burrill Lake compared to the Shoalhaven River. This highlights the future vulnerability of existing development in low lying areas.

For all four catchments, it can be seen that more buildings will be affected by overfloor flooding due to sea level rise.

Table 5 shows that the Average Annual Damages (AAD) will increase nearly twofold with a 0.4m sea level rise, and by nearly fourfold with a 0.9m sea level rise. Todays total AAD is $11 million, this increases to $44.7 million with a 0.9m sea level rise. This is a significant increase and will have a significant impact on the future economic viability of low lying floodplain areas.

There will be a significant increase in flood damages caused by a 10% AEP flood event across all catchments under sea level rise conditions (Table 6).

Table 5: Comparison of Average Annual Damages (AAD) caused by floods under existing and sea level rise conditions

	Current sea level condition. AAD (million $AUS)	With 0.4m sea level rise		With 0.9m sea leve rise	
		AAD (million $AUS)	Percentage increase	AAD (million $AUS)	Percentage increase
Shoalhaven River	4.7	7.5	60%	12.3	162%
St Georges Basin	2.6	6.2	138%	17.2	561%
Lake Conjola	1.8	2.1	17%	4.1	128%
Burrill lake	1.9	5.6	195%	11.1	484%
TOTAL	11.0	21.4	95%	44.7	306%

Table 6: Comparison of AAD caused by a 10% AEP flood event under existing and sea level rise conditions

10% AEP flood event damages	Current sea level condition. AAD (million $AUS)	With 0.4m sea level rise		With 0.9m sea level rise	
		AAD (million $AUS)	Percentage increase	AAD (million $AUS)	Percentage increase
Shoalhaven River	4.9	10.1	106%	19.0	288%
St Georges Basin	4.0	11.1	177%	86.0	2050%
Lake Conjola	4.7	5.8	234%	11.8	151%
Burrill lake	4.4	16.7	279%	32.1	629%
TOTAL	18.0	43.7	143%	148.9	727%

Flood damages caused by a 1% AEP flood event will increase across all catchments under sea level rise conditions. A comparison of Table 6 and

Table 7 shows that the increase in damages due to the 1% AEP flood event is not as significant as the increase in damages due to the 10% AEP flood event.

Table 7: Comparison of AAD caused by a 1% AEP flood event under existing and sea level rise conditions

1% AEP flood event damages	Current sea level condition. AAD (million $AUS)	With 0.4m SLR		With 0.9m SLR	
		AAD (million $AUS)	Percentage increase	AAD (million $AUS)	Percentage increase
Shoalhaven River	54.0	58.0	7%	63.0	17%
St Georges Basin	31.4	54.9	75%	86.0	174%
Lake Conjola	13.7	16.0	17%	22.8	66%
Burrill lake	21.3	32.1	51%	39.3	85%
TOTAL	120.4	161.0	34%	211.1	75%

Overall, Tables 4 to 7 show a significant increase in properties affected by abovefloor flooding as well as a significant increase in damages. They indicate a greater percentage increase in damages caused by sea level rise for the smaller events than the larger events. This is to be expected as the effect of sea level rise reduces with magnitude of the catchment flood. Therefore the larger the catchment flood, the less impact sea level rise has on flood levels.

The above results suggest that in the context of sea level rise more attention needs to be directed towards more frequent flood events rather than the design 1% AEP flood event.

Impact of sea level rise on engineered/structural flood mitigation options

A number of engineered/structural flood mitigation options were investigated as part of the Floodplain Risk Management Studies and Plans (FRMSP) conducted for individual catchments. The impact on these options and effectiveness of these options was investigated in relation to sea level rise. Identified engineered/structural flood mitigation options and the findings of these investigations are detailed below.

Levees

The Shoalhaven Local Government Area (LGA) has two major levee banks which are located along the Shoalhaven River at Riverview Road, Nowra and Terara Village. Raising these levees to mitigate the effects of flood level increases due to sea level rise was investigated as part of the Lower Shoalhaven River FRMSP – Climate Change Assessment. Due to the location of these levees approximately four kilometres upstream of the river entrance, relatively small increases in flood levels due to sea level rise (less than 0.1m) are expected. It was therefore found that the cost to raise these levees cannot be justified at this time on economic grounds.

New levees to protect low lying areas now and in the future were also considered. In the absence of detailed groundwater modelling analysis it was assumed that the areas located behind levees will be subject to increased groundwater levels, broadly commensurate with sea level rise. Thus, for areas that are already low lying, the construction of a levee for protection from ocean inundation will be futile as the inundation will literally come up through the ground.

House raising

Raising existing houses to a level above identified flood levels was investigated as a potential flood mitigation option. While the potential to raise houses above identified flood levels to account for sea level rise is possible, two issues were identified.

It is not possible to raise all flood liable buildings due to age, design and/or construction type. Even if all buildings could be raised other measures would need to be employed in conjunction with house raising to combat the effects of sea level rise, as discussed below.

It is expected that low lying areas will no longer be serviceable due to frequent aboveground inundation and high groundwater tables. This will impact property access, sewer and stormwater systems, among other things. This could jeopardise the structural stability of a property as high groundwater levels impact foundation integrity. By enabling buildings to remain in low lying flood affected areas, low level persistent flooding and nuisance flooding (which is already an ongoing management issue for Council) will be amplified. Therefore house raising was not identified as a viable flood mitigation option.

Filling of the floodplain

Two types of filling were considered in the FRMSP: incremental filling (which generally applies to existing infill development) and broad scale filling (which generally applies to greenfield development). It was found that due to the size of the floodplains, some filling could be considered with negligible impacts on flood levels. However, a number of challenges were identified with this option and are summarised below.

- Design fill levels
    - Given the design life of properties and the fact that progressive filling of land is not practical, design fill levels would need to consider a 70 to 100 year planning horizon and associated sea level rise. The fill level would therefore generally be quite high from existing ground levels and more so in low lying areas. At Burrill Lake, up to 2.5m of fill would be required causing significant issues related to serviceability (i.e. property access, sewer and stormwater), cost to property owner and amenity.

- Redistribution of floodwaters/local drainage
    - Filling would result in floodwaters being redirected and/or concentrated to non-filled areas resulting in more risks to those areas. Filling could block drainage paths and create low points resulting in a concentration of flows. Extensive filling of the floodplain in these low-lying areas would be required to combat these problems.

- Public access to waterways
    - Filling properties adjacent to foreshore areas will ultimately result in a complete loss of the foreshore environment, unless public foreshore areas are also raised. Rising water levels will eventually reach the boundaries of filled private land providing a hard edge between private property and the waterway. This would limit public access to the foreshore/waterway and the opportunity for public foreshore infrastructure such as boat ramps and beach access paths to be maintained and provided.

- Ecological impact
  - Foreshore areas are important for a range of terrestrial and aquatic flora and fauna. By creating a hard edge, filling will provide no space for ecological communities to migrate in response to rising sea levels. The loss of the foreshore will result in the loss of the interface between the waterways and developed areas resulting in water quality impacts and loss of habitat.

- Serviceability
  - Land filling options will only work if there is a corresponding adaptation of roads, stormwater drainage, water supply, sewerage, communications and other public and utility infrastructure. The piecemeal approach to land filling via redevelopment of individual properties provides issues with connectivity and serviceability of these networks.

- Visual impact
  - Due to land ownership, it is unlikely that large scale filling would be conducted. Instead piecemeal filling of suburbs would occur as individual property owners fill their land parcel. This would lead to a marked impact on the landscape and character of these areas.

- Cost
  - Large scale filling would have a significant public and private cost, which may not be feasible.

Because of these challenges large scale filling of the floodplain was not identified as a suitable flood mitigation option.

Entrance Management

Mechanical entrance openings of ICOLLs are currently conducted by Council. They are largely performed for the protection of low-lying public and private assets subject to inundation from elevated water levels as a result of entrance berm closure. From a floodplain management perspective the benefit of entrance management is largely restricted to alleviating low-level persistent flooding which affects low lying development. With increasing sea level it is expected that a corresponding rise in barrier berm height will occur. If current opening trigger water levels are maintained, mechanical entrance opening will become more challenging and costly due to greater quantities of sand in the entrance requiring excavation. It will also give rise to increased oceanic inundation, as it has been shown that open entrance conditions will become as problematic as elevated lake water levels when the entrance is closed. The modelling shows that with sea level rise the worst flooding will occur from the oceanic inundation rather than from a rainfall event.

This questions the ongoing suitability of conducting mechanical entrance openings for the purposes of flood mitigation.

Impacts of sea level rise on emergency management and evacuation

Emergency Management Options

As previously discussed, under sea level rise conditions, oceanic flooding in ICOLLs will give rise to similar peak flood levels as currently experienced from catchment flooding. Currently the peak catchment flood can be reached within 12 to 22 hours (Burrill Lake and Conjola Lake). This gives time for emergency plans to be implemented. For oceanic flood events, advanced warning time is significantly reduced, if available at all, which leads to reduced ability to implement emergency plans.

Oceanic flooding is driven by the superposition of storm surge on top of the normal tidal signal. Accordingly, the rate of rise of flooding coincides with the normal tidal cycles of approximately 7 hours, giving little warning time. The duration of coastal flooding is however typically shorter than catchment flooding, with the peak coinciding with high tide. Even with a reduced flood duration the impact of flooding will still be felt in its entirety, causing the same impact as a catchment flood event.

Evacuation Requirements

At present many low lying locations do not have adequate flood free access. This will be exacerbated with sea level rise. In addition, the minimal warning time worsens the vulnerability of these locations and the lack of adequate access may mean that some areas should not be further developed.

An alternative to evacuation is to “shelter in place” and has been considered for some flood prone areas where it is impossible to provide protection or voluntary purchase for all existing houses in the floodplain. However, shelter in place has not been considered suitable for any of the catchments within the Shoalhaven as the duration of catchment flooding is such that many residents will be effectively forced to leave through floodwaters due to lack of food, power, functioning sewerage or a need to access relatives or a medical emergency.

It has been shown that for the Shoalhaven LGA, engineered/structural flood mitigation options and emergency management and evacuation options will have limited, if any, success in mitigating against and preparing for flooding risks in the future.

Planning Responses

Land use planning and development controls are a key mechanism by which Council can manage future flood risk by legally controlling and directing future development and redevelopment of private and public lands. Because of the incremental nature of development, the benefits of flood planning controls may not be realised for many years.

Local Environment Plans (LEP) and Development Control Plans (DCP) are the key local planning documents/instruments that can assist Council in responding to flooding risk. LEPs and DCPs may be amended in the future and as a result, the opportunity remains to improve flood planning controls as our understanding of flood risks become more refined. Allow pre-emptive adaption to the future risk.

There are however limitations to the extent that a LEP or DCP can respond to flood risk. For example, the Shoalhaven LEP 1985 provided a range of provisions relating to flooding that extended from zoning that related specifically to flood liable or urban flood prone land to providing area specific provisions relating to flood prone land. In the transfer of the Shoalhaven LEP 1985 content to the Shoalhaven LEP 2014 standard instrument, consideration of flooding has generally been limited to Clause 7.3 'Flood Planning' (the Standard Instrument model clause) and associated mapping. The requirement to conform to the Standard Instrument LEP means that Council does not have as much flexibility as was experienced with the Shoalhaven LEP 1985. Greater emphasis is therefore required in the DCP to manage flood risk.

There are a number of ways planning mechanisms can be used to control future development. Identified strategies such as planned retreat, placing limitations on the extent of development, changes to exempt and complying development, rolling easements and land swaps are explored below.

Ongoing development/redevelopment

Sea level rise will mean that many localities in the St Georges Basin catchment (and elsewhere along the Shoalhaven and NSW coastline) will move from being low hazard (based on depth and velocity) in the year 2012 to high hazard (due to an increase in depth) in the future. If land is currently not developed and residential development is not permitted or supported by Council due to the high hazard categorisation, back zoning the land to reflect the constraints could be a useful tool to protect flood prone land. However, in many of these localities there is existing development such as at Sussex Inlet or surrounding Lake Illawarra, Tuggerah Lakes or Lake Macquarie. Should redevelopment be permitted in these areas?

Each area is different and needs to be looked at individually. It is therefore not possible to provide broad scale redevelopment guidelines that can be applied without further consideration of the local area. Local area studies would need to be undertaken to investigate local issues and provide advice to feed in to local planning documents and instruments.

Redevelopment of these areas is driven by the significant investment from the public and private sector, which would effectively be lost if these areas were abandoned. In the past, communities have been abandoned for flooding reasons (Terara Village on the Shoalhaven River) or not permitted to be redeveloped (parts of Maitland on the Hunter River) but such approaches are unlikely to be supported by the community today. The main issue with redevelopment is that communities will still occupy the floodplain and there remains the residual risk to lives and property.

Planned retreat

The issue of redevelopment and/or continued habitation in existing areas subject to sea level rise presents many issues for every coastal community in NSW and throughout the world. There is no simple viable solution and it will take time for residents and all levels of government to determine an equitable way forward. Consideration needs to be given to when the land becomes unsuitable for habitation due to frequent inundation.

It is expected that a strategic plan will be required to decide if the low-lying areas affected by frequent inundation should be abandoned or adapted. In Burrill Lake some streets are currently at a level of about 1m AHD, these areas will become unliveable with a sea level rise of 0.5m. The street level would be the same level as mean Lake level, while the groundwater level would likely be at the surface, making the areas permanently wet.

Therefore, if adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then a planned retreat of current occupied flood prone land may be an appropriate land use strategy. In order to implement this strategy, thresholds need to be identified that would trigger development to either be left or moved to another location. This strategy would help ensure the ongoing functionality of these areas, as well as allowing for the preservation of public land that can move landward as the ocean does.

Limit the Extent of Development

Under future conditions, the cost for Council and the community to maintain existing development and infrastructure is set to increase. While a separate study is required to quantify the effect in non-flood times, it is likely that at some time in the future the existing services will become unable to be maintained and it will have to be relocated or re-built. This may mean that the existing developments will need to be relocated or exist without the current standard of services.

A potential strategy for these issues is to limit the future residential development in low lying areas. Such areas could be reclassified to either the lowest residential zone or an environmental zone in the LEP, which could be further refined by increasing the minimum lot sizes. Thus any development that will increase the present residential density would not be permitted. As a result, dual occupancy, subdivision or increasing the percentage site coverage (increasing a buildings size) would not be permitted.

Exempt and Complying Development

Despite the existence of local development controls in the Local Government context, a recurring issue has arisen following the introduction of the *State Environmental Planning Policy (Exempt and Complying Codes) 2008 (Codes SEPP)*. Since the introduction of the Codes SEPP in 2008, a number of amendments have been made to “encourage the further update of exempt and complying development across the State for low risk and low-impact development” (State of New South Wales, 2010; p 1). Some changes have included a move from a total exclusion of complying development applications on flood prone land to additional restrictions within the Codes SEPP for complying development. Whilst complying development on land identified as high risk flood area cannot be undertaken under the current Codes SEPP, it is alarming that private certifiers without appropriate flooding expertise or information, can approve Complying Development Certificates as the determining authority assessing flood risk within the flood planning area.

The latest major amendment to the Codes SEPP commenced on 22 February 2014 and now generally permits exempt development to be undertaken on flood prone land without the need for approval. The NSW Department of Planning (State of New South Wales, 2013) explained that the purpose of this change was to reflect the minor nature of exempt development. This has resulted in unsuitable development occurring on flood prone land such as a farm buildings up to 200m^2 in size and boundary adjustments which may be considered as exempt development even when in a high hazard floodway.

Changes to planning controls at state level such as the Codes SEPP and the Local Environmental Plan Standard Instrument, as discussed above, have ultimately affected Council's level of control over development on flood prone lands.

Rolling easements

Rolling easements are gaining momentum as a potential mechanism to respond to sea level rise and flooding risk, especially those risks that are likely to be realised in the longer term.

The purpose of a rolling easement is to identify that the land to be developed is at a risk from a trigger point such as inundation from a flooding event (O'Donnell and Gates, 2013; O'Donnell 2014). Trigger points are usually event based (e.g. 1 in 100 year event) or time based (e.g. at a set time in the future). This flexibility enables the consideration of uncertainty and adaptation when new scientific knowledge is available (Yohe et al., 2007). Once the trigger point is reached, the easement mechanism would enable the land to revert to the purpose identified in the instrument.

There is an established consensus that rolling easements are most "challenging in areas that have existing development in place" (O'Donnell, 2014; p1), especially those that were ill-considered in vulnerable locations (Kellett et al, 2014). However, they can enable the highest potential/value of the land to be realised for a period, they provide advance notice of risk and will likely result in the risk being borne by a future land owner (O'Donnell 2014). They also demonstrate that the protection of the land/improvements is not to be at the expense of the wider public interest.

A rolling easement would enable Council to consider the flooding uncertainty of the future, whilst still affording a level of risk management and consideration of the wider public interest. A rolling easement is a more cost effective option than other schemes such as compulsory acquisition, the immediate abandonment of infrastructure and other improvements, land swaps or the relocation of structures (O'Donnell, 2014).

Operationally, a rolling easement mechanism could be included at the development assessment stage. Conditions of consent could "incorporate a lapsing mechanism which would be triggered when a certain threshold [the trigger] is reached" (O'Donnell, 2014, p2).

Due to their long-term nature, implementation of rolling easements as a development control is difficult to achieve. Their difficulty arise with perception that sea level rise is not an immediate threat, which make it difficult to conduct and implement the required future planning as property owners may not be affected in their time.

Land swaps

Land swaps are a less common approach to dealing with future rise, however they can be an effective mechanism where an extreme flooding event has been realised and where land is likely to continue to be inundated. An example of a successful land swap is the town of Grantham, NSW, where 100 lots were swapped with those on higher ground after the 2011 floods. The practicality of achieving a land swap arrangement in the Shoalhaven would be dependent on Council's existing structure plans and strategies and where future growth is expected to occur. Without a plan in place and/or identified growth areas, it is difficult to identify suitable sites and conduct land swaps when they are needed, that is, immediately following a flood.

Conclusion

This paper has discussed the expected impacts of sea level rise in the Shoalhaven LGA and outlined opportunities for response and adaptation to a changing climate.

In its eventuality, sea level rise is expected to have a significant negative impact on the people of the Shoalhaven. The main issues for the LGA are an increased exposure to flood risk and the associated physical and financial damages expected for infrastructure on both public and private land.

Studies conducted in this LGA have shown that engineered/structural flood mitigation options are not an effective strategy to combat effects of sea level rise. As a result, planning controls have been identified as the primary measure to protect the community from future flood risk. However, in the absence of strong government legislation, such controls are difficult to implement when the risk is not immediate.

References

BMT WBM, 2013, Lake Conjola Floodplain Risk Management Study and Plan, BMT WBM, Newcastle.

Kellett, J, Balston, J and Western, M, 2014, Sea-level rise and planning: retrospect and prospect, Australian Planner, vol. 51, no. 3, pp. 203-211.

Lyons, D, Schofield, A, Ghetti, I, Heubusch, D and Massie R, 2011, Flooding and entrance management: not an open-and-shut case, NSW Floodplain Management Association Conference, Tamworth.

McLuckie, D, Toniato, A and Smith, G, 2014, Development of practical guidance for coincidence of catchment flooding and oceanic inundation, NSW Coastal Conference, Ulladulla.

O'Donnell, T, 2014, Rolling Easements: A Flexible Solution, Coast to Coast Conference, Mandurah.

O'Donnell, T. and Gates, L., 2013, *Getting the balance right: a renewed need for the public interest test in addressing coastal climate change and sea level rise*, Environmental and Planning Law Journal, vol. 30, no. 3, pp. 220-235.

State of New South Wales, 2010, Planning Circular PS_10_027 Codes SEPP 2008 – Additional Codes, available from http://www.planning.nsw.gov.au/Portals/0/PS_10_027_Codes%20SEPP%20Additional%20Codes.pdf

Wainwright, D, Baldock, T and Callaghan, D, 2012, Coastal Lagoon Entrance Management – What Can Models Tell Us?, in 21st NSW Coastal Conference: Papers, *21st NSW Coastal Conference*, Kiama.

WMAwater, 2011, Lower Shoalhaven River Floodplain Risk Management Study and Plan – Climate Change Assessment, WMAwater, Sydney.

WMAwater, 2013, St Georges Basin Floodplain Risk Management Study and Plan – Climate Change Assessment, WMAwater, Sydney.

Yohe, G, Lasco, R, Ahmad, Q, Arnell, N, Cohen, S, Hope, C, Janetos, A, Perez, R, 2007, 'Perspective on climate change and sustainability' in Parry, ML, Canziani OF, Palutikof JP et al (ed.) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, U.K., pp. 811-841.