CRCWSC Research Synthesis
Discussion Paper | CRC for Water Sensitive Cities

Ideas for Ocean Reef Marina

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CRC for
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Diagrams have been provided by Realm Studios unless otherwise indicated.

This discussion paper contains ideas. Further evaluation is required, and the ideas have no formal status before this is completed.

The organisations and individuals who participated in the workshop did so in the spirit of collaboration and innovation, and were not required to endorse or commit to the ideas through their participation.

About this document

This document is the main output from a workshop that imagines a water sensitive future for the Ocean Reef Marina in Perth (WA).

The Ideas for Ocean Reef Marina assists DevelopmentWA as the developer to consider:

- Alternative non-potable supply for public open space irrigation and boat wash-down.
- Stormwater management to minimise environmental impacts.
- Use of water and green infrastructure to create a pleasing microclimate.
- Innovative use of technology and sustainable infrastructure.

About the workshop

On 27 and 28th September 2019, a workshop was hosted by the CRC for Water Sensitive Cities (CRCWSC), together with DevelopmentWA and the City of Joondalup.

The workshop was held to identify ways to improve the water performance of the Ocean Reef Marina, along with ideas to embed these outcomes within the development process.

At a high level, three challenges drove the need for a workshop – lack of a non-potable water supply, need for an environmentally sustainable development to reflect its location, and the need to be future proofed and resilient to physical and social changes.

Participants were encouraged to focus on water outcomes, but to also consider integration opportunities across transport, energy, built form and other aspects of the project.

Who was there

The workshop encouraged a broad mix of stakeholders to contribute to the development of ideas. Workshop participants included:

City of Joondalup

DevelopmentWA

OCEAN REEF MARINA
COMMUNITY REFERENCE GROUP

ORSSC

Whitfords Volunteer Sea Rescue VJ6LQ

Water Corporation

Department of Primary Industries and Regional Development
Government of Western Australia

Government of Western Australia
Department of Water and Environmental Regulation

Department of Transport

AUDRC
Australian Urban Design Research Centre

udla

m p rogers & associates pl
creating better coasts and ports

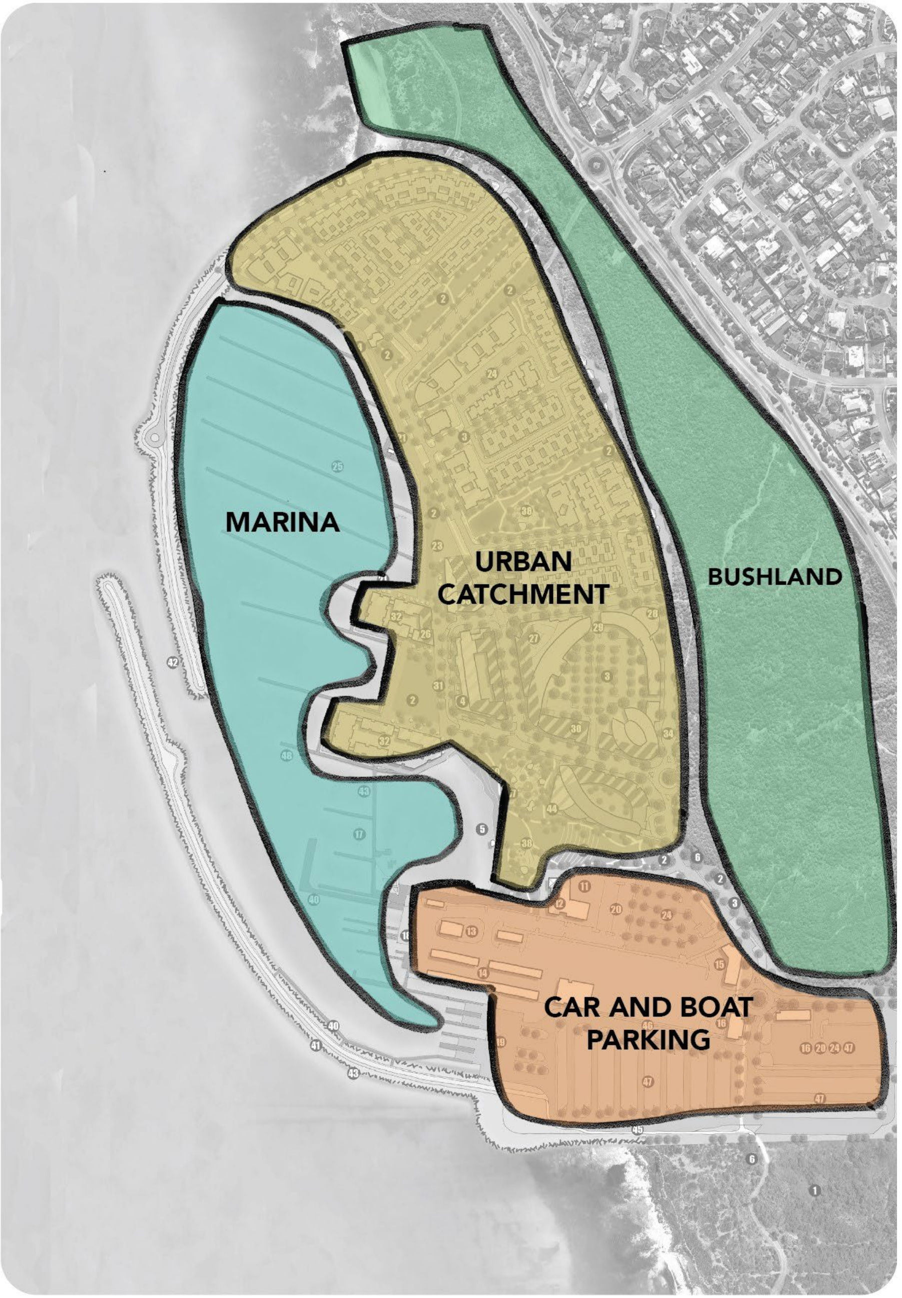
Hames Sharley

Taylor Burrell Barnett

Wood & Grieve Engineers

REALM studios

strategen JBS&G



About Ocean Reef Marina

Ocean Reef Marina is located 35 minutes from the Perth CBD, and will be the third marina located in the north-western suburbs of Perth.

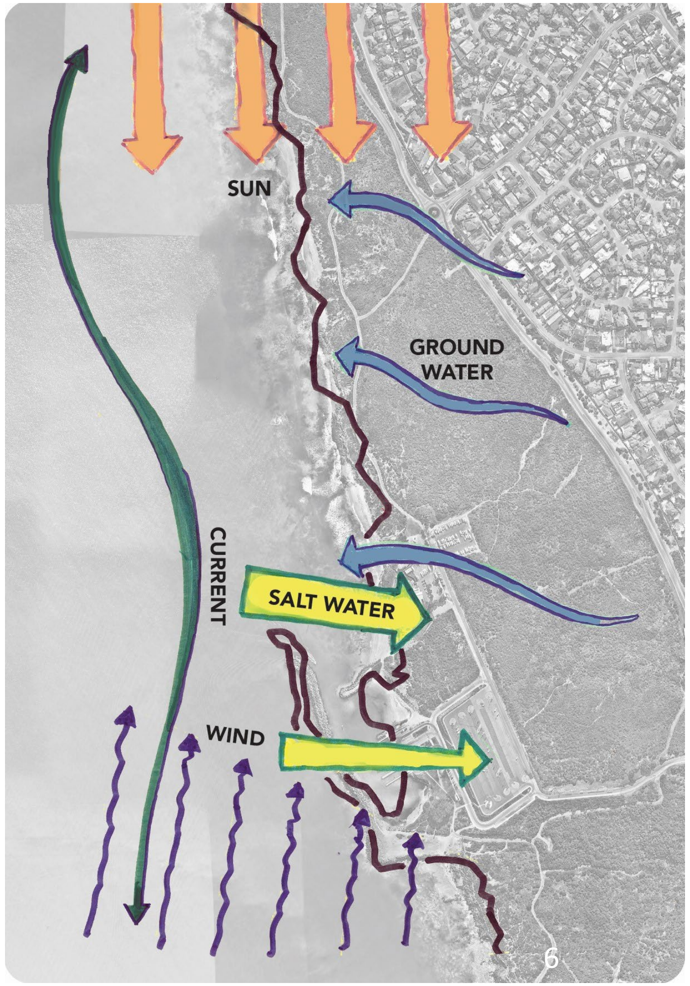
There is strong demand in the area for additional boat parking as well as the ability to live adjacent to the Indian Ocean. The 65 ha marina development will include retail and dining establishments, public open space, residential development along with boat pens and stackers. Located between a Bush Forever site and the Marmion Marine Park, the environmental sustainability and future proofing of the site is of high importance.

To date, the environmental approvals have been obtained, the Marmion Marine Park Reserves Bill 2019 has been passed and Metropolitan Regional Scheme amendment is pending. The Local Water Management Strategy, landscape design and other design guidelines are yet to be finalised and provide opportunities to influence the granular design and delivery of Ocean Reef Marina.

Context

When considering the water performance of the planned development, and its contribution to Perth's journey to become "water wise", several observations can be made:

- Ocean Reef Marina has an abundance of water, albeit of differing qualities and availability (i.e. timing). Water security should not be a barrier to Ocean reef Marina's success.
- Ocean Reef Marina has several water demands that are atypical for a new urban development (such as boat wash down). This creates new, fit-for-purpose reuse opportunities.
- Regionally, groundwater is already fully allocated. On site, approximately 5ML in summer and 8ML in winter groundwater discharges to the Indian Ocean daily, representing outflows remaining after 'upstream' bore extraction. Once the breakwater is constructed, this groundwater discharge will aid flushing the marina. In this regard a sustainable extraction yield will be determined by this flushing regime (as well as Government policy).
- The development of a higher density urban landscape will create areas that absorb heat and modify the microclimate experienced by residents and visitors. The southern precinct hardstand area is likely to be a particularly problematic hot spot, and radiant heat will be pushed into the development by southerly breezes. Water and vegetation will both feature as potential solutions to this issue.
- Wind patterns have already informed the orientation of jetties and boat pens, suggesting a need to extend this thinking to other areas of the site masterplan.
- DevelopmentWA and City of Joondalup have identified a number of success factors for Ocean Reef Marina. Establishing an 'iconic' development that is differentiated by its design and delivery is a priority amongst these.
- Planning for the development has a long history. The marina is important to the community. Recent community engagement yielded a large number of responses with a very high level of support for the marina.



Opportunities

Water

If Perth is to be a water-wise city, each new development should make a positive contribution by applying principles of “a city as a water supply catchment” where practical. This principle **ensures that water available locally is harnessed in preference to importing water from outside** (e.g. Scheme water). This will remove growth pressure on city scale water supplies. A similar local-first approach can be adopted for wastewater treatment.

When viewed this way, Ocean Reef Marina has a relative abundance of water, albeit of varying qualities and at different times: Scheme water, sea water, groundwater, rainwater and locally generated stormwater and wastewater. By way of example, rough calculations tabled at the workshop suggest that stormwater harvesting could yield 50,000 KL per year if stored, based on volume of rain and reasonable percentage that could be harvested. Similarly, 10,000 KL of rainwater could be available as for use within buildings for bathroom and laundry uses.

This approach can be applied by adopting **a hierarchy of sources matched to uses** – the highest quality matched with the most sensitive uses.

A third principle is to **mix and match sources**, based on availability. Sometimes, the potential sources are considered individually, they cannot provide the needed reliability across a year. Instead, multiple, different sources, including Scheme water, can be used to back each other up, delivering a range of benefits compared to any single source.

The fourth principle is to **maximise storage and distribution opportunities** as part of the design and architecture of the precinct. This can be delivered using a grid-style network of infrastructure as well as by employing passive watering techniques that direct runoff to soil and vegetation after storms as a natural storage.

One novel storage option at Ocean Reef Marina involves a response to the capped limestone at the site. This limestone may impede infiltration, resulting in stormwater moving across the capped surface. If so, it will be necessary to raise the soil landscape of the site to create drainage. A constructed shallow aquifer could be included in the new soil profile to create a manufactured sand aquifer lens. In this way, rain percolates through and is stored for reuse.

Further innovation could employ a wicking bed system in which the constructed aquifer is overlain with turf and passively irrigated through capillary rise driven by evaporative losses from the soil and vegetation. Such systems have been successfully used in Gladstone (Queensland) in the public and private realms.

A final consideration is to **ensure the urban design cleanses water that flows through it**. Water sensitive urban design approaches such as green walls and green roofs, swales and raingardens can be applied widely to ensure runoff to the marina or infiltration to groundwater is of the highest quality.

Urban Heat

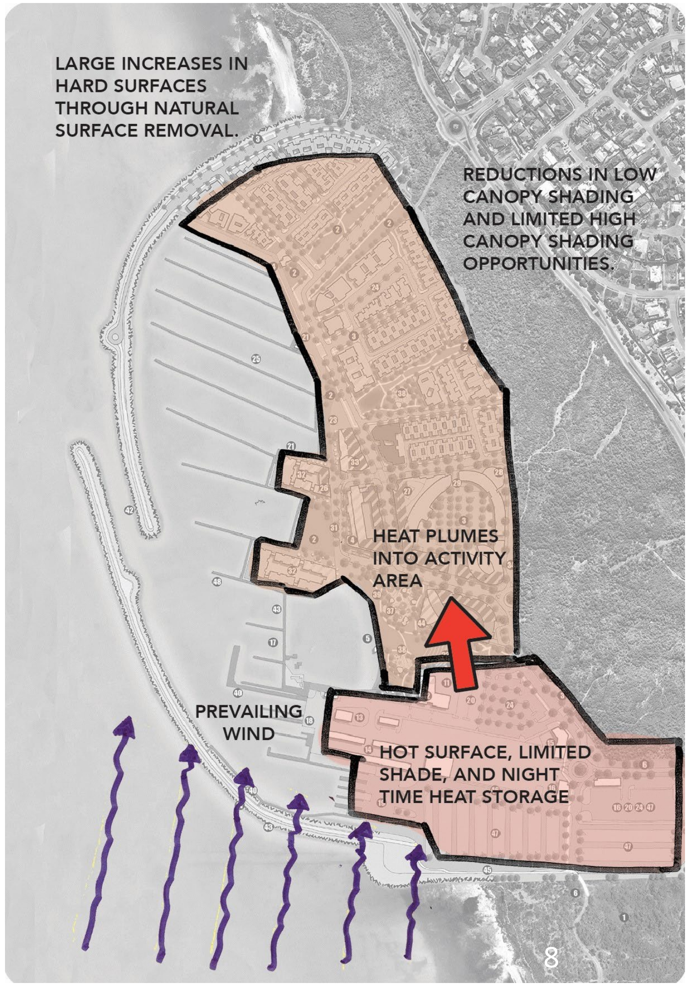
Converting areas from ‘green and natural’ to ‘urban’ creates a significant change in energy balances, generating hotter environments and eroding thermal comfort. As a result, we experience hotter conditions, and artificial cooling becomes the norm.

This effect is likely to be pronounced at Ocean Reef Marina. Notwithstanding the effect of sea breezes, the existing, natural landscape is being replaced with a hard, urban environment that will fundamentally change the area’s heat performance. The low dune vegetation that currently provides ground shade and roughness to aid heat exchange will be replaced by darker, harder and smoother surfaces that absorb heat (later radiated at night) and reduce heat exchange.

Designing precincts to be cooler involves:

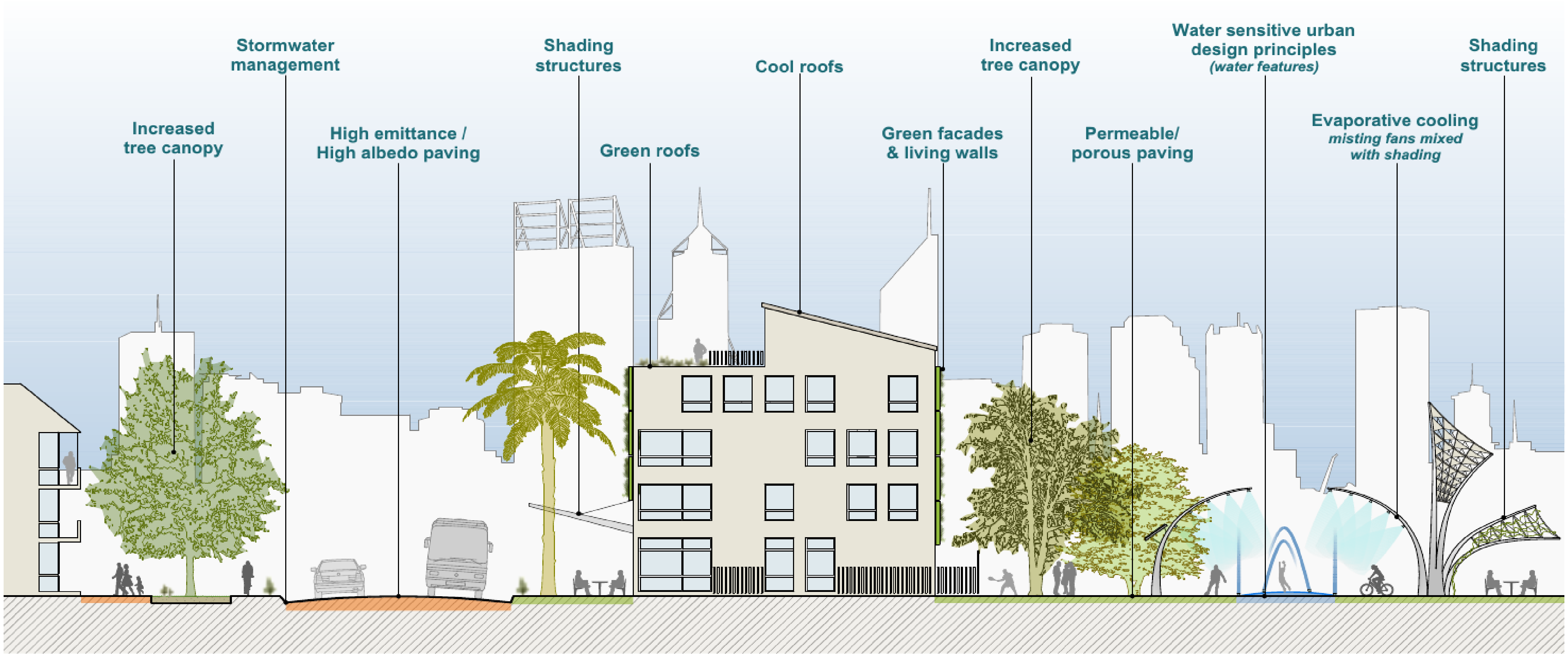
- **Greening:** trees and other vegetation will absorb solar energy, provide shade and facilitate evapotranspiration that cools the air. Substantial temperature differences have been recorded between hard surfaces and green areas.
- **Changing surface materials:** different materials, colours and perviousness will alter heat absorption, energy reflection and promote water infiltration to aid cooling. This can be a cost effective solution.
- **Adding shade:** this avoids heat build up and can be achieved using natural (e.g. trees) or artificial structures. Buildings themselves can also provide shade, depending on orientation and height. The shade effect from tree canopies alone can be pronounced – up to 4-7^{o}C change in surface temperature.
- **Adding water:** Non-irrigated grass has been shown to be as hot as concrete, and well-watered street trees have been shown to have larger canopies and longer asset lives. Widespread irrigation or passive watering (such as raingardens) is likely to reduce surface temperatures by several degrees. Water will be especially critical in maintaining building-scale and streetscape greening to ensure it performs through dry months.

These benefits can be **highly localised, meaning that the tactics above should be applied widely**. Within this, priority hot spots can be targeted. An example is the southern hardstand area that presents a large, impervious area. The southerly breezes will otherwise push the heat plume from this area back into the development. Similarly, the north and east side of streets and buildings will be much hotter and could be targeted for green walls or passively watered street trees.



Summer cooling strategies

Source - Osmond, P. and Sharifi, E. (2017) Guide to Urban Cooling Strategies, CRC for Low Carbon Living.



Urban Design

The coastal dune landscape has been self-sustaining for thousands of years, in the absence of an external water source or the addition of nutrients. It is informative to consider what Ocean Reef Marina's urban design and architecture would be if it's primary influence was the natural landscape of the site.

To maximise the water performance of the development, this context can guide the micro scale design of the site: the site can exist sustainably for a long period if designed the right way.

This approach can be extended as follows:

- The analogy of a harbour – the development **providing a retreat from the elements** of wind, water, and heat.
- Its position, with the dunes and escarpment structures on one side, and ocean on the other. This highlights the **criticality of the site edges**, such as the wharf that engages both water and land.
- **Facilitating human engagement** with the coast. Headlands are naturally a destination for recreation, meeting and dwelling. This informs the way the site is used.

An urban design response could include:

- Pier buildings that bridge water and land, providing a distinct site character.
- Creating space for the dune landscape to come through Ocean Reef Marina and meet the water. This provides an opportunity to apply water sensitive urban design as well as retaining the natural ecology as a central part of the development character rather than as an applied part of a reinvented landscape.
- Architecture that is influenced by local wind directions and matches the marine orientation. This creates ocean views for each residential unit and ensures marketability of the site.

Staging

Increasing density could be achieved by harnessing the natural topography of the dunes to sleeve the car parking under buildings and by adding extra levels without changing the overall building height. Two story pier buildings could match the yield of the current master plan, while three storey designs could increase yield by 50%. Delivered as an early stage, this establishes the design response and may increase finances for subsequent marina works.

Focus questions

Participants used these principles to propose a series of workshop questions in four main areas :

Water

- What role should different sources play in meeting Ocean Reef Marina's water needs?
- How can we store non-potable water for reuse?

Urban heat

- How can we use the built form, together with vegetation (green) and water (blue) to reduce heat island 'hot spots' at Ocean Reef Marina?

Urban design

- What would Ocean Reef Marina look like as an iconic development if water performance, the dunes and the coast were the focus of its master plan?

Integration

- Can water solutions also generate energy?
- Can Ocean Reef Marina's water performance be continuously improved by adapting to likely future changes in technologies and community needs?

These questions are adapted from a longer list developed during the workshop. The full list is provided in Appendix 1.

Ideas

11 ideas were co-designed in response to the workshops questions. The ideas are listed below and further explained in the following sections.

1. Groundwater for irrigation
2. Make water locally
3. Buildings as clouds
4. Energy from waste, on site
5. Cooling the hardstand
6. Adaptable parking that becomes future green space
7. Innovation precinct
8. Climate sensitive building design
9. East-west green corridors
10. Mimic the dunal landscape on the build form
11. Greening by wicking

Idea 1 – Groundwater for irrigation

Irrigation of public open space with groundwater as part of a sustainable groundwater allocation. A key challenge for this development is the supply of a sustainable irrigation water resource for public open space.

Currently groundwater flows from the Gnangara mound westward towards the ocean. When the groundwater reaches the ocean it directly discharges into the current marina or flows westwards in the superficial aquifer underneath the ocean floor.

Intercepting the deeper groundwater flow in the superficial aquifer was considered by some participants as a resource to be used. This would be done in a way that neither impacted upstream groundwater users, nor on the volumes of water discharged directly into the marina. Also discussed was the potential for extraction outside the groundwater allocation boundary, for example along the breakwater. Both going deeper and further out requires a groundwater licence based on 'available discharge' and 'sustainable yield' of the shallow aquifer. Preliminary assessment suggests that water demands for public open space irrigation would be a small percentage of this current discharge.

An argument put forward was that if the precinct is able to extract stormwater via rainwater tanks then why not water that has been infiltration into the unconfined superficial aquifer via galleries or an infiltration basin?

However the opposing argument places higher value on the role groundwater levels play in managing water quality in the marina, the risk of saltwater intrusion and potential impacts on other groundwater users.

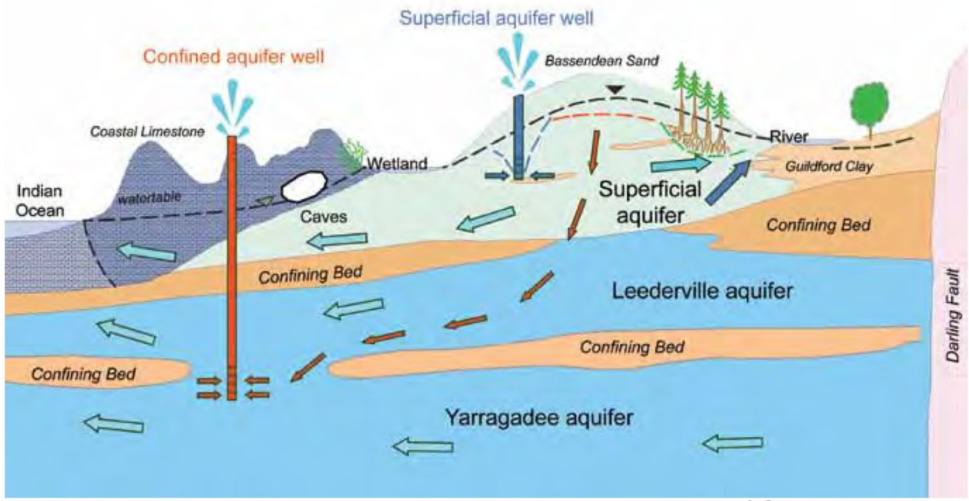
There is the potential for impacts both up and down gradient of the proposed precinct water source. For example up-gradient within 1 km of the precinct are three schools and one public open space groundwater licences.

The groundwater also plays an important role in maintaining water pressure that controls saltwater intrusion which is already threatened by reduced groundwater recharge and rising sea levels.

Of particular importance is the groundwater that flows directly into the marina as it is essential for water quality by flushing the current marina and the larger, proposed marina in the future.

Another issue it that WA's groundwater allocation system is the best practice approach for managing groundwater in a highly uncertain environment. To allow extraction will set a precent that may reduce the resilience of the system into the future.

The water regulator is not approving additional groundwater licences for the Gnangara management area as it is fully allocated and significantly impacted by climate change. Further discussions are required with the Department of Water and Environmental Regulation.



Gnangara mound cross section. Source – WA Department of Water

Idea 2 – Make water locally

Sea water, stormwater runoff form hard surfaces and the Beenyup ocean outfall are examples of water available locally.

Non-potable water demands could be met from an on-site desalination or water recycling facility.

Groundwater is the lowest cost and simplest water source for irrigation of public open space. However, it is at full allocation and further extraction has the potential for negative impacts and may not be approved. There are other potential potable and non-potable water sources that have less social and environmental impact and should also be investigated.

One option is to develop on-site water production options along with a local third pipe distribution network. These local sources can be available year round in a combined design and may be viable options to supplement seasonal irrigation or wash down needs.

The site is well located to access sea water for desalination.

An alternative to desalination is wastewater reuse. The Beenyup Ocean outfall is located to the south of the site. However there a number of challenges, firstly the quality and volumes are highly variable due to regular waste brine discharges from the Beenyup MAR/ desalinised water plant. Secondly, the Beenyup wastewater volumes may decrease in the future as more water is recycled for Perth's Groundwater Replenishment scheme. Finally, access would need to be negotiated with the Water Corporation to ensure that its ability to comply with licence discharge limits is not affected.

Another source of wastewater is the residential and commercial developments within Ocean Reef Marina. An on site wastewater reuse system treating water collected on-site could be established for the precinct to treat wastewater for local non-potable uses.

Idea 3 – Buildings as clouds

Rainwater harvesting is provides a high quality water resource. If considered during building design, this delivers a range of benefits.

Rainwater harvesting is commonly used throughout the world as a valuable source of water. In WA, it is less common as either a potable or non-potable supply due to the historically abundant supply of low cost groundwater, seasonality of rainfall during a short winter, concerns about water quality and the alternative option of managed aquifer recharge and recovery which is often more efficient than above ground rainwater tanks.

However as groundwater becomes scarce, and potable supplies increasingly turn to energy intensive desalinised seawater, opportunities for rainwater tanks begin to emerge.

At Ocean Reef Marina, non -potable water uses within the building can be met by roof water. First flush systems can intercept poor quality (salty) rainwater and the remaining rainwater can be directed into rainwater tanks before it is used for toilets, laundry, irrigation and potentially other uses. Pumping costs can be reduced if tanks can be located in multi-storey buildings or on the higher, eastern side of the development to harness gravity for street scale irrigation.

During high rainfall periods, overflow (including purge capability via internet connected tanks) can be directed to the marina to maintain water quality and flushing.

The best way to include rainwater tanks at Ocean Reef is within building connections in the Ocean Reef Design Guidelines.

Rainwater to hotwater, and more

This photo shows a test set up of the rainwater harvesting systems in use at Aquaerevo, Victoria.

Rainwater is now a major component of the water supplies for Villawood Properties' new estate at Aquarevo. The utility, South East Water, manages the system shown above, which harvests rainwater for reuse through each house's hot water system. In combination with estate-wide water recycling sourced from a local water recycling facility, potable water use is reduced by 70% compared to similar houses. Peak stormwater runoff is also reduced (by 25%) by remotely emptying tanks before storms.

Source – CRCWSC, 2017, Aquarevo- A smart model for residential development, September 2017

Wollert waste to energy facility

Yarra Valley Water, one of Melbourne's three major water utilities, has been operating its first local waste to energy plant since 2017. The facility processes commercial food waste, turning it into renewable energy to power, adjacent to the Aurora sewage treatment plant. The waste to energy process generates enough energy to power both the facility and the sewage treatment plant. Excess energy is exported to the electricity grid. Waste producers, such as markets or food manufacturers, deliver 33,000 tonnes of commercial food waste to the Wollert facility each year, diverting this waste from landfill.

Source- Yarra Valley Water
http://wastemanagementreview.com.au/yarra-valley-water-future-proofing-melbourne/

Picture source -
http://wastemanagementreview.com.au/yarra-valley-water-future-proofing-melbourne/

Idea 4 – Energy from waste, on site

Future energy generation through waste to energy wastewater treatment capability.

Previously discussed in Idea #2, was the potential for wastewater from residential and or commercial developments to be recycled via an on-site wastewater treatment facility. This could be designed so that it could easily be augmented at a later date to include waste to energy capability. This could involve allocation of a footprint for the additional plant as well as design of the wastewater treatment process with future energy recovery in mind.

Designing any local scale wastewater treatment plant with future augmentation and functionality in mind supports technological advancements and changed political, social , economic or environmental drivers such as reducing rainfall and energy policy.

Another source of inputs is the food waste and boat pump out waste from the precinct. Centralised collection of wastes from food and boat pump out could be used to generate biogas using a small-scale anaerobic digestion plant.

These sustainability credentials could become a point of difference for boat owners choosing a marina in the future.

As this is a future option to be retrofitted later, the location of such facilities should be considered now.

Idea 5 – Cooling the hardstand

Minimise heat from large areas of hardstand.

Located in the southern portion of the site is the boat trailer park, car park and boat ramps. This area of hardstand is likely to be a significant heat sink and will impact on the adjacent public open space.

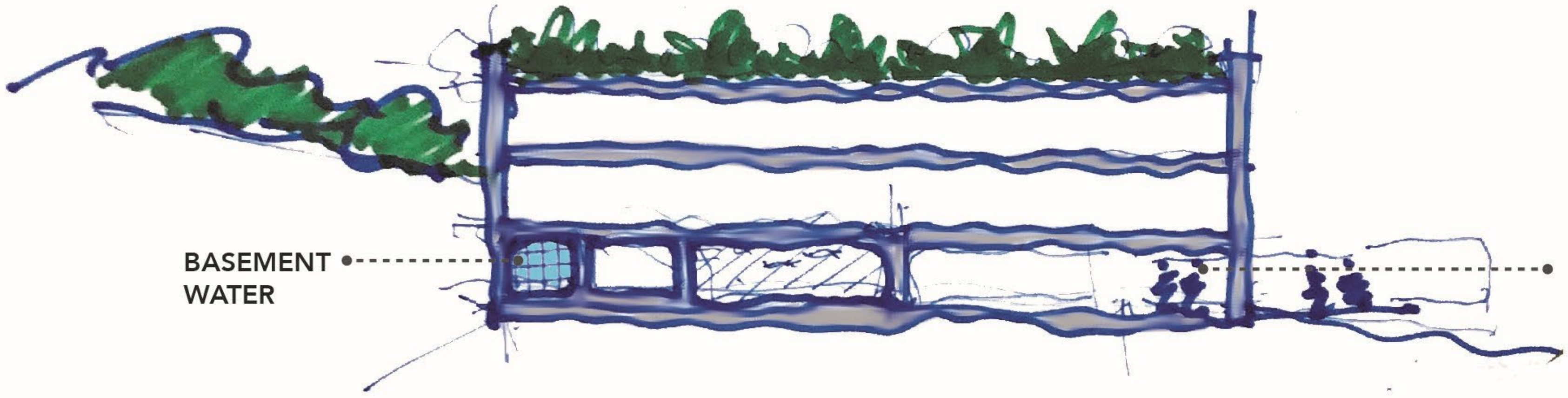
Heat radiated from this area will be distributed throughout the Ocean Reef Marina by southerly breezes impacting on the amenity and cooling costs of restaurants and commercial users, residents and visitors. A strategy to reduce major hot spots will focus on cooling the hardstand area and roads through the use of shade and green infrastructure.

Shade is important in and around the boat trailer and carpark in the southern portion of the site. Shade can be provided through trees or shade sails or other forms of shielding. For example a photovoltaic array can be used to provide shading and solar energy collection.

Providing green infrastructure has the advantage of both creating shade (in the case of trees) as well as a cooling microclimate created when water evapotranspires through leaves (if it is irrigated).

In addition there may be opportunities for mitigating heat off of hardstand through the type and reflectance of materials selected. For example white has a high albedo and will reduce temperatures but needs to be moderated so that it isn't too bright for users. Materials such as permeable paving will also facilitate water infiltration to further aid cooling.

Idea 6 – Adaptable parking that becomes future green space



The total area of green space can grow over time.

The amount of parking required today may not be indicative of the amount required in the future. Autonomous vehicles and the sharing economy have the potential to transform car ownership resulting in reduced demand for car parking in the precinct. However the impacts of population growth and demand for marina facilities may counterbalance this. The result is that future parking demand is unpredictable and any parking design should be adaptable to long term changes due to global trends

Demand for car and trailer parking is also likely to be highly seasonal with peaks occurring on public holidays, events and when the weather is good. However, the sharing economy may deliver opportunities to balance the peaks through more efficient scheduling of boat launching and ridesharing for not just people but boats!

Thinking of the longer term, a road and parking strategy could allow for reduced parking demand through future conversion of car parking spaces into other land uses including green areas or water/energy harvesting and storage. In this strategy, potential alternative uses of existing car parking areas are considered early and future adaptability is incorporated into their design to ensure such spaces are quickly and easily consolidated or re-purposed when opportunity arises. This includes consideration of roads, car parking and intra-development transport options by considering how car parking could adapt over time if demand changes.

Idea 7 – Innovation precinct

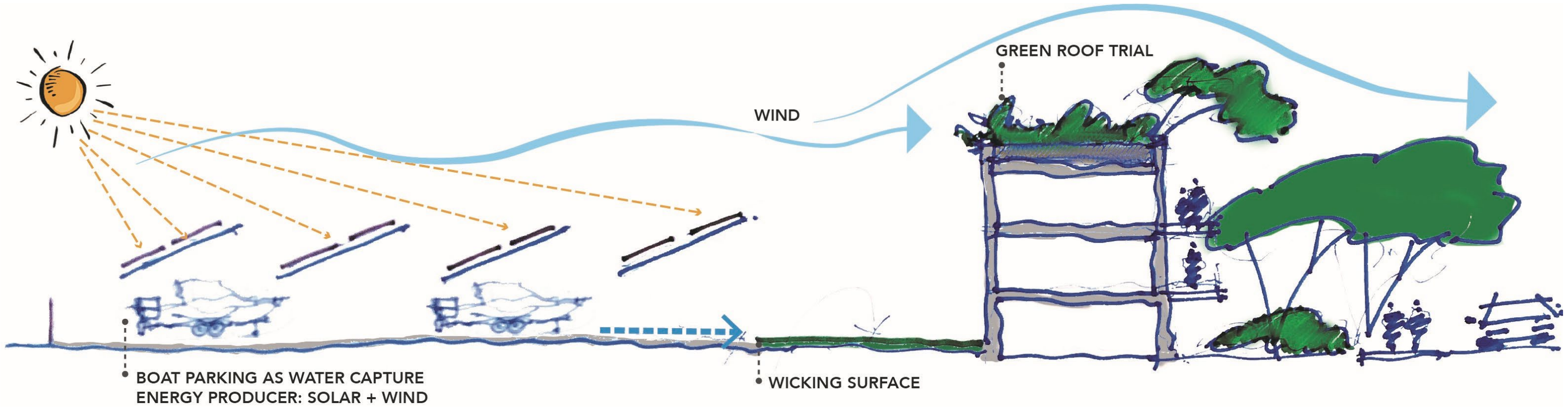
Boat trailer hardstand as the site of Ocean Reef Marina's water factory, battery and other innovations.

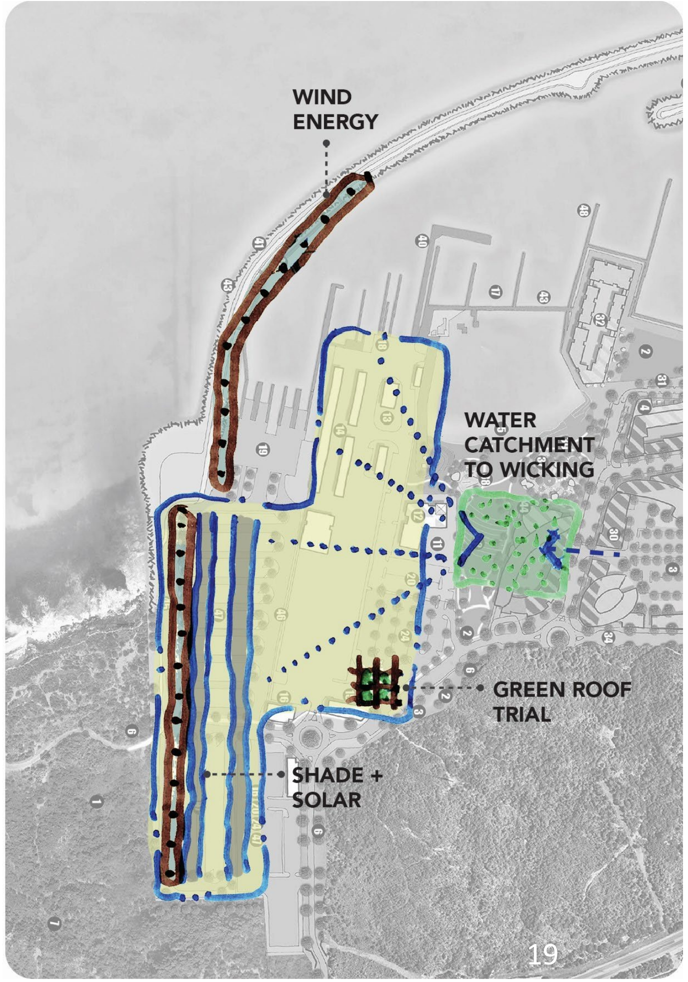
The southern hardstand provides an area to focus innovation in a practical and cost effective way. It can be a source of both water and energy.

As an innovation precinct it may feature the co-location of a photovoltaic array, designing this solar array to provide contiguous shade as discussed in idea #5.

In addition, this area can use water sensitive urban design to harvest and treat stormwater, below ground water storage, an on-site waste water treatment plant/battery. For example stormwater runoff can be directed underground to storage either underneath the hardstand or alternatively directed into underground storage underneath the public open space. Storage underneath the public open space can be combined with idea #11 (wicking beds).

The use of this area is highly seasonal and could support 'pop-up' community uses outside of peak parking periods, including the winter months and weekdays.





Idea 8 – Climate sensitive building design

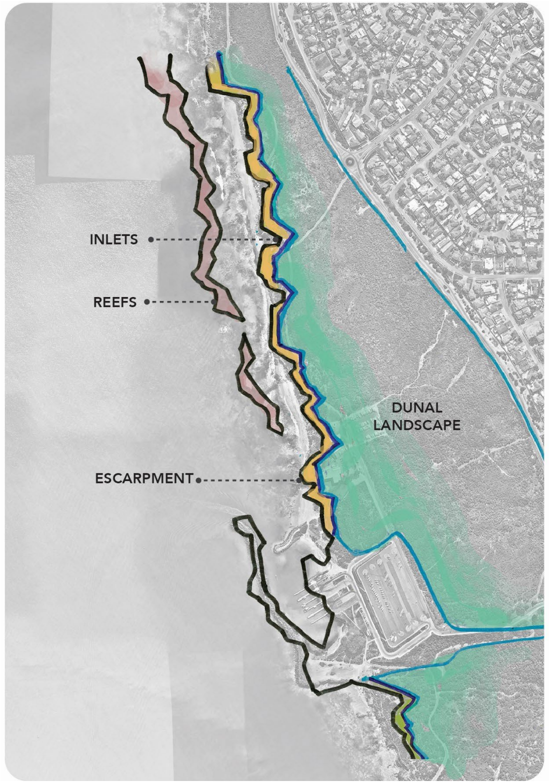
Using building orientation to provide shelter from winds and to create green refuge areas

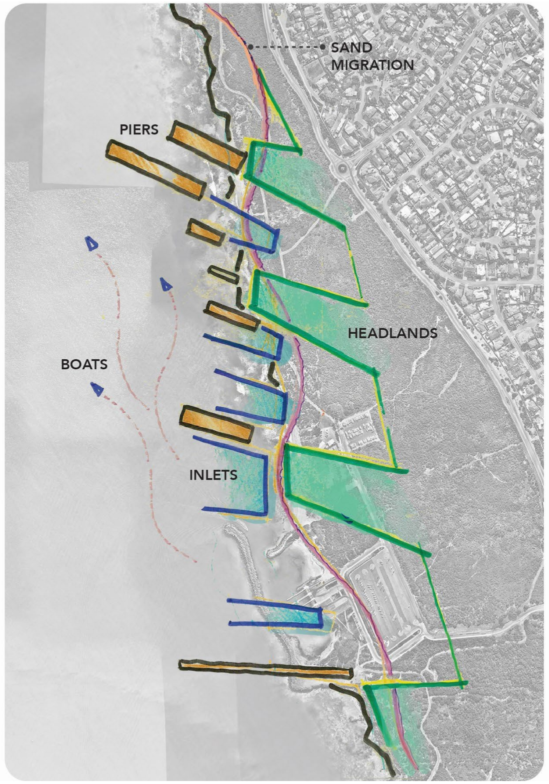
Building orientation and use of plantings are essential parts of climate sensitive design.

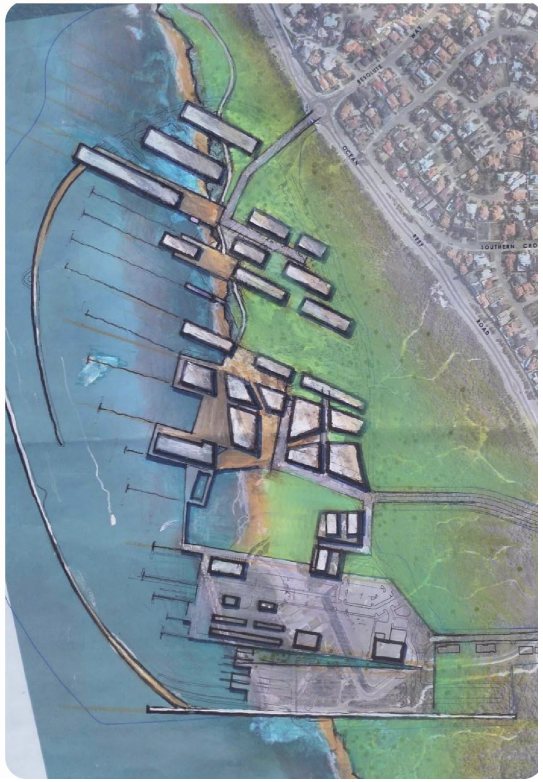
Boat pens have already been re-oriented to accommodate the south westerly winds to make it easier and safer to moor.

This principle can be extended to the orientation of larger buildings to create pleasing microclimates and water views. Doing so creates wind and sun refuge areas behind the buildings, supporting the growth of a wider palette of tree species, encouraging outdoor recreation in the windy afternoons and connecting to the north–south green corridor road.

Placement and species selection of green infrastructure should also be cognisant of building alignment. Green walls on south west corners/walls of buildings will provide shading and protection for building walls that are directly exposed to the hot sun. These green walls can be supported by the use of dunal species and passive or active watering to ensure they function as intended through the year.







Idea 9 – Mimic the dunal landscape on the built form

Using dune landscape inspired green roofs to improve the energy efficiency of buildings.

The dunes are a no-water environment and can be used as a template for green roofs, green walls or other plantings through the development.

Larger roof areas can adopt these ecosystem principles in the design of green roofs. In addition to blending with the coastal landscape, the soil and plant system of a green roof may provide insulation properties to reduce in-building temperatures. Further design and investigation is required to provide proof of concept of this novel idea. Further investigation could also be undertaken to evaluate the relative benefits of prioritising these larger roofs for rainwater capture or green roofs.

Green walls can use dunal vegetation or alternatively be passively watered by greywater from the buildings or rainwater tanks.

Dunal vegetation can also be used elsewhere in the development to provide an ecological link with the surrounding Bush Forever site.

Existing retaining walls are a no-water environment but sustain vegetation

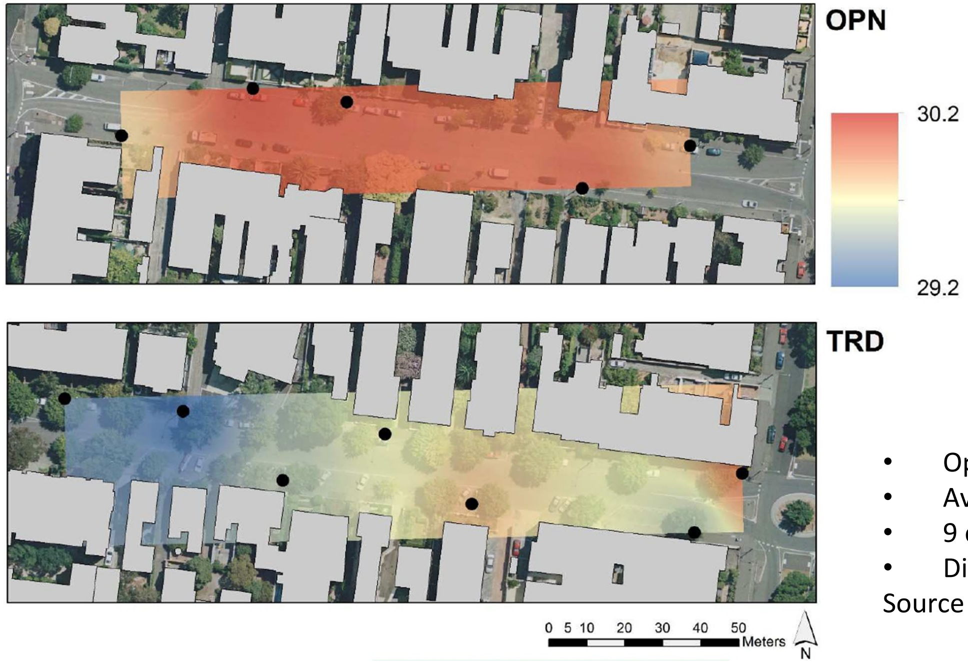
Idea 10 – East-west green corridors

Street swales can create green streets along an east –west alignment.

The site may be accessed by local residents on foot via pedestrian access paths. As these trails enter the development they will follow the road alignment towards the ocean. Greening these access corridors will provide amenity and temperature relief to both residents and local visitors as well as opportunities for stormwater management.

Preference should be given to vegetation designs that mimic the surrounding dunal landscape. But in recognition that more substantial tree canopy is required in an urban setting, passive tree watering designs and at-surface stormwater conveyance systems can also be used to direct storm runoff to swales and trees, enhancing tree health and canopy size for shade. This provides amenity and reduces the amount of water required to establish and maintain plantings.

East-west swales have the additional advantage of intercepting stormwater and promoting the uptake of nutrients hence improving water quality before it discharges into the marina.



Street tree cooling

A range of urban greening options are available including trees, green open space, green roofs and green walls. Trees are especially effective for urban cooling for several reasons. Trees provide cooling through both transpiration and shade. Shade in particular is critical for improved human thermal comfort during warm sunny conditions. Green open space and green roofs will not provide shade for pedestrians unless trees are included. Green walls and facades can provide shade if grown over artificial structures. Trees are an effective solution for several reasons. A vast range of tree species enables the selection of trees that best fit with the climate and environment of the location (e.g. soil type, water availability, light availability, etc).

Trees provide multiple benefits in addition to urban cooling, including reduced stormwater runoff volumes, air quality benefits (depending on tree species selection), carbon uptake and storage, habitat and building and neighbourhood energy savings. Trees can also provide amenity benefits. Finally, people have a greater connection with trees than with other types of urban vegetation such as green roofs.

Adapted from Coutts, A and Tapper. N. (2017). Trees for a Cool City: Guidelines for optimised tree placement. Melbourne Australia: Cooperative Research Centre for Water Sensitive Cities.

- Open (OPN) street versus a tree lined (TRD) street
- Average daytime air temperature
- 9 consecutive days exceeding 32oC
- Difference of up to 3.1^{o}C among the seven stations in TRD

Source - Coutts et al (2015)

Idea 11– Greening by wicking

Passively irrigated open space using wicking bed technology.

Both private and public open space can be irrigated using wicking bed approaches. These systems create an artificial groundwater aquifer which is recharged from the chosen water source. Using capillary rise, water is drawn up to the root zone of the turf and gardens above. Such systems have been successfully applied in other Australian contexts. The super park in the southern precinct is particularly suited to this approach using runoff from the adjacent hard stand area, if the park itself can be terraced to create a series of level surfaces to support the artificial aquifer layers.

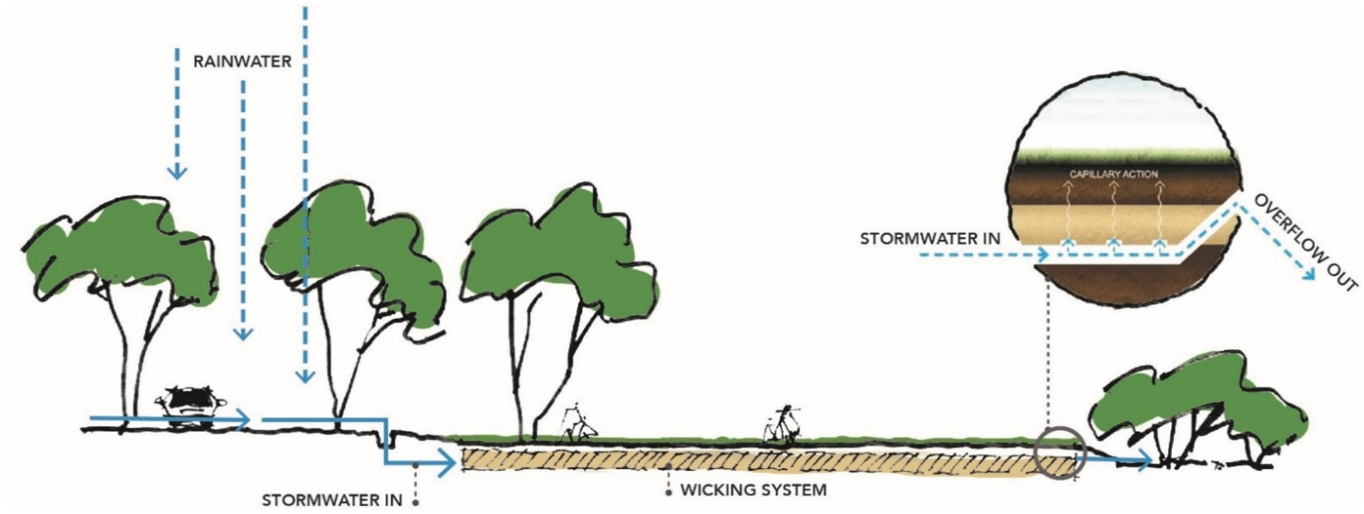
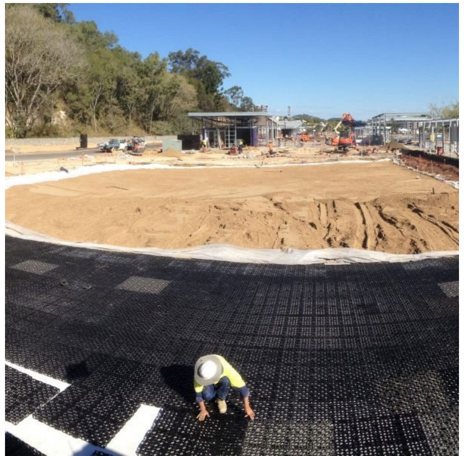


Diagram adapted from E2DesignLab



Gladstone wicking bed sports oval
Source: E2Designlab

An action plan

Do Now

- Quick wins
- No-regrets first steps
- Time critical actions

Do Next

More work required:

- What evaluation is needed?
- Who should be engaged?
- What data is needed?

Do Later

- What are the uncertainties – and an action plan to address these?
- Who will be the champion?
- What does success look like?

The ideas were developed along with a phased action plan. This recognises that some innovations will need a longer time frame to fully develop and engage stakeholders, yet the pathway towards this outcome can begin immediately with quick, tangible steps.

Examples of **Do Now** actions: Pre-feasibility studies to establish the technical feasibility and concept design of key action, such as wicking bed irrigation.

Examples of **Do Next** actions: Detailed design, business cases, regulatory approvals and governance arrangements for priority ideas. Some ideas can be incorporated into Design Guidelines at this stage.

Examples of **Do Later** actions: Addressing key knowledge gaps that are a barrier to some actions, or retaining options that will only be activated if the initially preferred solutions prove unviable.

Specific actions are outlined in the following pages.

Do now

1. Design
1.1 Innovation precinct masterplan
1.2 Sizing and design of a below ground water storage(s)
1.3 Pier/mooring water supply and wastewater collection infrastructure.
1.4 Design eastern (rear of building) open spaces as afternoon refuge parks.
1.5 Design southern hardstand area

2. Build
2.1 Install trees and ground mounding civil works to establish wind breaks for the site.

3. Develop guidelines
3.1 Adaptable car parking spaces.
3.2 Include mandatory water cycle items in the Improvement Scheme and Design Guidelines (such as on lot rainwater tanks and mandated uses).

4. Pre-feasibility assessments
4.1 Model wind to inform building orientation, public realm greening, park location and urban heat 'hot spots'.
4.2 Confirm the site geology and stormwater infiltration potential to derive the WSUD potential of the site and stormwater design response
4.3 Finalise site water demands including the required qualities and seasonal profiles.
4.4 Continue discussions about groundwater allocations.
4.5 Investigate the potential cost offsets from Water Corporation fixed water and sewer charges if demands on these systems can be reduced or avoided.
4.6 Develop a business case for alternative/on site water supplies and wastewater treatment.

5. Communication
5.1 Develop the story about water at ORM and how it moves across the site.
5.2 Brand and promote the precinct. Test stakeholder receptivity

6. Form partnerships
6.1 Engage Department of Transport as a collaborator.
6.2 Engage the Water Corporation regarding the potential for local desalination brine or wastewater disposal via Beenyup outfall, and business case for precinct scale recycling with third pipe network.

7. Establish on-going pilots
7.1 Wicking bed systems
7.2 Green roof

8. Governance
8.1 Establish a decision making framework for longer term adaptability of infrastructure, including principles to inform individual design guidelines and infrastructure decision points.
8.2 Determination on special rates for the development landscape and public realm WSUD management and maintenance. Collate examples of this being used in other developments.

Do next

1. Design
1.1 Solar farm concept design
1.2 Detailed stormwater (WSUD) strategy for the site
1.3 Detailed design for green infrastructure, wicking bed
1.4 Design final water infrastructure based on final water source portfolio
1.5 Design of an artificial superficial aquifer storage – volume, injection wells, extraction points, surface uses and maintenance
1.6 Design of green roof and walls based on pilot outcomes.

2. Develop guidelines
2.1 Greening guidelines completed
2.2 Concept design for key sites and inclusion in design guidelines

3. Pre-feasibility assessments
3.1 Explore funding and ownership models

4. Governance
4.1 Governance structure in operation
4.2 Brief for an integrated service provider developed.
4.3 Contracts and partnership models in place based on pre-feasibility studies
4.4 Business case for alternate water source options:

- Economic benefits
- Financial arrangements
- Governance
- Environment impacts and benefits

4.5 Decision point for third pipe scheme. If connection to public open space only- council asset; if connected to buildings and internal uses – needs a third party service provider.

Do Later

1. Design
1.1 Concept design of an on-site water manufacturing option, including waste to energy options.

2. Build
2.1 Impact to staging determined and resolved.

3. Pre-feasibility assessments
3.1 Long term adaptation strategy for car parking developed – which roads, car parks can be transformed? What will they become?

4. Communication
4.1 Develop integrated apps for residents providing information on water uses, energy use, climate.

5. Governance
5.1 Ownership models for precinct scale water and energy assets resolved
5.2 Business and operating model for integrated services resolved, covering – smart city tech, whole of precinct water, waste, energy, sewer.

Appendix – Workshop questions developed by participants

Initial workshop aims	Site observations	Revised workshop questions
Alternative water supply for POS irrigation and boat wash-down	• ORM is water rich – of different qualities and availability. • ORM has unique water demands that can be matched with supplies.	• What are the different sources at ORM and what role can they play? • What will the partnerships look like to secure these water sources? • How do we store large volumes of non-potable water for reuse? • How can we capture the community story of the site's hydrology?
Stormwater management to minimise environmental impacts	• The environmental impact is specific to marina flushing. • Roof water can be a resource.	
Using blue and green to create a pleasing microclimate	ORM has taken a natural environment, made it hotter and added people.	• How can we mitigate the heat island effect in the southern precinct? • How can we use the built form to mitigate heat islands?
	ORM can be 'iconic and world class' by using its context to stand out.	• What makes it Ocean Reef? (to merge the dune, urban and coastal landscape). • What would it look like if we 'reverse engineered' Ocean Reef to make water the focus of urban planning? • How can we use the built form to enable water wise outcomes? • How can we create a community that is resilient and internally self sufficient?
Technology opportunities for sustainability	Integration opportunities: • Heat+roads (Traffic) • Hardstand+runoff (Traffic) • Water + energy (Energy) • IoT + irrigation (smart cities)	• How do we generate energy (to transport and treat non-potable water for reuse)?
	• Implementation, business models are part of the solution	• How can we attract private enterprise to fund public amenity? • How can staging help implement opportunities (or avoid creating problems for water, heat?)