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The Gold Coast

Background

The Gold Coast is situated on the east coast of Australia, nestled in the south east corner of Queensland. In less than a century this stunning coastal strip has evolved from a string of seaside villages to become Australia’s sixth largest city. With a five year average population growth rate of 3.2 per cent, compared to 1.8 per cent for the rest of Australia, the Gold Coast is one of Australia’s fastest growing regions.

No doubt contributing to the population boom are the city’s picturesque beaches. The Gold Coast boasts 52 kilometres of golden sand beaches, which helps attract more than 14.2 million visitors annually. These visitors generate more than $5.9 billion in expenditure for the local economy. It makes sense then, that the community and local government have an interest in protecting and enhancing the beaches as a valuable natural asset.

In 2013 the Council of the City of Gold Coast (City) endorsed an Ocean Beaches Strategy. A major objective of the strategy is to protect local infrastructure from coastal hazards. In a world first, the City has also adopted a Surf Management Plan. The Plan commits to managing our world renowned surf amenity according to best practice, informed by data collection, design and innovation.

These two initiatives have driven the development and successful delivery of the Palm Beach Shoreline Project; an innovative project involving beach nourishment and construction of an artificial reef with the primary objective of enhancing coastal protection along one of the city’s most vulnerable coastlines.
Palm Beach history

For decades, significant erosion events along Palm Beach have threatened beachfront infrastructure, exposing seawalls and jeopardising the lifestyles of locals through the temporary loss of usable beach.

When several severe storms battered the region in 1967, residents at Palm Beach were forced to take the drastic measure of retaining the eroded shoreline using old car bodies.

Since 1967 there has been a number of erosion events along Palm Beach. More recently in 2009 sections of the seawall were exposed and a viewing deck lost in large swell events. During ex-tropical cyclones in 2013 and 2016, swell reached the boundaries of many beachfront properties at Palm Beach.

Such erosion events present a significant safety risk, damage beachfront infrastructure, and jeopardise recreational beach amenity through temporary loss of usable beach. These events can also damage the City’s reputation and result in economic loss through negative impacts on tourism. City of Gold Coast has long recognised a need to find a sustainable solution to protect Palm Beach.

The challenge

Palm Beach is a four kilometre stretch of coastline on the southern Gold Coast. It lies between Currumbin and Tallebudgera Creeks and is positioned more easterly than beaches further south, which are somewhat protected by Snapper Rocks. This exposes the beach to higher wave energy, as southerly swells are refracted around Currumbin Rock.

As with any open coastline, large and prolonged storm events can remove sand from the beach and the inner sand bar and deposit it further out to sea on the outer storm bars.

This sand does not always return to the beach by natural processes before the next storm event. Without a sufficient volume of sand on the beach, this erosion can significantly impact beach amenity, threaten beachfront infrastructure and beach accessibility.

The City has collected hydrographic and beach survey data since the 1960s, and this information is used to monitor the health of our entire coastline. This data shows that Palm Beach has the lowest volume of sand compared to all Gold Coast beaches backed by beachfront infrastructure.

No long-term trends of sand volume growth were evident, which suggested Palm Beach would remain susceptible to coastal erosion unless management strategies were implemented to increase sand volume.
Developing the solution

The City collaborated with a talented team of scientists, coastal management experts, engineers, environmental officers, and dredging consultants to find a sustainable solution to protect Palm Beach. Local residents, the surfing community and other interest groups were also important stakeholders in the project, consulted throughout the design and construction process. This body of work would become known as the Palm Beach Shoreline Project.

An initial feasibility assessment followed by concept design investigations developed and evaluated a total of 18 management options. Each option was assessed and compared based on expected cost, coastal protection benefits, and impacts on a range of aspects such as coastal processes, ecology, surfing, and beach amenity.

This resulted in a preferred option consisting of beach nourishment stabilised by an artificial reef. This option was favoured, largely due to its low visual impact and the long term retainment of nourished sand.

Project timeline

JAN 2013
18 options to manage erosion issues along Palm Beach compared through multi-criteria analysis, with an artificial reef combined with sand nourishment emerging as the preferred solution.

2013–MAR 2014
Detailed assessment of three management options, two from the feasibility assessment and one alternative solution, including computer modelling studies.

MAR 2014
A concept design was adopted by the City.

2015–2018
Sand nourishment stabilised by an artificial reef was adopted by the City as the best solution for Palm Beach.

Major investigations are undertaken to inform the final design of the artificial reef.
COASTAL ENGINEERING PROJECTS OF THIS NATURE ARE CHALLENGING AND COMPLEX.

Aerial view of the artificial reef at Palm Beach during construction.

- **JUN–SEP 2017**: 470,000 cubic metres of clean sand is delivered to Palm Beach as Stage 1 of the project.
- **MAY 2019**: Stage 2 of the project commenced with construction of the artificial reef.
- **SEP 2019**: The Palm Beach Artificial Reef is completed ahead of schedule and within budget. A plaque was unveiled at Nineteenth Avenue, Palm Beach, to commemorate the Palm Beach Shoreline Project.
- **BEYOND 2019**: The City will continue to monitor the reef at Palm Beach on an ongoing basis. Data collected from the project may help to inform the design of future artificial reefs.
Design investigations for the Palm Beach Shoreline Project adopted a ‘multiple lines of evidence’ approach, involving real world data capture, several forms of sophisticated computer modelling, and two programs of scaled physical modelling (wave tank testing).

Using a variety of investigation methods allows cross-checking between the results of the various design investigations and provides confidence in the unique design solution.

Field data

Data about wave patterns and sand volume was collected and integrated into every aspect of the project from numerical and physical modelling inputs, to construction planning, and defining the project’s performance indicators.

Coastal images and surveys of the beach were analysed to assess the long-term changes in beach width and sand volume along Palm Beach.

Multiple wave monitoring campaigns were undertaken to measure waves and currents at the artificial reef location and over the broader area. A key objective of these campaigns was measuring the impact of the offshore natural reef system on the incoming wave field.

Numerical modelling

A series of numerical models were used in the development, and to predict the performance, of the artificial reef. Aspects impacting the proposed design that were modelled include wave behaviour, sand transport, dune erosion, and surf amenity. This modelling confirmed the required location and size of the artificial reef to achieve the desired coastal protection and surfing outcomes.

Based on the models, surfing amenity was predicted to be variable depending on the prevailing conditions, including tide level, wave height and direction, wind speed and direction. Under certain swell conditions, the artificial reef is predicted to produce right-hander waves suitable for intermediate and advanced surfers. The reef is also expected to provide increased peakiness in the inshore wave field generally having a secondary positive impact on surfing amenity.
Physical modelling

Two programs of physical modelling were undertaken to test the artificial reef design and verify the accuracy of numerical models.

A model of the reef was built in a wave tank at the Queensland Government Hydraulics Laboratory using a 1:42.5 scale. These investigations provided information to determine the minimum rock sizes to ensure structural stability, as well as measurements of wave transmission and surf amenity over the artificial reef.

A smaller model of the reef at a scale of 1:59 was then built in a wave tank at the University of New South Wales Water Research Laboratory (WRL). The purpose of this modelling was to examine the impact of the artificial reef on sand movement and currents.

Quantified conceptual model

To bring together the different lines of evidence, a quantified conceptual model of sand movement was developed and used to provide an overall understanding of coastal processes along Palm Beach.

This model showed the sustained increase of sand volume to Palm Beach would be in the range from 200,000 cubic metres to 450,000 cubic metres, with the area benefited extending from Nineteenth Avenue south to the Palm Beach Surf Life Saving Club. Other predicted benefits included improved surfing amenity over and inshore of the artificial reef and reduced storm erosion inshore.
The artificial reef design

Following intensive investigations, the artificial reef was constructed approximately 270 metres offshore from Nineteenth Avenue between the beach and the existing natural reef. The artificial reef footprint is 160 metres long, 80 metres wide and is 1.5 metres below the average water level at its highest point.
The artificial reef works by influencing the surrounding waves and currents to promote a long term increase in sand along vulnerable sections of Palm Beach. The increase in sand will be located just offshore within the surf zone, not always distinctly visible to beach users, but in a position to act as a protective buffer from erosion into the future.

The artificial reef is constructed of basalt and greenstone rock, both chosen for being particularly durable, heavy and dense. The rocks were classed into four sizes at the quarry, with smaller rocks making up the core of the structure, stopping sand moving up from the seabed and undermining the reef.
Delivering the solution

Beach nourishment – Stage 1
In 2017 sand nourishment was undertaken with more than 470,000 cubic metres of sand delivered along Palm Beach. The extra sand works as a buffer to protect the coastline from the impacts of storms and large swells.

A specialised dredge vessel collected clean sand from offshore reserves and distributed it around the wave breaking zone by ‘bottom dumping’ and ‘rainbowing’. Bottom dumping is where the collected sand is deposited to the wave breaking zone through the vessel hull. Rainbowing involves sand being projected from the bow of the vessel to the wave breaking zone as a sand/water mixture.

A novel beach nourishment framework used multiple data sources and methods to inform sand placement locations on a weekly basis, with the aim of balancing operational, morphological, social and environmental outcomes. This innovative methodology drove placement of individual artificial sand banks or a ‘sand pattern’. This approach was successful in reducing beach use interruptions, safeguarding nourishment production and delivering temporarily enhanced surfing amenity.

Appointing a contractor
The artificial reef is an unusual coastal structure, with a submerged crest, broad flat shape and tight construction tolerance requirements. The project site is also complicated, exposed to the open ocean wave climate and located within the active coastal zone where seabed levels are variable.

To gain the best project outcomes, the City hosted several collaborative workshops with two shortlisted tenderers. The tenderers worked with the City’s design consultant and several maritime construction experts prior to the contract being awarded. The workshops fostered construction innovation and allowed delivery risks to be identified and mitigated early. This ensured the construction phase of the project ran smoothly and contributed to the artificial reef being completed ahead of schedule and within budget.
Building the artificial reef – Stage 2

The artificial reef was constructed using 60,000 tonnes of rock quarried in South East Queensland. The rocks, each weighing up to eight tonnes, were loaded onto Split Hopper Barges at the Port of Brisbane before being shipped over 20 hours to the site offshore from Palm Beach.

Once on site, the barges were positioned and the rocks deposited on the seafloor by opening the hull of the barge. A specialist marine construction vessel called a backhoe dredger then moved the rocks into position using GPS technology. The backhoe dredger was fitted with a sophisticated machine control computer system that allowed the operator to visualise the seafloor level, the artificial reef design levels and the position of the backhoe dredger in real time. The rocks could then be accurately positioned according to the design of the reef.

CONSTRUCTION OF THE $18.2 MILLION ARTIFICIAL REEF WAS COMPLETED OVER A FOUR MONTH PERIOD FROM MAY TO SEPTEMBER 2019.
Post-construction

In September 2019, a plaque was unveiled at Nineteenth Avenue, Palm Beach to mark the completion of the Palm Beach Shoreline Project.

The City is closely monitoring sand movement, surf amenity and ecology around the artificial reef at Palm Beach on an ongoing basis. Initial monitoring results are positive, with a build-up of sand starting to form inshore of the reef soon after completion.

In another triumph for the project, the City accepted an Excellence Award in the category of ‘Innovation’ from the Queensland Branch of the Institution of Public Works Engineering Australasia in October 2019.
Looking forward

The City of Gold Coast is committed to managing our beaches through the implementation of the Ocean Beaches Strategy 2013–2023 and the application of best-practice coastal management.

Data collected from the Palm Beach Shoreline Project may help to inform the design of future artificial reefs. The City is keen to share learnings from this signature project with other organisations with a vision for improving coastal protection and enhancing surf amenity.