Attachment A

Disposable Infrastructure including Relocatable Buildings – adapting to climate change

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ABSTRACT

In Australia most coastal villages, towns and suburbs started as camping areas, fishing shacks and/or holiday houses, all with basic, self-contained, infrastructure. As the intensity of development increased, so did the demand for more conventional "permanent" infrastructure. The assumption behind this evolution was that the properties the infrastructure was servicing were going to exist for a long time into the future. Shoreline recession due to sediment imbalances, but more recently also associated with the likely impacts of climate change, places permanent styled coastal development and infrastructure at risk. The problem of managing such a situation is exacerbated by the still poorly defined climate future and hence the uncertainty as to when the infrastructure, and the development it serves, will be impacted. Given this uncertainty, a novel way of approaching the problem is to accept the potentially temporary nature of the real estate and hence adoptive an adaptive philosophy of disposable infrastructure and relocatable buildings. The challenge is to provide an acceptable standard of building and infrastructure in areas that may come under threat in the future, but to facilitate the implementation of progressive withdrawal as shoreline recession occurs. This calls for an innovative approach to infrastructure and building design.

Keywords: climate change, adaptive solutions, disposable infrastructure, relocatable buildings.

1. INTRODUCTION

Erosion events and long-term shoreline recession are natural phenomena that occur to both coastlines and riverbanks; they only become a problem when inappropriate assets are constructed in harms way. Coastal and riverbank villages and towns have often evolved in ignorance of the potential threats that exist from the forces of nature. The infrastructure servicing these developments can represent a significant public investment of both capital and operational funds. The infrastructure includes not only roads, water and sewer, power and telecommunications but also hospitals, schools, police stations and emergency services. Infrastructure is paid for by the entire community hence its loss and/or disruption through shoreline recession has a broader impact than just on those directly affected.

In many cases the original forms of coastal and riverbank development were camping areas, fishing shacks and holiday homes. Because most structures were relatively self sufficient with their own water tanks, sewerage disposal and alternate arrangements for power and lighting, public infrastructure investment was minimal. Roads were of a basic nature, often not sealed and stormwater was simply allowed to infiltrate into the ground. Over time as coastal and riverbank villages developed the original buildings were replaced with more substantial structures. As the villages grew so did community desires for more conventional infrastructure, leading to expectations of reticulated water, sewerage, electricity, telecommunications, sealed roads, kerb and gutter and stormwater disposal systems not to mention hospitals, schools and other public buildings. What started out as low cost, adaptable services became capitally intensive infrastructure with little flexibility to adapt to changes in environmental conditions.

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2. CLIMATE CHANGE/VARIABILITY

While there is compelling evidence that significant changes in the global climate have taken place over many hundreds of thousands of years, in more recent times concerns have grown as to the potential for anthropogenic impacts. These recent concerns should however be scientifically balanced with the ever growing body of evidence that even during the current epoch, from Roman times till today, significant climate changes have occurred. Recorded history and archeological finds have identified two previous warm periods and two cold periods each of which lasted approximately 400 years during the past 2000 years alone. The current warm period, the third, commenced around the mid nineteenth century. It is important to understand these historical trends when developing adaption strategies, as there is a great deal to learn from the past; some societies developed effective adaption approaches and survived, others didn't. Of those that survived their strategies were often simple and practical whereas those that didn't either failed to recognize the threat or used inappropriate methods to deal with the changing climate. Interestingly, many of the societies that failed used complex approaches, often based on defending their sophisticated, sedentary culture. In contrast, those that succeeded often had far less sophisticated and more readily adaptable ways of life. Diamond (2005) and Fagan (2008) have documented a number of examples including the demise of 400 years of Norse conventional farming settlement in Greenland due to their inflexibility and therefore inability to adapt to onset of the Little Ice Age around 1350 CE as compared to the survival of the Inuit in the same area because of their more adaptable nomadic "hunter" society.

Conventional planning and engineering has been predicated on climatic conditions that could be adequately described using the assumption that natural events can be defined by statistically stationary series. This approach has provided the basis for assessment of the likelihood and consequence of the impact on development of natural events. While the historical records on which the statistical criteria were based were recognized to be somewhat deficient in extent, the reliance placed on the long-term stationarity has generally not been questioned when extrapolating those records to generate future climatic conditions. The emerging understanding of the potential for shifts in climatic conditions means that many of these traditional approaches are no longer valid.

3. RESPONSE TO HAZARD AWARENESS

As awareness of coastal recession and river course change has grown, the approach adopted for areas to be rezoned for development has been to set back conventional styled development, and its associated infrastructure, from defined shoreline hazard zones. The width of such zones has conventionally been calculated on the basis of projecting historical average recession rates forward 100 years. Over time greater sophistication has progressively been introduced into determining setbacks, such as including an allowance for short-term fluctuations and geotechnical issues relating to foundation capability. The possibility of anthropogenic climate change acceleration of hazard development has resulted in the inclusion of a further recession term into the setback equation. However, little thought has generally been given to what happens when the setback is expended, it is simply a contingent liability legacy for future generations.

Conventional thinking for existing areas of development and/or those currently zoned for development has been to consider three management options: defend, withdraw or adapt; with little or no thought for the significant public investment in the infrastructure servicing the developments nor for the practicalities of dealing with the reality of the progressive overwhelming of the often capitally intensive development. Withdrawal strategies are dependent on the concept that at a point of time a trigger mechanism, such as a distance from an approaching erosion escarpment or a time frame at which a Development Consent simply lapses, can be applied regardless of the type of structure or the associated public infrastructure investment. While seemingly logical, these approaches do not necessarily reflect the reality of the decision making environment of Australia's community/political driven participatory democracy (Gordon,1997), nor do they actually make sense as they fail to provide a sustainable solution past some arbitrary date of say 2100; an illogical discontinuity in a continuum.

Of greater significance is that they assume the community has sufficient faith in scientists' assurances that the current state of knowledge is adequate to confidently predict, not project, the 2100 situation. Given the public controversy the climate change debate has experienced to date, and the associated public loss of public credibility regarding climate science and scientific predictions/projections, there should be little comfort in reliance on the community embracing "ivory tower" thoughts put forward by scientists. Solutions need to be practical and readily imbedded in conventional processes.

Therefore, rather than idealistic solutions with unrealistic implementation outcomes, what is needed is a new paradigm that recognizes the ambulatory nature of coastlines and riverbanks. In doing so this new approach needs to provide guidance as to the provision of infrastructure and buildings that are inherently adaptable/disposable at the end of their economic/practical life. That is, structures and infrastructure that can be easily withdrawn or removed from harms way and planning controls that, through their approval of the built form, ensure this can readily occur.

4. HOW INFRASTRUCTURE ISSUES EVOLVE

The first step in considering future infrastructure adaption strategies is to understand current infrastructure trends in areas of interest and how they came into existence. The pattern for development in emerging coastal and riverine areas has often been dictated by the initial access tracks to the area and the tendency for a laissez-faire approach to planning in what start out as remote locations. The access tracks often followed rivers and beach alignments, albeit generally at some distance landward, as determined by the topography, natural drainage paths and the soundness of the ground substrate. In some locations such as the NSW North Coast (Gordon et al, 1978) the main transport routes, and their associated reserves, were even established along beaches and foredunes. This seemingly unusual choice of alignment was occasioned by the extent of swampy areas landward of the beach, and the fact that early transport was either by foot or horse. Unwittingly these earliest tracks often set the infrastructure layout for the future development of villages, towns and even cities as they were progressively upgraded and people started building dwellings in the most opportunistic and/or "desirable" locations. Further, as development filled-in and demand increased, a typical evolution was the construction of further road systems landward, and parallel, to the first. With a growing population came the demand for more sophisticated infrastructure: sealed roads, gutters and stormwater, reticulated water supply, sewerage, power and telecommunications and the buildings associated with public service infrastructure: schools, hospitals, police stations and the like.

It is therefore not uncommon in Australia to find that in villages, towns and even cities located on the coast or riverbanks, the main spine of the infrastructure is in the most vulnerable location, either along the main road parallel to the shoreline or in shoreline parkland. Further, the infrastructure has usually been designed and constructed as an inflexible system using conventional materials with major components such as pumping stations, transformers and stormwater outlets in the vulnerable locations. As shoreline recession starts to impact on infrastructure corridors, the initial reaction has usually been to tip rock at the threatened site. Often what begins as a small, piecemeal, emergency defence reaction grows in extent as recession progresses until, without necessarily intending to do so, a defence management strategy to protect the infrastructure becomes committed to by default. The by-product of the defence of the shoreline infrastructure is the defence of any development landward of the infrastructure, albeit at the cost of the loss of the public foreshore amenity.

5. DISPOSABLE INFRASTRUCTURE

5.1 General

As a basic principle service infrastructure, other than the main spines and connectors, should be laid out with a shore-normal rather than a shore parallel configuration and be constructed in such a manner and of such materials that, as shoreline recession progresses, the infrastructure can be readily abandoned/disconnected or recovered and disposed of without loss of service and at minimal cost to those not currently directly affected. The more capitally intensive infrastructure components such as main roads, principal water and sewerage mains, pumping stations, switchyards and public infrastructure buildings, to name a few, should be located sufficiently far inland that their economic life will be exceeded before it is reasonably anticipated recession will impact on them. In determining the distance inland consideration must include a time provision for the possible eventual need to relocate the spines. The infrastructure directly servicing individual buildings should be designed and constructed to allow ready disconnection as the building comes under threat. This will however require a change in community expectations and engineering design so that to all intents and purposes the desired level of service is achieved, but at a standard that reflects its ultimate disposable nature. Although public education and on-going dissemination of information are important mechanisms to introduce the changes, it must be realistically appreciated that such changes in expectations can only be effectively achieved through non-appealable planning controls that have been promoted and embraced by all spheres of Government. The 2011 Queensland floods and cyclone Yasi provided salutary lessons in the potential economic impact on the entire Nation as a result of laissez-faire infrastructure planning and inappropriate planning and building controls. The 2013 Federal Government's enquiry into the impacts of, and the readiness for, extreme events has estimated that the cost to the Federal budget, and hence the Australian taxpayers in general, of both the relief and re-construction of infrastructure following the 2011 Brisbane floods, was $2,950 million (ECRC, 2013). This is over and above the cost to the Brisbane City Council ($400 million), the insurance payouts of $3,700 million, the significant losses experienced by those uninsured and the estimated economic losses of between $5,000 and $6,000 million (ECRC, 2013).

5.2 Roads, bridges and railways

Main roads should be sited far enough away from shorelines, and at sufficient elevation that they will fulfill their purpose to reliably serve the community, at all times, for the likely economic life and social requirement of the road infrastructure of the region. Major re-builds and bypass construction provide the opportunity to re-align main roads in keeping with potential future climate threats. There is planning sense in co-locating the spines of other types of infrastructure in the same corridor easement as major roads. Secondary roads connecting main arterials to residential and commercial areas are more problematic as their design and location will be dependent on local factors. However there should be an active design philosophy that seeks to minimize their exposure to potential future harm.

Residential streets and those connecting residential and commercial areas to shoreline areas should be constructed to a shore normal rather than shore parallel configuration, as much as is practical. The underlying philosophy for the layout, design and materials employed should be that as shoreline recession progresses roads can be progressively abandoned. To prevent degradation of the coast and minimizing dislocation of properties not already impacted by the recession, the road construction materials should be easily recoverable and recyclable. Grass verge dish drains rather than concrete kerb and gutter should be standard and road reserves sufficiently wide with corners of adequate radii and intersection designs to facilitate the movement of re-locatable buildings. The ability to withdraw buildings, in whole or in parts, as shoreline recession progresses should be an essential design tenet. Kerb and gutter and piped stormwater drainage should be discouraged or kept to a minimum with use made of natural drainage, creeks and ground water absorption opportunities.

Given the uncertainties of the future climate, and the costly nature of bridges, consideration should be given to either simple structures that can be disposed of at the end of their practical life or bridges that have been designed and constructed so they can be removed and/or adaptably elevated in the future if greater clearances are required. Their abutments and approaches should be capable of being modified to accept greater forces due to increased future loading. Where a bridge is likely to no longer be in a viable location at some time in the future, its design should include provision for ready re-location. Adaptable and disposable bridge design has long been a feature of response to emergency situations and in warfare. What is required is a more sophisticated approach to develop functional designs that can be readily adapted as required by changing climatic conditions.

The tendency to use road bridges as supporting structures for other infrastructure should be tempered by considerations as to the vulnerability of the structures, to climatic uncertainties and the consequences of taking the risk involved in bundling infrastructure at a singular crossing. Loss of other attached infrastructure due to bridge collapse can take some time to address, with associated community distress and disruption. The approach of sometimes hanging other infrastructure, such as water supply, sewerage pipes and/or power/telecommunications, under a bridge demonstrates a failure to understand the reduction in waterway area that can result and the additional side loading produced by flood debris trapped by the increased bridge profile. While this is true for any bridge it is of particular relevance to bridges in locations where climate change/instability might result in a greater incidence and/or magnitude of flood flows.

Minor pipe culverts are generally constructed of easily disconnected individual pipes and therefore readily recoverable. However box culverts normally require an in-situ cast concrete base and are therefore less flexible and more difficult/expensive to recover. Larger culverts can be substantial, often masonry (concrete), structures with relatively long practical lives. Such culverts are inflexible and expensive to remove hence are poorly suited to locations where recession and/or changes in flow conditions due to climate may occur. Adaptive bridges rather than culverts are preferable in such places. There are however some forms of large culvert based on a corrugated iron form that have economic advantages, more limited lives and can be more readily removed, hence could be considered disposable.

Railways require a very substantial capital, and on-going maintenance, investment in their "permanent way" and its associated infrastructure. Because there are limited opportunities for economically viable alternatives to the traditional, inflexible, "permanent way", railways are not readily adaptable nor can be constructed as disposable infrastructure. Where possible rail lines should therefore be located well away from receding shorelines and at elevations able to cope with future climate uncertainties.

5.3 Water Supply infrastructure

Coastal and riverside settlements initially relied on tank water for individual dwellings and where possible, supplemented this with bore water from the underlying sandy aquifers with grey and black water returned to the aquifers through septic tank systems. Reliability of supply, drinking water quality, progressive pollution of the aquifers and the growing need for provision for fire fighting, tended to migrate these early systems into permanent pipe networks fed from dams through central water treatment plants, and with distribution systems that had sufficient pressure to maintain peak daily flows and meet fire-fighting demands.

In areas likely to be subject to shoreline recession there is good reason to recall and re-work the earlier infrastructure philosophy, and to move away from more sophisticated water supply infrastructure that has replaced it. Tank water for individual households/buildings, delivered by a pressure-controlled pump and passed through a suitable treatment module can provide an acceptable service, particularly if supported by a "trickle" water distribution system. The "trickle" system is a low-pressure water supply through an underground plastic pipe network that, by providing a 24 hour connection to a central dam, can top-up tank water, albeit at a slow flow rate. The individual property tanks should be sized to provide a reliable supply for both fire fighting and peak summer demand periods and should be permanently connected to the trickle system through an automatic stop-cock. Where possible grey water re-uses should be encouraged to reduce the demand on the "trickle" system. The advantages of the "trickle" system approach is that most of the infrastructure potentially at risk, is directly associated with the individual properties and therefore has the flexibility to be recovered or disposed of as individual properties become impacted by shoreline recession. The low-pressure plastic pipes are sacrificial, as recession progresses the pipes can be progressively cut, capped and removed so as to minimize adverse impacts on the public foreshore amenity.

An alternative is to continue with high-pressure distribution of centrally treated water but to use modern high pressure, flexible, plastic pipe networks. These should be configured so that it is possible to disconnect individual dwellings/buildings, as they become affected by recession, without compromising the supply to all remaining dwellings/buildings. Currently this type of network is in use as a temporary measure in areas where the conventional, inflexible, pipework has failed and is in the process of being replaced. However, these typically above ground temporary lines, could form the basis of an underground network that could be readily adapted as shoreline recession progresses.

5.4 Sewerage infrastructure

The on-site, septic tank type, disposal systems that initially serve developing coastal and riverine areas are generally poorly suited to the building lot sizes as intensification of development progresses. Over time aquifers become overloaded and polluted hence on-site disposal, even with advanced treatment systems, progressively becomes undesirable and may lead to public health issues.

Conventional sewerage reticulation design preferentially favours rigid gravity systems. Given the natural shoreline inclined topography of coastal and riverine areas, the main collector line is usually located immediately behind a beach or a riverbank. Because these systems require collector wells and pumping stations to transport the effluent from the gravity collectors to a centralised sewage treatment works, these infrastructure hubs often end up being located in areas that are potentially vulnerable to shoreline recession and erosion/inundation events. Because gravity networks are inherently inflexible and involve significant capital investment, they are difficult to design for withdrawal as shoreline recession progresses. Further, because of the reliance on gravity an erosion event, which only damages a relatively short length of the system, may produce significant impacts on the functionality of a much larger portion of the network.

The inflexibility of gravity systems, and the pollution issues generated by on-site disposal, dictates that a new paradigm be considered for sewers in potential hazard areas. There are two methods of providing a more flexible and adaptable outcome; reducing effluent loads through the re-use of suitably treated grey water can enhance both.

The first is the use of a vacuum rather than a gravity system to collect the effluent and transport it to either a central pumping station or directly to the treatment works. This is the most flexible approach both in terms of the infrastructure and the ability to disconnect individual buildings, without compromising the network. Unfortunately however, vacuum systems can be expensive to construct, maintain and operate due to the inherent vulnerability of a system reliant on maintaining a vacuum environment. The second type of system is one that collects effluent on-site in an in-ground tank that is either pumped out regularly by a visiting tanker, or preferably has its own pump which discharges from time to time into a pipe network connected to a centralised treatment works. The visiting tanker option is the most flexible and least capitally intensive but generally is the most expensive to operate. Instead of a tanker service, an on-site tank can be connected to a small diameter plastic rising main if the effluent has been at least primary and preferably secondarily treated in the tank. This involves settling the solids and then using the pump, when off duty in disposal mode, to aerate the effluent in the tank.

Combined with grey water re-use, an on site tank system pumping partially treated effluent through a pipe system to a centralised works provides a flexible relatively low cost system, where much of the infrastructure is associated with individual buildings and can be readily removed if the building is threatened by long-term shoreline recession.

5.5 Parks and public access

Foreshore parkland and access to foreshores are two highly prized public infrastructure assets yet these are the first to be lost as long-term recession progresses. Often public investment in toilet and change facilities, walking paths, children's playgrounds, vegetation plantings and other "beautification" elements fails to recognize the potential for loss of the foreshore park resulting from shoreline recession and storm erosion. Planning of "improvements" to foreshore parks should take into account the likely "life" of the area, the value of the public investment and the consequences of the loss of the "improvement" when recession eventually occurs. Planning for foreshore parks should therefore be based on enjoyment of the asset while it is there, and not involve over investment in infrastructure. "Improvements" should have an economic life in keeping with their likely future.

As shorelines ambulate landward, beaches and riverbanks can progressively fall under private ownership. Some properties are defined by the "old system" High Water Mark Boundary that at least allows public access to the foreshore at stages of the tide, regardless of on-going recession. However most private property holdings have been changed to the "Right Line" system that fixes the boundary by survey lines and therefore has the unintended consequence of converting foreshores, beaches and even near shore waters into private property as shorelines' recession progresses, thereby causing a reduction or cessation of a public access right. To date, while this has resulted in beaches being fenced off from the public in the United States, this has not occurred to any extent in Australia, even though several Australian beaches are now theoretically in private ownership.

The "Rolling Easements" concept championed by Titus (2011) envisages a process in which adaptive development is progressively withdrawn in an adequately timely manner so as to preserve public access to foreshores. While a sensible way of dealing with ambulatory shorelines and the maintenance of public foreshore reserves and access, unfortunately the concept falls foul of Australian property law and the rights of owners. In order to achieve Titus's goal of maintenance of foreshore reserves/public access, disposable property rights are required. This is not easily achieved with the current land tenure system in Australia unless, rather than freehold, foreshore lands, and lands some distance landward of ambulatory shorelines are converted to leasehold. Gordon et al (2011) proposed a rational and practical method for achieving this for areas at the time land is rezoned from non-urban to urban use. The concept is not so readily applied in regions already zoned for urban use. However the pre-purchase of properties, well ahead of their being adversely affected, would allow their conversion to leasehold with a lease back provision that could assist in funding the purchase. By this mechanism the potential for rolling easements could be realized, and although it would require significant up-front loan funds, these could be offset by the rental return, provided properties with sufficient life were targeted. Thus, with leasehold rather than freehold, coastal and riverbank lands, well-designed disposable foreshore parkland infrastructure and public access can be rolled back as recession progresses.

In many locations foreshore public parkland was initially set-aside for caravan and camping parks; normally in the care control and management of the local council. Originally these parks had minimal infrastructure however over time they have tended to be upgraded with formal roads, power to campsites, permanent high quality facility blocks with showers, toilets, laundries, "camp kitchens" and even campsite on-suites. Further, as quality camping areas became an important revenue source for councils, the trend has been to include cabins of varying complexity and sophistication. While much of this infrastructure, including the cabins but often not the masonry facility blocks can be relocated, as long as forward planning has provided an alternate site, both the revenue generating potential and the public investment means the temptation is to defend rather than withdraw as recession progresses. Unfortunately a defense strategy usually results in the loss of the beach; often the major attraction offered by the park. Clearly all infrastructure, including facility blocks, associated with camping/caravan parks located on foreshores, should be disposable or readily re-locatable and that the public investment in infrastructure, and the council reliance on income recognizes the temporary nature of the land the asset is sited on. A "Rolling Easement " approach can accommodate relocation.

5.6 Power, telecommunications and gas

Power and telecommunication distribution systems present a dilemma. The most economical and adaptable form of distribution is by the traditional aerial cable network. Interestingly, such systems have tended to fall out of favour in coastal areas where they are perceived to interfere with views. Aerial distribution systems can also both reduce the effective width of road reserves and their overhead road crossings, potentially inhibiting the ready withdrawal of re-locatable buildings. Alternatively, rather than running aerial cables along road reserves they could be strung on poles located along rear fence lines, with cross-street undergrounding. While this has some limitations in regard to access for regular maintenance it does have the flexibility required to allow ready removal in the future as shoreline recession progresses, providing the overall layout of the area is one of shore-normal streets. Undergrounding cable networks is a more expensive option and results in less adaptable infrastructure, which is also more vulnerable to inundation, however it provides less restrictions for re-locatable building movement and therefore has some benefits; hence the dilemma.

Transformers, switchgear and telecommunication hubs should be sited in locations where they will fulfill their economic lives before being adversely affected by shoreline recession or should be of a readily disconnected and portable nature. Further, in siting this infrastructure consideration should be given to the potential vulnerability to inundation due to possible increases in either, or both, river and oceanic flooding resulting from future climate change.

While centralized household gas distribution systems have migrated to light weight, flexible, reinforced plastic pipes making them easy to underground and to connect and disconnect, there remains the issue of the potentially unexpected release of gas should a line be fractured during an erosion event. Reticulated gas systems therefore need special provisions for rapid emergency shut off for local areas. Alternatively, bottled gas, rather than a reticulated supply, could be used for individual establishments (households, restaurants and the like) as an energy source in areas vulnerable to shoreline recession.

6. RELOCATABLE BUILDINGS

With changing societal aspirations and values in regard to the desirability for shoreline living, there has been a tendency to construct increasingly large buildings in coastal and river front areas. These include not only dwelling houses but also buildings housing commercial/industrial operations and public service infrastructure such hospitals, schools and police, fire and ambulance stations. In recent years the trend has been away from the traditional lightweight timber framed, fibro or weatherboard clad buildings, towards masonry structures that involve considerable investment in both the building and the associated infrastructure. This has had the by-product of locking in a defence strategy mentality, eliminating other options that may be more beneficial and economic for the overall area and/or the longer term. A further unintended consequence is the necessity to intensify development in threatened areas in order to fund construction of a defence option, and for its on-going maintenance.

While much has been made of the need to adapt to climate change, there has been a failure in all spheres of government to recognise the important role planning and building standards can play in managing the issue of ambulatory shorelines. Regardless of growing threats from shoreline recession, with or without consideration of climate change impacts, there has been no National effort to impose planning and building standards that reflect the temporary nature of the land on which these buildings are located. The potential national contingent liability, and in particular demand on the Tax dollar, to cope with predictable emergencies and the long-term threats to the buildings in shoreline areas, is neither appreciated nor addressed. In fact encouragement for unwise development is enhance by Federal Government attempts to ensure insurance cover for buildings at threat due to erosion and long term shoreline recession. Clearly this is not an insurance issue as there is no risk of loss, rather certainty, and hence the Federal Government is operating on an inappropriate paradigm. A "sinking fund" rather than an insurance approach better reflects the true situation, where the only unknown is when the loss will eventuate. Encouragement should be towards a property market value system that correctly reflects potential outcomes, and a situation that more appropriately sites public buildings rather than one that encourages inappropriate development through subsidised insurance cover.

Where buildings are allowed in areas that are likely to be adversely impacted by erosion and/or long-term recession, they should be of a re-locatable form. This not only provides the opportunity for willing owners, including government bodies, to at least recover the building asset before it is destroyed, but of equal importance, where abandoned by owners, it allows for authorities to remove the structure before it has an adverse impact on the public foreshore amenity and causes danger along the coastline/river. The modern forms and materials available for construction allow for conventional-looking buildings to be constructed as lightweight structures. For example it is now possible to construct large two story buildings that have the appearance of masonry structures using rendered foam. The real challenge is for architects and engineers to develop innovative structures that fulfil their client's desires but at the same time are removable and are serviced by disposable infrastructure.

7. CONCLUDING REMARKS

While much of the focus in recent times has been on the potential for anthropogenic climate change, failure to recognize the historical natural cycles and their potential role in the future is to seriously compromise societies ability to learn from the past and to adapt to a future of both natural and anthropogenic change. Ignorance of history is not a valid, nor credible, scientific position.

Ambulatory shorelines in regions that may be adversely impacted by an uncertain future climate require a new paradigm in planning, infrastructure, building types and management of development located in zones that may be subject to future hazard. The capital cost of infrastructure and its on-going maintenance represents a major investment of public funds. In areas potentially subject to future loss, this investment should be based on innovative considerations of types of infrastructure that will provide the desired services, yet be of a disposable nature so that its eventual loss does not compromise services to other development, nor represent an unexpected financial burden on a community. Nor should the need for infrastructure protection be the cause for adoption of an overall defence strategy for a developed area. A philosophical approach of disposable infrastructure should be also linked to one of relocatable buildings; fundamental tenets for a responsible approach to adaptability to climate change and/or an uncertain climate future.

This paper is not intended to be a comprehensive expose on disposable infrastructure or relocatable buildings but rather to be indicative of the types of infrastructure and the philosophy of disposable infrastructure that is more appropriate in future hazard prone areas. Infrastructure in "at risk" areas should be not as capitally intensive nor as inflexible as traditional forms yet to all intents and purposes provide the same level of service delivery, while being capable of ready disconnection and removed, if required, due to advancing shoreline recession and/or increased oceanic/riverine inundation.

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