Reconciling Foreshore Development and Dune Erosion on Three Queensland Beaches: An Historical Perspective

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ABSTRACT

Yeppoon Main beach, Kinka beach and Keppel Sands beach are nestled around Keppel Bay in Queensland, Australia. Before white settlements were developed adjacent to these beaches, they were comprised of extensive sand dune systems operating in dynamic equilibrium. Over the past century, there has been a popular misunderstanding about the way beach systems work, evident in all kinds of foreshore development along these beaches. This has led to a delayed but cascading effect of worsening dune and beach erosion. Once sea walls and other kinds of foreshore construction begin, historically it becomes unlikely that the authorities will stop and reverse such development. Rather, more expensive construction becomes the remedy for the earlier mistakes as the local government attempts to reconcile coastal development and dune erosion. There is also the issue of how sand was regarded and whether that was a motivating factor for its removal. Was sand perceived as a 'nuisance' and 'readily renewable', and therefore dispensable? Of this trio of beaches, Kinka beach is fortunate to have experienced the earliest implementation of so called soft protection that initiated a natural renourishment resulting in the sea wall mostly disappearing under a build up of sand. This paper examines the historical development, as well as the motivation behind this development, of these three beaches and the subsequent implications for the beaches during the inevitable big seas and cyclones. This coastal environmental history informs local coastal communities about the importance of foresight in protecting dune systems in their natural state.

KEYWORDS

Capricorn Coast Queensland, Causeway, cyclone, dune erosion, Keppel Bay, Keppel Sands beach, Kinka beach, sand nourishment, sea walls, Yeppoon beach

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INTRODUCTION

Keppel Bay is located along the Queensland coast (Australia) about half way between Brisbane and Townsville, and in line with the Tropic of Capricorn and Rockhampton. There are three townships situated along the mainland coast of

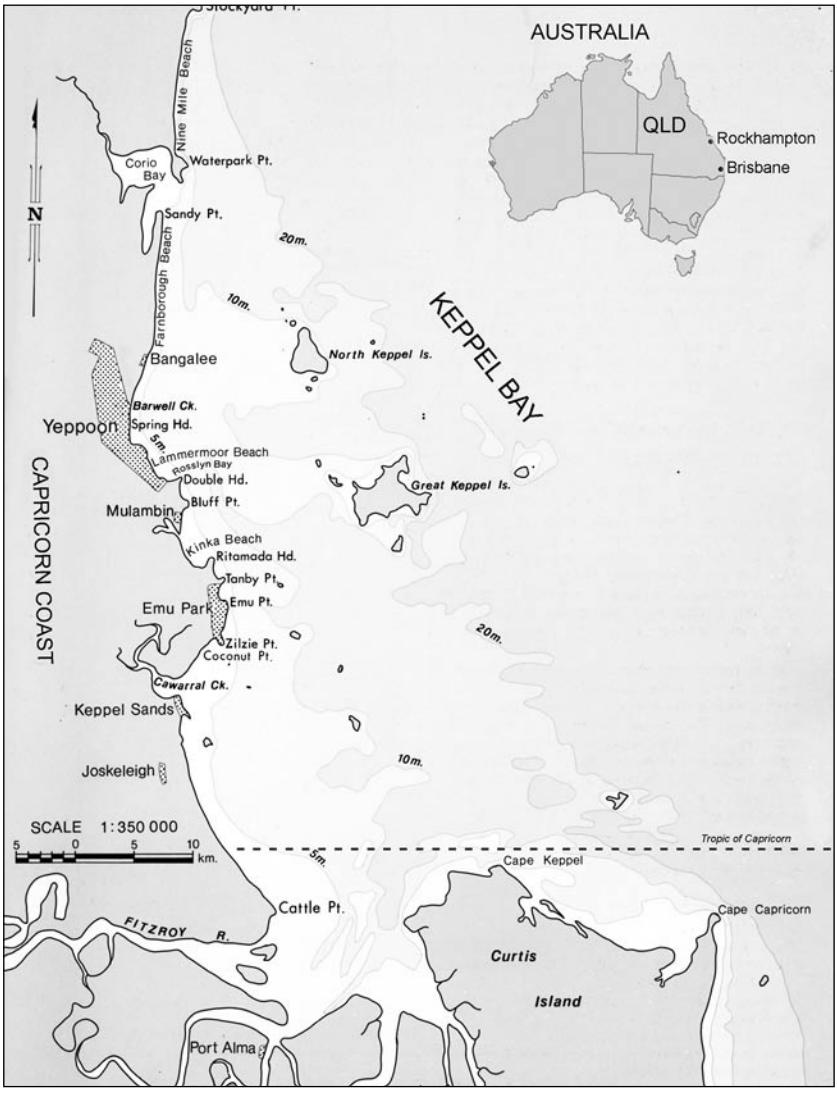


FIGURE 1. Keppel Bay Locality Map. Source: Piorewicz, 2003: 6.

the bay, namely Yeppoon, Emu Park and Keppel Sands (see Figure 1). Keppel Bay has many fine beaches that have historically drawn summer crowds and a growing number of residents who like to live as close to the beach as possible in what is termed a sea change lifestyle. However, dune erosion and threats to coastal infrastructure are ongoing issues affecting some of these beaches, and remain a concern for local residents. Both natural coastal processes, such as cyclones, and human interferences, such as sea walls and other barriers, are responsible for this erosion. In fact, the sea walls that were constructed along Yeppoon's Main beach, Kinka beach and at Keppel Sands in order to protect the nearest esplanades have all been instrumental in exacerbating rather than preventing dune and beach erosion, especially during extra large tides accompanied by rough seas and strong winds. This paper examines approximately a hundred years history of development and erosion on these three beaches as well as the local government and community responses to same. History clearly indicates that residents are now living with the consequences of misguided human interference in the beach systems during earlier times. The paper is an insight to different historical periods' engagement with enduring environmental challenges.

YEPPOON MAIN BEACH

Yeppoon Main beach is north south aligned between Spring Head and the bluff in the north, and Ross Creek outlet in the south (see Figure 2). Photographs from c. 1910 show an undeveloped, well-established dune system (see Figure 3). First impact was caused by access tracks across the dunes to the beach by campers who had travelled down to the coast in order to escape very hot conditions further inland and invigorate their health. Photographs from c. 1920 show an increase in tracks, some widening to sand blows.[1] The area behind the dunes was low-lying and therefore conducive to sand blows.

Despite the well-established dune systems, the beach had an appearance of being hard. Mullins[2] in his *Shifting Sands: Yeppoon* pictorial article had this to say about Yeppoon's Main beach:

> The earliest written accounts of Yeppoon main beach describe it as 'hard and tawny'. Indeed, in the 1880s, Boxing Day race meetings were held on the sand, and the beach served as a road to the farms and pastoral stations further north. By the 1920s it was common for locals to drive motorcars on to the beach and to park above the tide, and barnstorming pilots were happy to land their machines on the sand. Yeppoon main beach today is still 'hard and tawny', partly because of the geomorphology of Keppel Bay on which it lies, and partly because of the heavy sediment load the Fitzroy River carries, entering the Bay about 40 kilometres to the south. Within living memory the beach has been depleted of sand and this erosion, whether it be a natural phenomenon or a result of coastal development, concerns local residents.

FIGURE 2. Aerial view of Yeppoon Main beach, c. 1999. Source: Piorewicz, 2004b.

FIGURE 3. Well developed dune systems evident on Yeppoon Main beach, 1920s. Source: Capricornia Collection, Central Queensland University.

Buggy rides were also a feature of the main beach in the 1880s with the hard surface providing smooth rides.[3] Before they were destroyed, the vegetated sand dunes along Yeppoon's Main beach were extensive, and early black and white

photographs show how the sand drifted inland a considerable way, reaching at least to where the buildings along the esplanade are today and, in places, occasionally stretched almost the length of the town block (about 100 metres – see Figure 4). Rough tracks and pathways from town streets across the dunes

FIGURE 4. Sand drifting a long way into Yeppoon township, c. 1910. Source: Capricornia Collection, Central Queensland University.

FIGURE 5. Opening of Beach Café on Yeppoon Main beach, 1936. Source: Capricornia Collection, Central Queensland University.

to the beach trodden on by increasingly more people who travelled to Yeppoon on the new train service from 1909 began to disturb the dune cover and create these problematic sand drifts. Some sand dunes naturally spilt over into the low-lying area as well. By 1914, the sand blown onto the end of Normanby Street caused endless complaints and made passage difficult for the few motorcars. The accumulated sand was deposited by horse and dray into the swamp, which when drained became Yeppoon's Central Business District.

During the early 1920s a timber post and netting protection fence was built along the northern part of the beach, 'probably with the purpose of preventing sand blowing onto the nearest road' (see Figure 6). These sand drifts would have been a nuisance to the town's residents and authorities. Sand shifted across roads, accumulated in a popular beachfront park and damned drains causing minor flooding during rain. For the next fifty years managing encroaching sand, not beach erosion, was a principle occupation of the shire road gangs. The beach was also used as a roadway by sulkies, bicycles and motorcars until in 1923 the Livingstone Shire Council (LSC) prohibited any vehicles from using it. In the late 1920s a track was pushed along the crest of the dunes and later became known as Anzac Parade (see Figure 7). It was bituminised in 1936. The LSC permitted the removal of large quantities of sand from behind the foreshore for this road and parking spaces. Recreational infrastructure was built on the main beach (at high water mark) from about the 1910s to 1930s as part of establishing the seaside holiday resort atmosphere of Yeppoon, and some of this infrastructure necessitated more sand being removed from the dunes. Mullins[4] writes:

> A line of bathing boxes, privately owned but licensed by the shire, had been multiplying since 1909. Publicans and boarding house keepers erected them for their house guests, the two girls' boarding schools had their own, as did the Country Women's Association, and some were built by wealthy individuals. By the late 1920s the shire had succumbed to pressure from the local progress association to erect public changing boxes, male and female, and shelter sheds, and a £300 life-saving clubhouse had been built, all on the beach. This infrastructure took a terrible battering between April 1928 and February 1931 when three tropical cyclones passed the coast, one curving back, effectively striking twice. The February 1931 cyclone produced a tremendous sea that swept away all the bathing boxes, shelter sheds, and the life-saving clubhouse, and left debris spread over much of the beach.

In the depths of the great depression the shire was reluctant to take on any additional debt, and decided to hand over the redevelopment of the foreshore to private enterprise. Yeppoon Beach Improvements Ltd. built and owned most of the structures. The centrepiece of the development was the Beach Café constructed in 1936 (see Figure 5) on substantial stone and brick foundations. Flanked by private and public dressing rooms, enclosed sun baking areas, hot and cold showers, and shade pavilions – it was a virtual 'paradise for the pleasure seeker', as a promotional pamphlet put it. However, the dune system was now

FIGURE 6. Timber fence and changing sheds on Yeppoon Main beach c1930. Source: Capricornia Collection, Central Queensland University.

FIGURE 7. Well vegetated dunes once existed where Anzac Parade was built, 1930s. Source: Capricornia Collection, Central Queensland University.

under greater threat than ever. The removal of sand and vegetation from behind the beach café caused large volumes of rainwater to cascade down to the beach from Anzac Parade scouring away the dunes, and threatening the foundations of the buildings. A stone retaining wall was built and backfilled north from the beach café, but most of the buildings remained on the beach. The beach café and associated buildings were destroyed in a 1949 cyclone, and that finally put an end to development on the sand.

Between 1935-38 a stone retaining sea wall was built and the dunes levelled as part of the 'foreshore improvement scheme'. This was done for various reasons. For example, it was partly 'to provide, it is thought, better access to the beach and a grassed area for picnicking'. The wall was also constructed to stop dwellings, which were built within the natural buffer zone between the beach and back dunes, from washing away.[5] The wall helped to provide a solid foundation for the development of a new recreational area. Furthermore, the LSC may only have decided to proceed with the work because of the ready availability of unemployment relief funding from other levels of government during the depression.[6] At the official launch of the scheme, Shire Chairman William Todd said 'the unsightly sand dunes that continue from the main street to Ross Creek will be done away with and in their stead there will be green lawns, seats, shade trees and plenty of parking places for cars'.[7] However, the wall also prevented natural dune erosion and replacement.

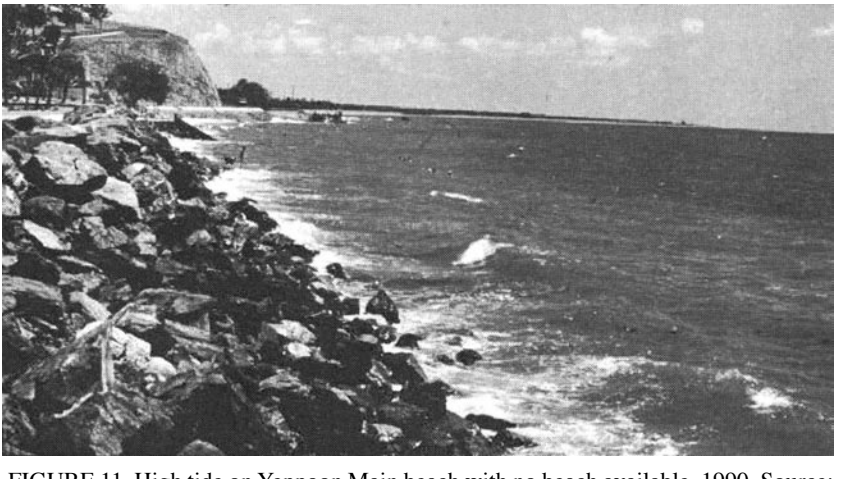
The sea wall was built in front of the dunes, below the spring tide line, running 150m south from the bluff. After the dunes were levelled the area was grassed[8] (see Figure 8). It is hard to imagine that the Main beach dunes would not have been destroyed considering their location directly in front of a growing town at a time when access to other beaches was difficult and understanding of dune systems was not as advanced as it is today. The sand blows did not help their protection either. Chairman Todd's attitude was indicative for the times. The provision of facilities for visitors and the protection of structures on the beach, on Anzac Parade and the road around the Bluff, which represented large investments by business and the LSC, were the limits of beach management. The preference for levelled grassed surfaces over undulating sand surfaces has been a continued feature of LSC public works, appearing in Council minutes as late as 1973.[9] Even though there might have been individuals around in the 1920s and 30s who worried about detrimental future impacts of these infrastructure decisions on natural systems[10], apart from lobby groups campaigning for more national parks, healthier cities and attempting to protect native animals from traders, it was not yet the era for community conservation groups to form and challenge the authorities about impacts on dune systems. In fact, at the time engineering feats were generally and widely praised.[11] Future generations of Yeppoon residents have probably grown up not realising that sand dunes were once an extensive part of the Main beach and are therefore not aware of their loss.

Early photographs showing the original dune alignment indicate the wall was constructed about 20 metres forward of the dune scarp, and the dunes levelled and pushed forward against it. This indicates that the wall was built in an active beach zone, coinciding with high water mark.[12] Therefore, there is almost no usable beach available at most high tides (see Figures 10 and 11). Furthermore, the LSC noted that the constructors had to cope with the sea filling the excavations for laying the foundation stones of the sea wall.[13]

FIGURE 8. Vertical sea wall and levelled grassed area, 1938. Source: Capricornia Collection, Central Queensland University.

FIGURE 9. Same view as Figure 8 but in 2003 (road has been widened). Source: Photo taken by Mike Danaher, December 2003.

FIGURE 10. Sea wall built just below high tide mark, 1930s. Source: Capricornia Collection, Central Queensland University



.FIGURE 11. High tide on Yeppoon Main beach with no beach available, 1990. Source: Piorewicz, 2002: 85.

In 1949, 1955 and 1976 Yeppoon Main beach and its man-made structures were exposed to cyclonic conditions that damaged the sea wall considerably. On each aftermath, the sea wall was extended, and the beach was further separated from the remaining dunes. This meant more sand was depleted and the level of the beach fell. After Cyclone David struck in 1976, the beach in front of the sea wall was significantly lowered, and reconstruction of the wall included a rubble-mound sea wall that extended the entire length of the beach. This wall

effectively separated the entire beach system from the dunal buffer and sand storage.[14] Cyclone David was responsible for significant foreshore dune erosion towards the southern end of the beach. The wall's main purpose is to protect the esplanade or Anzac Parade, as it is known. However, the sea wall has also caused erosion to the main beach to the extent that it can no longer be claimed as one of the Coast's most popular beaches.[15] Since there are no dune systems left along the main beach, the beach cannot be replenished by these reservoirs of sand. Furthermore, a lowering of the beach profile has increased the strength of wave action. During big seas the reflective wave action erodes the base of the rock wall as well as the sand accreted there by onshore drift processes, therefore that sand is not maintained. The sea wall is then the reason why the main beach no longer has the capacity to accrete sand and naturally restore itself, and at low tide it has the appearance of a tidal mudflat. The erosion has also resulted in expanses of exposed, rocky beach at low tide, wet through by trickling groundwater.[16] Although the beach long before was hard and tawny, it was not rocky. During the beach races, if a jockey fell, they could not fall on stones.[17] Maintenance of the wall has been an ongoing cost for the LSC and local ratepayers.

Dune destruction was not the only reason for sand being displaced from the Main beach and in Ross Creek. From around 1965 to 1972, approximately 91,000 cubic metres of sand was: carted out by train to Mt. Isa Mines (approximately 1,300 kilometres away) for construction purposes and to build a beach around a man-made lake; used in the Yeppoon Sewerage Scheme; and was removed for Ross Creek reclamation.[18] The 'muddy sand' dredged from the bottom of Ross Creek was ideal as a fill. The LSC could remove sand from the mouth of Ross Creek under a permit issued by the Department of Harbours and Marine. In 1972, when the Marine Board Office asked the LSC if it had any objection to a private firm dredging 10,000 cubic yards of sand from Ross Creek for land reclamation elsewhere in the town, the council offered no ecologically based objection.[19] This reflected the willingness of the LSC to have sand removed from within Ross Creek and on the beach near its entrance for public projects. The sand was replaced though from littoral movements during incoming tides, but this was probably eroded sand as a consequence of the sea wall. Since the LSC did not have any expert coastal engineering advice at this time to guide them, the dunes at the mouth of Ross Creek were 'probably' seen as an unlimited source of sand renewable by longshore sediment transportation. There was no sea wall at this particular location at this time to separate the dunes from the beach.

The intrinsic cultural value of the beach and the monetary value of associated infrastructure have inevitably led to protection strategies for the beach. In Queensland, the *Beach Protection Act of 1968* was the first legislation introduced specifically to protect beaches. This Act was enacted as a reaction to storm erosion of tourist beaches on the Gold Coast threatening high-rise development that had been located too close to the shoreline. It established a framework

for regulating coastal development through establishing erosion prone areas, coastal management control districts and coastal management plans and managing development within these areas. The Act and its amended version (*Coastal Protection and Management Act 2003*) is administered by the Beach Protection Authority (BPA), with day-to-day management by the Environmental Protection Agency.[20] The beaches and dunes though remain the responsibility of the local government.

The functions of the BPA are to: provide advice and reports on coastal management to Ministers, State Government Departments, Port Authorities, Local Governments, River Improvement Trusts and other persons; conduct investigations, experiments and demonstrations on coastal management; plan preventive and remedial measures for adverse effects upon amenity of coast; record and evaluate results of investigations, experiments and demonstrations; disseminate information on coastal management to members of the public; and exercise and perform powers, authorities, functions and duties conferred upon it.[21] As an advisory body only, the BPA had no real capacity to control development such as the removal of sand in and near Ross Creek, and the levelling off of sand dunes adjacent to houses as a 'beautification' scheme during the late 1960s and early 70s, though this began to change later when the Act was strengthened.

By the early 1970s, there was evidence of united community concern for the lack of responsibility shown by the LSC for dune and beach protection. The Capricorn Coast Protection Council (CCPC), which formed in 1972, began a campaign to combat sand removal from Yeppoon's main beach and Ross Creek in June 1974. The CCPC became an irritant to the LSC and a regular enquirer to the BPA. It wrote to the BPA about the removal of this sand by the LSC, and enquired if any area of the Capricorn Coast had been declared an erosion control district under the Act.[22] The BPA replied that the LSC had made no enquiries about sand removal nor was its approval required, but consideration was being given to the declaration of the whole coastline as an erosion control district.[23] Once beach erosion control districts were gazetted, the LSC had to act on BPA advice to protect them. The BPA opposes sand removal from beaches. In one press clipping, it was mentioned 'not one word of objection had been raised to the council removing sand by the truck load from the Main beach despite Yeppoon being a tourist town'.[24] At a meeting in March 1975, the LSC said that no further sand will be removed from the mouth of Ross Creek.[25] Nevertheless, two months later LSC sought to remove more sand from Ross Creek for use as bedding for the sewerage scheme because it was cheapest to take it from that location.[26] Later in 1975, the BPA and Harbours and Marine Department were successful in advising against LSC's request for more sand to be removed for the sewerage scheme, stating that such removal would result in a reduction of the height of the Main beach.[27] Subsequently, the BPA has been asked by the LSC for its professional advice on all beach erosion situations along the coast.

In 1974, the BPA commenced a comprehensive survey of the Capricorn Coast's dunes, beaches and coastal vegetation leading to the gazettal of 75 kilometres of the coast as Beach Erosion Control Districts No. 15 on 9 January 1975.[28] This declaration provided the BPA with statutory control over various activities within the area and required it to prepare a scheme for the protection of the beaches from erosion, or encroachment from the sea. A scheme of works when approved by the Governor in Council would be a legally binding guideline, although responsibility for implementing it rested with the LSC.[29] With the proclamation of the Great Barrier Reef Marine Park in 1975, jointly managed by the Commonwealth and the Queensland Parks and Wildlife Service, a new regulatory regime would constrain coastal activity along the Capricorn Coast, and LSC was now required to conform to new rules. It appears that until the emergence of the BPA and subsequent coastal engineers, there was no guiding expertise in place for the LSC to consult on 'beach development/beach protection' matters. However, the BPA is not very well funded, even today. At one stage the LSC considered disbanding it unless its prescribed work was backed by sufficient funds.[30] Moreover, there were strong voices opposing restraints on development, despite the gains made by the conservation movement. The Deputy Chairman of the Capricorn Tourist Organisation in 1981 considered that 'a vocal minority' was jeopardising job prospects; LSC stated that development would not be stopped by 'knockers' if plans were within the by-laws.[31]

By 1977 two new buildings were built on the space between Anzac Parade and the high water mark, where formerly dunes existed, effectively defining the bathing beach as an area of flat sand about 400 metres in length. To the north, the Yeppoon Surf Life Saving Club built a large clubhouse, its planned foundations being deepened on advice from the BPA. It had earlier requested the removal of children's swings and play area to allow construction of a ramp to allow vehicular access to the beach.[32] At the southern end, the new building of the Keppel Bay Sailing Club replaced 'the old tin shed', formerly the Skating Rink, which until its destruction in Cyclone David in January 1976 stood on the beachfront about 150 metres north of the new site.[33]

During the 1990s, despite no cyclones, the erosion of the Main beach was so severe that the stability of the rock wall raised serious concerns. In December 2000 the reconstruction of the sea wall was commissioned by the LSC. A newer rubble-mound sea wall, a viewing deck and entrances on to the beach were constructed to meet with BPA regulations for the protection of the developed recreation area. However, the worsening beach condition remained unaddressed.[34]

Near the Ross Creek outlet, the rubble-mound sea wall constructed after Cyclone David in 1976 is now well-buried under sand. However, north of the sailing club and continuing along the beach, there has been no sand accumulation on the 2001 sea wall. 'It is not possible to effect any beach restoration without additional engineering measures'.[35] Since the construction of the rubble-

mound sea wall, the Yeppoon Main beach seasonal cycles of sand erosion and replacement have been 'in balance'. However, the beach cannot be considered as protected or restored. Storm impact could be serious, and result in damage to the beach and the esplanade.[36]

For a long time, decisions made by the LSC on beach protection matters were made without the benefit of any recorded field data and relied heavily on intuition and local knowledge of the areas involved.[37] Since Yeppoon's settlement picked up in the early 1900s, foreshore development along its main beach has been an ongoing issue, carrying through to the present, with the latest project ($4.72 million) being completed in 2003. The rock wall has been rebuilt, in a tidal zone, over the course of the town's history. The LSC intends to restore more sand to the main beach based on BPA advice.[38] It is not far-fetched to say that Yeppoon's main beach has been, for one reason or another, 'under construction' for the last century, costing local rate payers hundreds of thousands of dollars. Protection of the town is clearly the major concern of the LSC; as the BPA observed, 'Beach erosion is commonly regarded as a problem only when it represents a threat to property and improvements. The problem of loss of the beaches themselves is often overlooked…'[39] It argued that 'the problems of the deterioration of recreational beaches and the erosion threat to development go hand in hand.[40]

At the beginning of 2003, the LSC commissioned the Central Queensland University Engineering Faculty to provide an analysis of different options that might prevent further erosion and that would restore sand to the beach, now that data on sediment movement, waves and currents has been significantly extended. The engineering models undertaken provided the following predictions. Positioning of groynes near Ross Creek outlet will probably encourage further erosion in front of the rubble-mound sea wall, and will encourage longshore sediment transportation from the south into the mouth of Ross Creek. Upgrading the existing Spring Head rocks into a groyne will result in accumulation of sand on the northern side of the groyne, with little or no effect to the main beach. Positioning groynes at both Ross Creek outlet and Spring Head will have no remarkable effect on the beach. The construction of a 'rocky peninsula' at Spring Head would have no influence on beach conditions. The construction of a 'rocky peninsula' at Spring Head, together with a groyne at Ross Creek outlet would have no influence on beach conditions. However, artificial supply of 60,000m^2 sand (beach nourishment) will continue to have a positive effect for at least six years. The construction of a 'rocky peninsula' at Spring Head, together with beach nourishment shows promising trends in the improvement of the beach.[41]

KINKA BEACH/CAUSEWAY LAKE

In 1936 a 'charming' scenic highway was planned to link Rockhampton's two principal seaside resorts, Yeppoon and Emu Park, and to introduce the public and tourists to the coastal scenic views previously 'hidden'.[42] In realising this plan, the causeway and bridge were built across the mouth of Mulambin Creek (sometimes referred to as Shoal Creek) in 1939 and were open to traffic on 20 November of that year.[43] This was the final link of the scenic highway. Before construction, the path of the creek ran directly out to the sea. The bridge was constructed on a concrete sill, founded on existing rock.[44] The construction created a permanent lake, namely the Causeway Lake. The local paper described the bringing together of the two ends of the bridge in triumphal terms:

> The closing of the gap was done without flourish or spectacle, but it represented the conclusion of long, careful planning and thorough organization. All sorts of factors had to be taken into consideration and the various operations synchronised accordingly.[45]

Despite the engineers of the time 'carefully planning and considering' tidal flow and the more intense velocity of flow-through seawater due to a significant narrowing of the creek mouth, the construction of the bridge and causeway was instrumental in delayed dune erosion along Kinka beach to the immediate south. The resultant restricted tidal prism from the lake reduced the width of the original channel across the beach, changed its original path to a southward moving path by the 1950s, and created a sizable sand bar at the mouth of the inlet to the lake (see Figure 12).[46] The hydrographical and morphological consequences of changes caused by constructions such as causeways were largely unknown at the construction stage.[47]

By the 1970s, dune erosion at Kinka beach had reached serious levels. In January 1979, the *Morning Bulletin* reported 'another 1.5 metres of Kinka Beach foreshore disappeared after the onslaught of a 5.3 metre tide'[48] and in 1984 the same newspaper reported, '1.3 metres of foreshore dunes were washed into the sea'.[49] These kinds of alarming media reports continued as residents feared for their homes. The accelerated dune erosion is a result of building the causeway that, in turn, resulted in the reduction of the tidal prism, diverting outflow southward along the dunes. Waves reflected from the sea stirred the bottom material which was taken away by the ebb tidal currents in the newly formed channel. It is the residents living along Kinka beach that lead the protest on the beach erosion. Much of the rest of the coast community is accused of 'idly standing by while their beaches disappear'[50], suggesting there is little community foresight on beach protection.

Between 1982 and 1985 the Main Roads Department constructed a rock sea wall along Kinka beach's eroded dunes in order to protect the Yeppoon-Emu Park road and adjacent residences from the sea.[51] By 1985, almost $500,000 had

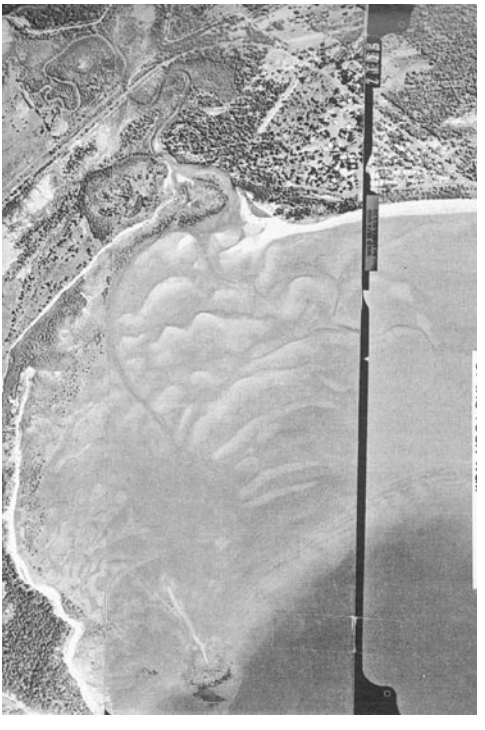


FIGURE 12. Aerial view of Kinka beach showing southward moving channel, 1988. Source: Piorewicz, 1999.

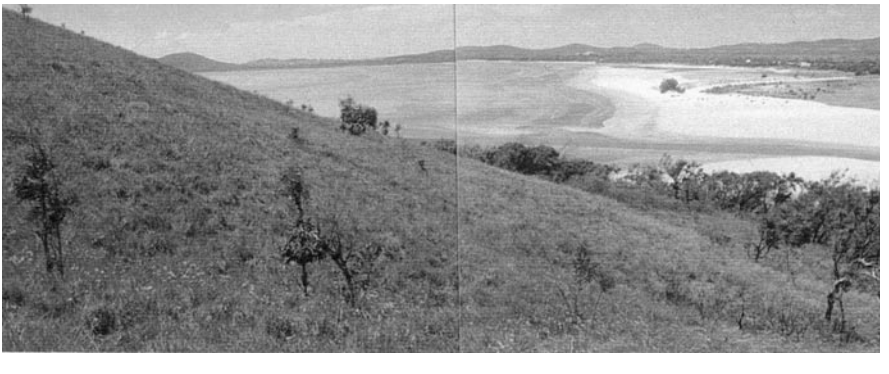
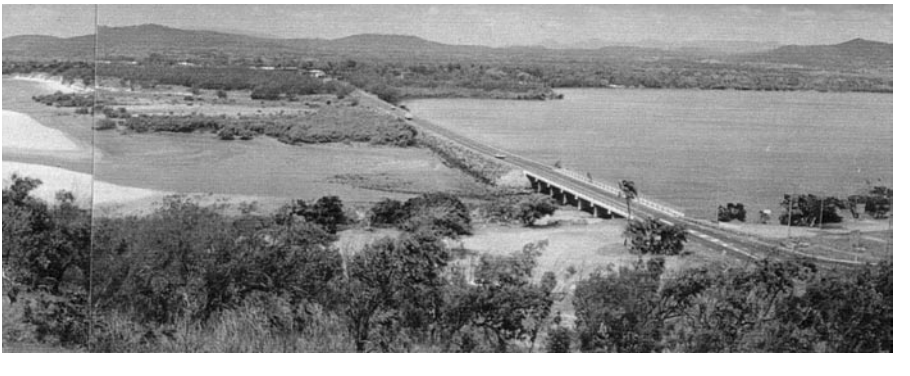


FIGURE 13. Kinka beach, tidal lagoon and the causeway, south view, 1997.



Source: Piorewicz, 1999.

☐ Strong gusts whipped up a sea which eroded Kinka Beach to within a few metres of the Scenic Highway at the weekend. E584/14

Heavy sea erodes Kinka Beach

Livingstone Shire Council and the Queensland Transport's Main Roads division are monitoring erosion at Kinka Beach.

A strong south-east wind at the weekend caused significant wave erosion over about 50 metres at the northern end of the rock wall.

Council and Main Roads officials inspected the damage yesterday.

Beach Protection Authority representatives also will inspect the erosion when they visit Yeppoon on Thursday.

Council engineer Mr Pat Murphy said the erosion had gone to within three or four metres of the sealed edge of the Yeppoon to Emu Park road.

The organisations were waiting on approval to start work.

Plans include returning sand and minor rock protection.

FIGURE 14. Severe dune erosion along Kinka beach in 1994. Source: *Morning Bulletin*, 6 December, 1994.

FIGURE 15. Natural sand nourishment results at Kinka beach by 1997.

been put towards building cyclone-proof protection for Kinka beach.[52] However, this mitigation did not prove successful at all, causing further erosion of the dunes at both ends of the sea wall, and the fear that the sea would wash away the main road and homes remained.[53] [54] On 5 April 1989, the *Morning Bulletin* reported 'the Scenic Highway is just 2 metres from the edge of a 2.5 metres sheer cliff to the beach'.[55]

The engineering department of Central Queensland University and the BPA were key players in finding a solution to this erosion crisis. Kinka Beach's dunes were replenished by natural sand nourishment as a result of constructing a sand dam between 1988 and 1989 (the sand dam in its initial stage is shown in Figure 12). The sand for this dam was gathered by dredging a new channel at the same location where the channel was before the causeway was constructed which was a path from Mulambin Creek directly out to sea. The sand dam was constructed across the southward moving channel that had appeared after the building of the causeway. The sand dam acted to increase the tidal prism by creating a tidal lagoon in front of the causeway (see Figure 13) and reshaping the beach shoreline to its more parabolic statically stable conditions. Between 1993 and 1997, 80 per cent of the rock wall was completely buried under the naturally accumulated sand, and dunes have achieved their natural shape and become covered with grass and shrubs (see Figure 15).[56] However, further work was required to stop erosion at the southern end of Kinka beach and this continued until 1998. Coastal Engineer Jurek Piorewicz warns that if the sand dam that was constructed in 1989 washes away, then the dunes on Kinka beach will face another erosion crisis.[57] This beach reshaping solution is part of a recent

Source: Piorewicz, 1999.

trend in beach protection that is moving away from hard engineering structures as far as it can be possible.

KEPPEL SANDS BEACH

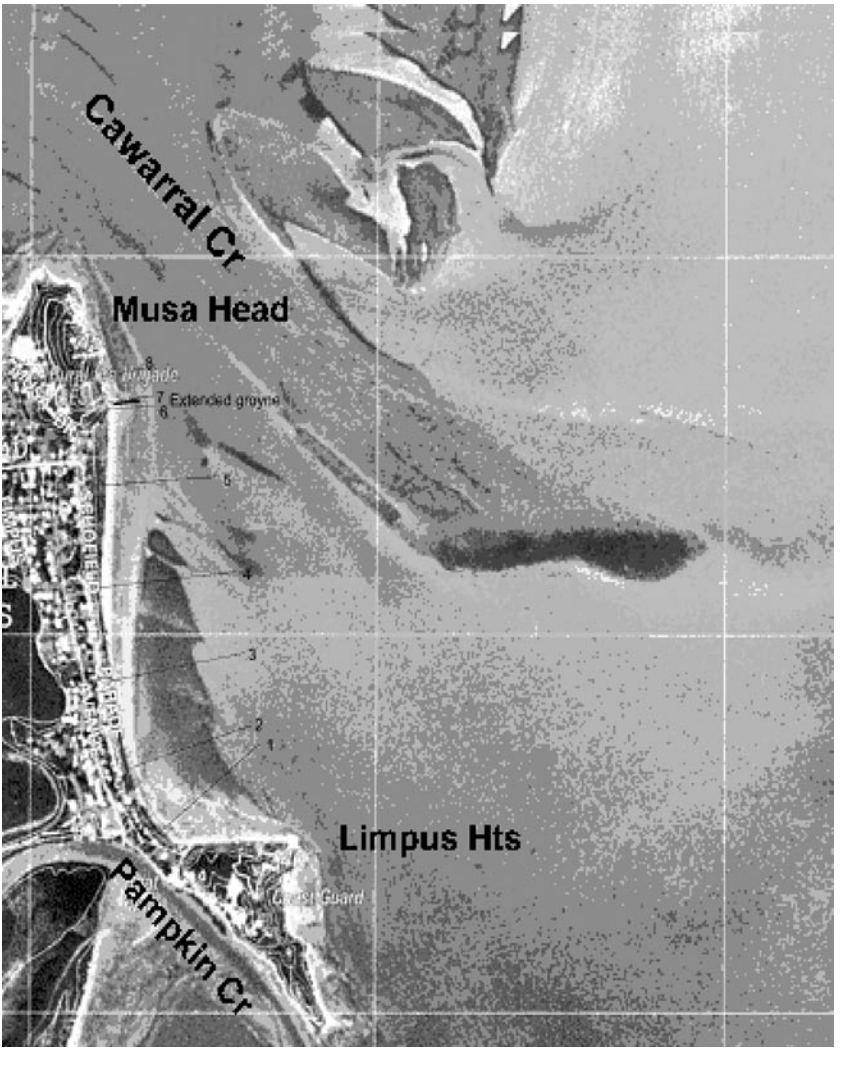


FIGURE 16. Aerial view of Keppel Sands. Source: Topographic Image Map 9051-24 Emu Park [scale 1:25000].

Keppel Sands beach is approximately 1,300 metres in length, and is sited between the Limpus Heights headland in the south and Musa Head to the north. Pumpkin Creek crosses the southernmost aspect of the beach and Cawarral Creek (also known as Coorooman Creek) crosses the beach in the north – see Figure 16.

At Keppel Sands, a small seaside town in the south west corner of Keppel Bay, houses are located on narrow, but relatively high dunes with only a residential access road between the allotments and the beach.[58] This road was pushed through heavy sand in the 1950s, basically dissecting a series of sand dunes (see Figure 17). The road gave access from the northern end of the beach to the bluff at the southern end, and was the initiative of the newly formed Keppel Sands Advancement League.[59] The one-way road was completed and sealed in

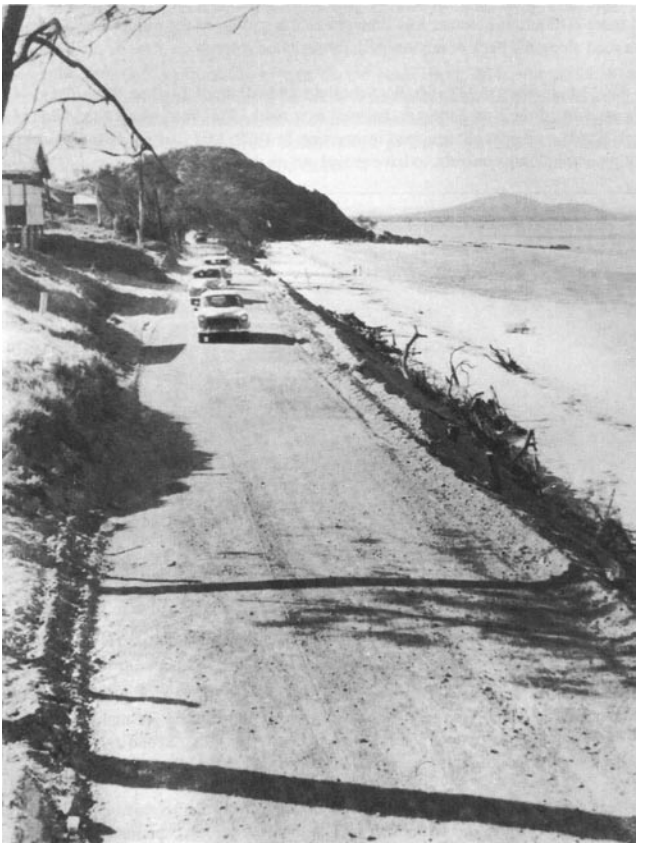


FIGURE 17. Opening of new road on sand dunes, 30 March 1957, north view. Source: Keppel Sands Historical Society, 1995: 68.

March 1973, and renamed Schofield Parade.[60] At times, the road and houses are threatened with erosion during storm surges and cyclonic events. Keppel Sands beach is particularly vulnerable to severe storms.

A wall made from Ti-tree logs was first constructed along the beach in the 1940s when the local residents attempted to combat natural dune erosion. In the 1950s, another 'unattractive' wooden wall was constructed in affected areas, this time out of old railway sleepers obtained from the railway department[61] (see Figure 18). These walls did not prevent dune erosion, and the sleepers were in danger of being scattered across the beach. In 1976, the BPA did not support LSC's request for approval to extend the sleeper sea wall, saying it was ineffective, dangerous, unattractive, would give a false sense of security to people and was a waste of money.[62] The wall has been extended over time in a haphazard way whenever money was available to add more rocks and tyres, and now extends for about half of the length of the beach towards the southern end.[63] The LSC suggested that the wall along the beach at Keppel Sands be filled with rock quarried from one of the headlands[64] and this would have scarred a prominent landform.

In 1979 the BPA reported that Keppel Sands beach required protective action to prevent erosion. The recommendations included rebuilding the existing sea wall, beach nourishment, and the construction of a groyne.[65] The sea wall that was first built in the 1940s was maintained by the local community until 1999. The LSC made financial contributions to this project, but did not consider beach erosion a major priority, so the upgrading of the wall was based on ad hoc works rather than predictive modelling.[66]

FIGURE 18. Railway sleepers vertically placed to act as a sea wall at Keppel Sands. Source: Keppel Sands Historical Society, 1995: 189.

FIGURE 19. LSC constructing a rock wall on Keppel Sands beach. Source: Keppel Sands Historical Society, 1995: 85.

The LSC constructed an 80m groyne at the northern headland in 1982 in order to trap sand drifting northwards as an attempt to renourish the beach at the southern end.[67] But sand was not accreted the length of the beach, only in the vicinity of the groyne. In 1994, the Council erected a mesh fence against wind erosion and it appears to be improving the dune system.[68]

In 2001 the groyne was extended to 100m (see Figure 20) with the intention that the construction would create an artificial 'headland', thereby increasing the possibility of natural accretion of sand and increasing the stability of the beach by its parabolic reshaping. Monitoring of shoreline movement in 2003 showed that a contributing factor to erosion is 'cross-shore transport sediment'. Simulations show that future change to the shoreline is not continual and progressive, but is dependant on the wave conditions and is 'dynamically changeable'. Accurate prediction of the future change in the Keppel Sands shoreline based on 'crenulate shaped bay theory' or the action of persistent swell requires continuous monitoring to verify the theoretical predictions.[69]

Three years after the 2001 groyne extension there was an increase in sand accretion in the central part of the beach, and some along the rock wall. While some accumulation of sand in front of the rock wall was expected, the permanent or significant accumulation of sand in front of the rock wall is unlikely without some corrections to the groyne. This calculation is based on six years of recorded wave conditions data, monitored wave dynamics and changes to the Keppel Sands beach.[70] [71]

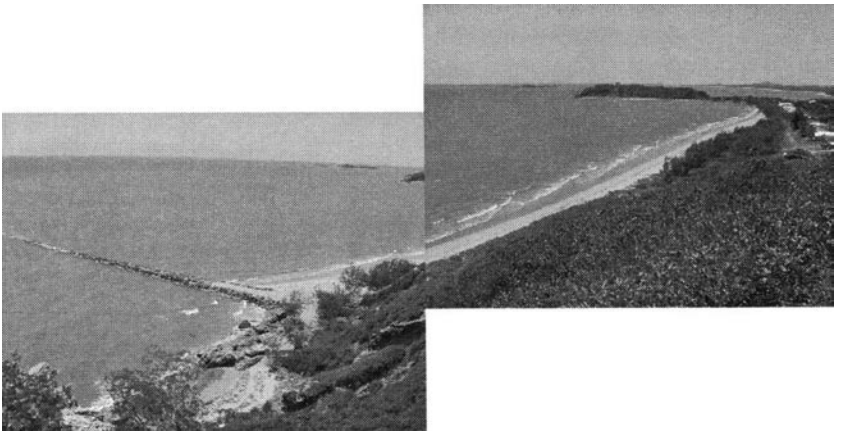


FIGURE 20.The extended groyne at the northern end of Keppel Sands, 2002. Source: Piorewicz, 2002: 106.

Similar to the condition of Yeppoon's main beach, the Keppel Sands beach in front of the existing rock wall is becoming more flattened owing to the action of reflected waves on the bottom of the beach.[72] Rock walls stop the natural process of beach renourishment by cutting off access to the sand reservoir in the dunes.

CONCLUSION

This paper examined approximately a 100 years environmental history of development and erosion on three Queensland beaches, as well as the local government and community responses to this erosion. Natural dune erosion was discovered when roads and buildings built close to the beaches were threatened by stormy seas in conjunction with high tides. This led to various kinds of sea walls being built for coastal protection, but these proved to be an unsuccessful mitigation. The sea walls and sand removal were encouraged by a lack of expert knowledge within the LSC on how beach (eco)-systems worked, and by a lack of community foresight and protest. The paper also documented changes in attitudes towards dunes, and attitudinal change is most evident in the creation of the BPA, which was a reaction to the intrinsic cultural value of the beach and the monetary value of associated infrastructure. In recent times, there appears to be an understanding that the most effective and ecological way to remedy dune damage is to properly implement a soft type of beach protection (as has been the case with Kinka beach) and then leave the dunes connected to the wind and wave actions of the beach. The LSC is now keen to restore sand to the beaches.

Owing to the relatively small population, most of the beaches around Keppel Bay have not had their dunes cluttered with man-made objects, and those beaches might experience dune erosion only during extraordinary big seas. They then, in time, revert back to a healthy dynamic balance because of the storage of sand in the dunes. However, roads have been constructed within the buffer zone immediately adjacent to the fore-dunes of some beaches and these roads could be threatened during cyclones. The beaches are the essential drawcard for people to the coast and without them in a healthy state the local economy would be adversely affected. Moreover, the coastal environment is, and continues to be, the most settled environment in Australia. There are important lessons for enhanced coastal management and protection from understanding how and why the three beaches in this paper were developed over the last century.

NOTES

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[2] Mullins, 2002b.
[3] Cosgrove, 1984.
[4] Mullins, 2002b.
[5] Milburn, 1988.
[6] Mullins, 2002a.
[7] Carpenter, 1991, 307.
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[9] LSC, 1973a.
[10] Mullins, 2002a.
[11] Hutton and Connors, 1999.
[12] Piorewicz, 1991, 8.
[13] LSC, 1938.
[14] Piorewicz, 2004a, 5.
[15] Beach Protection Authority, 1979, 16.
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[17] *Morning Bulletin*, 12 January, 1886.
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[26] LSC, 1975b.
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[30] LSC, 1976a.
[31] *Morning Bulletin*, 5 June, 1981.
[32] LSC, 1973b.
[33] LSC, 1976b.
[34] Piorewicz, 2004a, 6–8.
[35] Ibid., 12.
[36] Ibid., 47.
[37] Piorewicz, 1991, 1.
[38] *Morning Bulletin*, 12 May, 2001.
[39] BPA, 1979.
[40] Ibid.
[41] Piorewicz, 2004a, 37–8.
[42] *Morning Bulletin*, 6 March, 1936.
[43] Piorewicz, 1999, 1.
[44] Piorewicz, 1991, 10.
[45] *Morning Bulletin*, 21 November, 1939.
[46] Piorewicz, 1999, 1.
[47] Ibid.
[48] *Morning Bulletin*, 30 January, 1979, 1.
[49] *Morning Bulletin*, 5 April, 1984, 17.
[50] *Morning Bulletin*, 28 January, 1989.
[51] Piorewicz, 1991, 10.
[52] *Morning Bulletin*, 12 November, 1985.
[53] *Morning Bulletin*, 18 January, 1988.
[54] *Morning Bulletin*, 28 January, 1989.
[55] *Morning Bulletin*, 5 April, 1989.
[56] Piorewicz, 1999.
[57] Ibid., 24.
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[59] Keppel Sands Historical Society, 1995.
[60] Ibid.
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[62] LSC, 1976a.

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[64] *Morning Bulletin*, 30 January, 1979, 1.

[65] Piorewicz, 2003, 5.

[66] Ibid.

[67] Piorewicz & Bhuiyan, 2001.

[68] Ibid.

[69] Piorewicz, 2003, 2–3.

[70] Ibid., 40–41.

[71] Piorewicz, 2004c.

[72] Piorewicz, 2003, 2–3.

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