INTEGRATION OF SUSTAINABLE STORMWATER MANAGEMENT INTO COASTAL DEVELOPMENTS

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Abstract

Casuarina Beach displays the forefront of engineering design solutions, which are both sensitive and compatible with the environment, adjacent coastal beaches and the Cudgen Creek Nature Reserve.

Cardno MBK introduced an innovative and unique integration of water quality and stormwater drainage management including Water Sensitive Urban Design (WSUD) concepts with shared use recreational facilities throughout Casuarina Beach.

The engineering techniques integrated practical results and benefits to the community, environment and benefits to the erosion control industry.

The predeveloped site had a number of relatively unique characteristics which were significant drivers in the solution and implementation of construction and operational phases of water quality control.

Alternative, innovative engineering designs for the stormwater and water quality management were formulated. The use of natural resources with in the site benefits Cudgen Creek, the dunal systems and the ocean by treating the stormwater on site and mitigating any adverse effects in the natural environment by substantially reducing the direct stormwater flows into these features.

Key Words: Casuarina Beach, WSUD, Stormwater, Infiltration, Water Recycling, Water Quality, Drainage.

Introduction

Casuarina Beach is a new major urban development located on prime beachfront land on the north coast of New South Wales (Figure 1). The development includes residential lots, villas and an international hotel and commercial precinct, which will ultimately be home to some 6,000 people. The development will cover a total of 180 ha, which is situated on a sand peninsula surrounded by the Pacific Ocean and beach dunal systems to the east and the Cudgen Creek Nature Reserve to the west.

Figure 1: - Locality Plan

Cardno MBK has been the engineering consultant for the project since the planning phase, and was responsible in association with the Project Team for obtaining all necessary approvals for development, as well as completing detailed design and supervision of the subdivisional works. A significant part of the brief given to Cardno MBK by the client, Consolidated Properties Pty Ltd, was that the major natural features of the site should be retained and enhanced as much as possible. A strong feature of the major advertising campaign run for the project has been that Casuarina Beach represents an opportunity to return to the type of beach environment that people remember fondly from their childhoods. Accordingly, the focus has been on low-key development, and maintenance of a traditional beach culture which strongly embraces water-based activities such as surfing.

The implementation of Water Sensitive Urban Design (WSUD) principles was adopted as the key element in the development of the site. In this regard, the Casuarina Beach region had a number of relatively unique characteristics, which were significant drivers in the selection, and implementation of construction and operational phase water quality control measures.

The Site

Casuarina Beach is effectively part of a large narrow peninsula, which runs from Cudgen Lake to Kingscliff. This peninsula is bounded on the eastern side by the Pacific Ocean, and on the west by Cudgen Creek (see Figure 2). While the creek has important ecological value, water quality has been adversely affected in the past by poor land use practices within the catchment, particularly in respect of disturbance of acid sulphate soils and farm erosion. Maintenance of at least existing conditions was therefore an important element. Protection of water quality within the Ocean at the doorstep of the project is also a critical issue for a high profile, high value beachfront community.

This peninsula is composed almost entirely of sand. In the 1950s, 1960s and 1970s, the area now occupied by Casuarina Beach was one of the principle sand mining areas in Australia.

Figure 2: - Casuarina Beach

The entire beachfront and dune system between the Cudgen Point and Bogangar headlands was worked extensively over this period for mineral sands, primarily rutile and zircon. Sand mining was carried out using cutter suction dredges which were progressively moved from one dredge pit to the next. The sand was then washed and the heavy fractions, including the valuable mineral sands, extracted. The unwanted white sands were simply pumped back into the previous dredge pit. Virtually no part of the present development site was left untouched, with all vegetation being removed and the pre-existing dune structure being completely destroyed. Aerial photographs taken during this period show the entire site denuded of vegetation, with bare sand areas being worked by dredges operating in pits.

Consequently, the pre-development site had virtually no topsoil. Geotechnical investigations showed clean beach sand throughout to depths well below the water table. In hydrologic terms, it is likely that surface runoff from the site only occurs during very intense events, with the majority of rain falling on the site being converted to groundwater by infiltration and percolation. The lack of runoff, plus the limited concentrations of fine soil particles over the site, meant that impacts on Cudgen Creek from suspended solids (at least from this site) were minimal. Similarly, the intense disturbances during the sand mining phase, including removal and off-site disposal of all natural vegetation, have produced very low soil nutrient concentrations. This, combined with the lack of surface runoff, indicates that the pre-development site contributed only small amounts of nutrients to Cudgen Creek.

Following the completion of the mining activities, the site was revegetated using a mix of native and exotic species, although there was no attempt to replace the pre-existing floristic systems. The vegetation existing on the site prior to the commencement of development activities has been described as 'synthetic', with little ecological value. In addition, and as a consequence of the extensive site earthworks carried out during dredging operations, the pre-development site displayed little variation in topography. A reasonable proportion of the total area nominally drained towards the dune system and the ocean, with the remainder draining to Cudgen Creek.

Lastly, the land use designations on and around the site were a major issue in dealing with development issues. It is important to realise that Casuarina Beach allotments do not have direct and unfettered access to the beachfront. The beach itself, and the dunal system landward of it, are contained within what is known as Lot 500, which is land owned by the New South Wales Department of Land and Water Conservation (DLWC). Activities within this area required specific approvals from the Department, involving a high degree of negotiation at times.

In addition, almost the entire 3 km frontage of the site was designated as erosion prone. Tweed Shire Council planning controls, implemented via the Tweed Local Environmental Plan, therefore imposed significant constraints on what could be constructed within a strip approximately 30 m wide along this frontage.

Several of these site characteristics would be a significant constraint on conventional urban development, especially in respect of stormwater and water quality management. Conversely, in many instances, these same characteristics, as well as the others for the site, present an excellent opportunity for the implementation of Water Sensitive Urban Design principles.

Drainage Strategy

Drainage on the site is generally directed towards a swale running the length of the development along the eastern boundary. This swale is then collected and directed westward at two major locations (see Figure 3). The general drainage strategy was adopted to avoid discharging directly to the ocean beach while maintaining the general topography. This also increased flow distances hence increasing the time of concentration at the outlets and increased opportunities for infiltration.

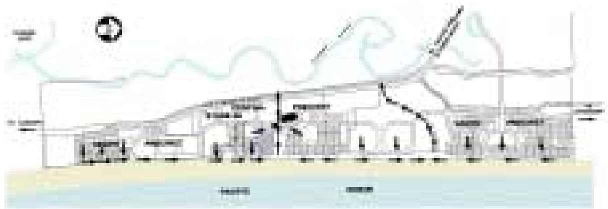

Figure 3: - Stormwater Flow Paths

For the recurrence intervals for the Casuarina Beach project a three-tier approach was adopted which included looking at the 3month, 5 year and 100 year design events. The three-month event (40% of the one year event) was adopted for the stormwater treatment strategy while the 5-year event was adopted for the road piped drainage system and the 100-year event was adopted for the major design case. This allowed the infrastructure for water quality and for road drainage to be rationalised and made more cost effective.

Water Quality Strategy

Based on a comprehensive appraisal of the physical parameters of the site, involving detailed technical site and desktop investigations, and relevant directions from Tweed Shire Council, the Environmental Protection Authority and the Department of Land and Water Conservation, the drainage and water quality management system for the site was developed and implemented. The two key elements of the stormwater system on the Casuarina Beach site are:

- The dedication of a 10 m strip along the frontage of the site to be used for drainage and water quality control purposes. This land becomes public open space under the control and administration of Tweed Shire Council.

- A substantial reliance on infiltration of stormwater runoff, both at source and elsewhere within the development. In this regard, the soil parameters of the site were clearly ideal for this form of water quality management.

The treatment train adopted for the Casuarina Beach development was as below.

- *Roof water infiltration*
- *Limited road drainage infrastructure*
- *Trash Racks*
- *Oil/sediment traps*
- *Infiltration basins*
- *Dispersed overland flow*

Maintenance plans were formulated for the various treatment devices and regular maintenance will ensure the long-term effectiveness of the scheme. An on going water quality monitoring program has also been implemented to assess the continual effectiveness.

The measures utilised to manage water quality included:

Roof water infiltration

While not actually treating stormwater the use of roof water infiltration allows the total quantity of runoff to be reduced and hence reducing the costs of infrastructure. It also prevents relatively clean water from the roofs of buildings etc from mixing with water from areas such as roads and garden areas which would have had a chance to pick up contaminants such as sediments and nutrients. The direct infiltration also adds in the recharging of the underlying freshwater aquifer.

The construction of infiltration trenches for public parking areas to capture and treat runoff at source has also been utilised to reduce loads on the drainage network and downstream infiltration facilities (Figure 4).

Figure 4: - Infiltration Trench Adjacent to Public Carpark

Limited road drainage infrastructure

The installation of an underground stormwater drainage network only within limited parts of the development area. This allows runoff from roads and hardstand areas to be directed to treatment devices prior to ultimate discharge. In other areas, all drainage is directed via surface runoff, either to the frontage of the site or to swale drainage located within the subdivision itself. The size of drainage infrastructure was able to be reduced due to an allowance for a reduction in peak runoff due to infiltration of roof waters which is conventionally discharge to kerb or directly to the piped drainage network.

Trash Racks and oil/sediment traps

Trash racks and proprietary gross pollutant traps (Humeceptors) were installed to strip trash, coarse sediment, and oils and greases from all roadway areas within the development. All road and hardstand areas within the development are designed to drain to these treatment devices, which are located in open space areas adjacent to pathways for easy vehicular access and maintenance. The treatment devices are located immediately upstream of major infiltration basins to prevent large loads causing long term clogging and reduce visible trash in the basins.

Infiltration basins

The frontal swale which runs the full length of Casuarina Beach is intended to capture all runoff up to the 100 year Average Recurrence Interval, and, if required, to run it to specific westward flowing drainage paths constructed within the development. The drainage swales also operate as pathways, passive recreation and open space areas, thereby maximising developable area without compromising on engineering design standards. The swales incorporate a series of depressed infiltration basins to trap the 3-month event volume.

Infiltration basins were lightly vegetated using native dune grasses of local provenance, while the remainder of the drainage swale was revegetated as part of the overall dune rehabilitation program which was undertaken on site. The drainage swale was also integrated with a cycle/walkway which provides excellent access to the all parts of the development. Infiltration in this way therefore mimics the pre-development behaviour of the site, where surface runoff was a rarity rather than the norm. This achieves not only a good water quality outcome, but also maintains the status quo in respect of the hydrological functioning of the local area. In particular, it ensures that those groundwater flows which maintain the ecology of Cudgen Creek and surrounding wetlands are sustained.

Figure 5: - Isolated Infiltration Basin in Central Precinct

Figure 6: - Infiltration Basin in Frontal Swale.
(Note the boardwalk has been integrated into the swale area)

The sandy nature of the site is ideal for infiltration of stormwater with no preparation required for the sub-grade material. Other sites within south east Queensland have also utilised infiltration however due to reduced infiltration rates on clay based strata it has been necessary to import sand to create a bed with a subsurface drainage network to collect and discharge the filtered water. Hence the basin tends to act as a large sand filter with treatment by bio-retention.

During the development of the site measures were taken to aid in the implementation:

- During and after construction, protection of bare sand areas with mulch sourced from cleared vegetation on the site itself, and rapid re-grassing and revegetation following earthworks disturbance. No topsoil was imported to the site for the project, and the mulch consisted of a mix of sand, decomposed vegetation, grass seed and limited organic fertiliser. The existing beach sand consists of medium to coarse particles which are relatively easily settled, in contrast to finer soil particles and colloids which are typically generated from topsoil materials. The exclusion of topsoil therefore reduced the risk of erosion and sediment transport, as well as ensuring the infiltration basins used on the site could function satisfactorily without the risk of clogging.

- The installation of temporary retardation basins during the construction phase, to trap and settle sediments, which may have been, transported into the infiltration areas causing premature clogging during the construction phase.

Dispersed overland flow

No runoff is discharged from the site directly to the ocean, and significant vegetative filtering of runoff will occur prior to runoff discharge to Cudgen Creek. The western part of the site remains undeveloped as public open space, and provides substantial buffering of Cudgen Creek for water quality purposes. On the rare occasion that flow discharges from the site the discharge under Cudgen Road is dispersed overland using a weir arrangement to reduce the possibility of channelisation.

Water Recycling

Another important feature of this site was the presence of a significant groundwater resource. In this regard, the South Kingscliff peninsula is similar to the isolated sand islands of southern Queensland, with ground levels well above those of the adjoining water bodies. Brackish groundwater at depth is overlain by a lens of freshwater mounded up under the higher central spine of the site. In the pre-developed state, this groundwater was not put to any use. A water recycling strategy has been utilised with underlying fresh water lens being utilised for irrigation purposes and for flow supplementation to the sewer system for the early stages of the development to control septicity and maintain minimum flows. The heavy use of infiltration on the site readily recharges this natural storage hence maintaining a reliable supply. This significantly reduces the pressures on the potable water supply while providing a cost effective water supply for these purposes.

Conclusion

The unique stormwater system at Casuarina Beach has been implemented successfully into the development and displays these key elements:

- Bare sand areas promptly grassed or mulched from on-site vegetation.
- Conventional stormwater pipes used only in limited areas of the site being the road network with gross pollutant traps to capture coarse sediments and oils from roadways.
- The use of off-line Trashracks / Humeceptors in drainage paths to remove suspended solids.
- Drainage swales along the full eastern frontage of the site.
- Establishment of infiltration basins and overland flow paths within drainage swales vegetated using native dunal grasses.
- Swales integrated with shared use functions as drainage, cycleways, playing areas and passive recreation.
- Lateral overland flow paths from the development to the swales, to carry excess allotment and road runoff.
- Two swales flowing west to Cudgen Creek from eastern frontal swale. Safeguard drainage swales to capture flows in excess of infiltration capacity.
- No runoff from site discharged directly into ocean.
- Significant vegetation filtering of runoff prior to flowing into Cudgen Creek.
- Western, portion of site remains undeveloped and in natural state. Provides nature reserve and substantial buffering of Cudgen Creek for water quality purposes.
- Individual residential allotments have their own stormwater infiltration pit system to capture all roof and hardstand runoff.
- Use of groundwater for irrigation.

These key elements combine to provide a satisfactory result to the key stakeholders and provide a solution ensuring the ongoing sustainability of water quality within the receiving waters.

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Rod has nine years experience in a variety of Civil Engineering fields within Northern New South Wales and South-East Queensland including structural, geotechnical, hydraulic, environmental, municipal and planning.

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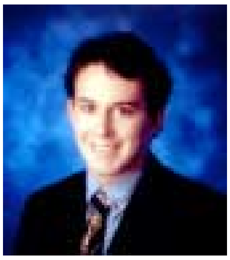

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