CRCWSC Research Synthesis

Discussion Paper | CRC for Water Sensitive Cities

IDEAS FOR BRABHAM

CRC for Water Sensitive Cities

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Ideas for Brabham

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Ideas for Brabham

This discussion paper compiles ideas generated at a workshop hosted by Peet, The Department of Communities and the CRC for Water Sensitive Cities (CRCWSC) on 13 and 14 June 2018. These ideas focus on the Brabham development project in the north east urban growth corridor in Perth (Figure 1). This development can provide a practical example of Perth's commitment to become Australia's most water sensitive city, and this discussion paper outlines on-ground initiatives to realise this outcome. More specifically, this discussion paper address the need for more innovative development approaches that combine water management and urban design to create sustainable and liveable communities in locations challenged by high groundwater tables.

Whilst the ideas were generated by researchers, experts from the water and development industries and other stakeholders, the workshop outcomes do not represent an endorsement by their respective organisations.

About the workshop

The workshop created a forum for collaboration and research translation, with a specific focus on the Brabham development. It brought together the research of the CRCWSC with the experience of Perth's water and development industry to apply this knowledge to the context of urban development in high groundwater areas. The workshop approach included:

- Visiting the site to appreciate the 'as-is' context, and hearing from the key development partners about their drivers, aspirations and challenges for the project.
- Inviting research and practice experts to share current water sensitive city research findings, developments and thinking.
- Using group work and collaboration to interpret these insights and generate novel, alternative ideas for water management and urban design for Brabham.
- Developing these ideas further into tangible ideas for the development project. These propositions are practical and evidence based, and are intended to challenge conventional practice.

Site Location

Legend

Brabham

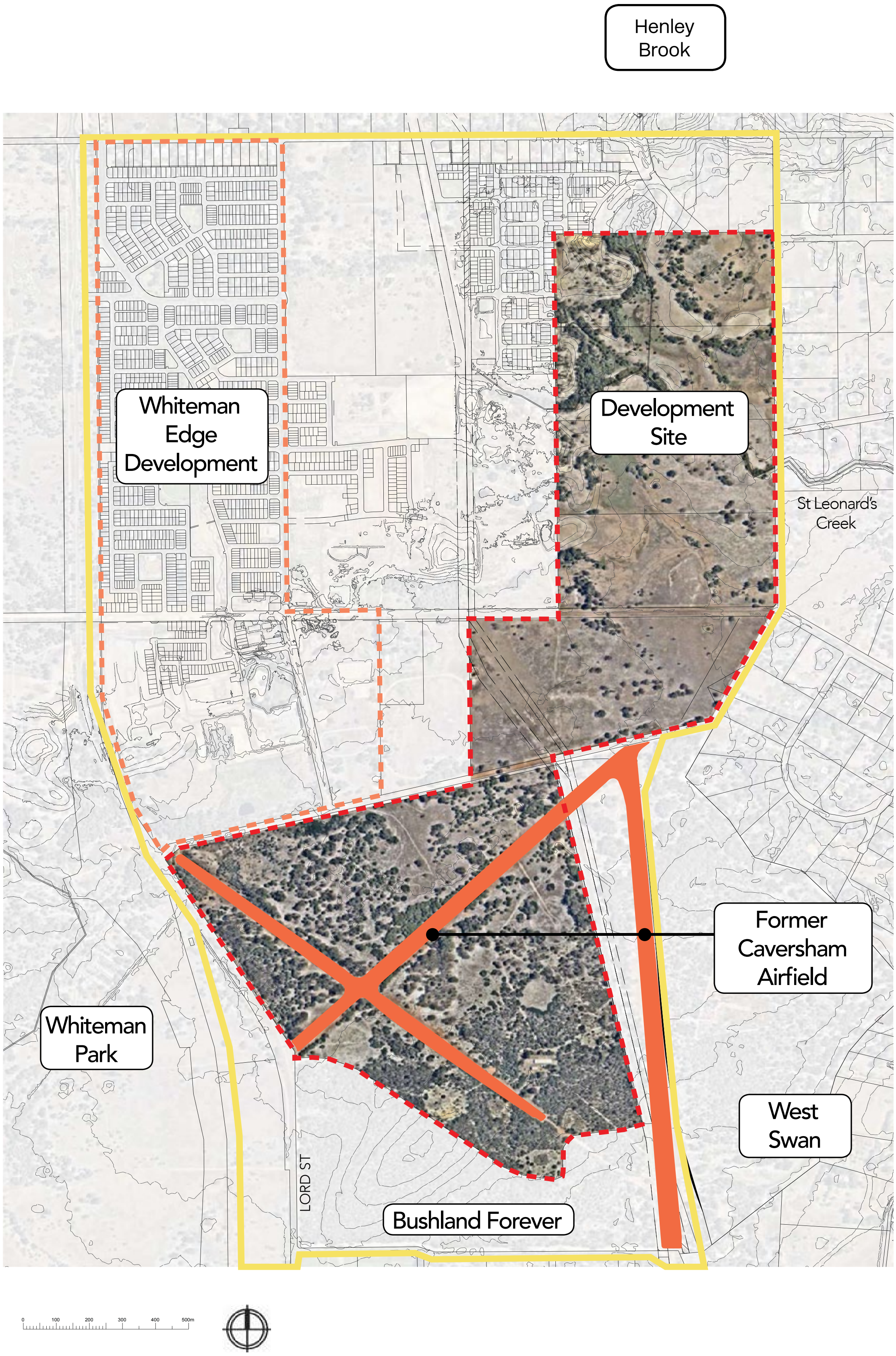

Figure 1 – Brabham aerial (picture credit – Realm Studios)

Context

About Brabham

The Brabham development is located within the City of Swan on the planned METRONET Morley-Ellenbrook rail line, approximately 23 km from Perth's central business district. When completed, it will provide sustainable and affordable housing in Perth's north-east corridor and will be a major transit-oriented development linking the Swan Valley to Perth. The development will provide more than 3,000 dwellings, schools, neighbourhood shops and recreational areas and its population will include young families and groups of older people.

Key site features include the former Caversham airfield and an historic motor car racing track that was used for the 1957 and 1962 Australian Grand Prix. The southern boundary of the site adjoins a Bush Forever site that protects native vegetation, and St Leonards Creek flows through the northern portion of the site. Site drainage also connects to Horse Swamp, an 18.7 ha natural wetland located within Whiteman Park downstream of the development.

The water need at Brabham

Higher density greenfield developments rely on the amenity created by public open space. This in turn requires a reliable and affordable water supply. The City of Swan estimates that an additional 115 – 130 ML/y of water is needed for public open space irrigation in Brabham alone.

Water availability

Traditionally, irrigation is supplied from groundwater, however the South Swan groundwater sub area has a projected shortfall of 1,600,000 KL per year by 2040. The implication is that new licences will not be issued, and existing allocations may be reduced in the future to reach more sustainable allocation levels. As a result, an additional 4.3 GL/y of non-potable water is needed regionally by 2040 for agriculture and open space irrigation.

High groundwater tables

Some sections of the development site have high groundwater levels that cause water-logging in the winter months. Figure 2 shows the depth to groundwater, ranging from areas greater than 1.5 m depth to groundwater to areas where groundwater is at 0 m. In a wet year, many parts of the site will experience ponding of water on the surface and to manage high groundwater tables in these situations, fill is imported. For Brabham up to 4m of fill is required in some areas, with a total estimated volume of 2,500,000 m^3 across the site.

By the numbers

Area	Area of public open space	Number of Lots	Number of dwellings	Expected population
220Ha	at least 22 ha	2,600	3,300	12,300

Key stakeholders

Brabham must deliver specific outcomes for three key organisations, as well as meeting the needs of the community that will ultimately live there.

Department of Communities

The Department is the landowner and project partner in the development of Brabham. The Department has a mandate to create sustainable communities in Perth. It uses its roles as a significant landholder and developer to design and create more resilient communities that minimise the need for future government intervention and to ensure that sustainable living is affordable.

Peet

Peet is a developer with a long history and large presence in Perth. It has been appointed as the Department's development partner to deliver Brabham and wants to use the opportunity to drive innovation in the development sector. As Development Manager, Peet is responsible for the planning, design and implementation of the Brabham development. Perron Group is also involved as a project partner.

City of Swan

The City of Swan provides local government services across the municipality and will ultimately become the owner of many of the assets and public open spaces in Brabham. The City of Swan is also the local authority responsible for approval of the subdivision plan, including the Local Water Management Strategy. In delivering these roles, the City has a vision for a liveable urban development that provides communities with useable and attractive public open space, schools and other services. However, Council recognises it can't implement these solutions on its own and is seeking to build partnerships with other agencies and the developer.

Other stakeholders

Other stakeholders include Water Corporation, the Department of Biodiversity, Conservation and Attractions, the Department of Planning, Lands and Heritage, the Department of Water and Environmental Regulation and adjacent developers.

Insights

1. There is a shared agenda for innovation, and project level partnerships are already in place to facilitate this outcome.

2. The site has a distinctive wetland characteristic, with areas that are permanently or seasonally wet during the year. This provides a unique natural character for the site.

3. Depth to groundwater ranges from 0 m in the west to greater than 1.5 m to the south-east (figure 2). This creates opportunities for different urban design, built form and architectural styles that respond to different groundwater levels.

4. The historic runways follow the groundwater-surface water gradient. Both the runways and the groundwater gradient are distinctive site features.

5. Urbanisation removes vegetation that would otherwise control the water table through evapotranspiration. This means that:

    a. The natural hydrology provides a template for managing the post-development water cycle.

    b. Removing this additional groundwater recharge can replicate the effect of evapotranspiration: it returns groundwater closer to this natural hydrology.

    c. Harvesting this water potentially creates a significant new water source without impact on stressed regional groundwater resources.

6. The import of fill to manage high groundwater tables represents the single largest development cost as well as having environmental impacts, particularly the loss of vegetation onsite where fill is placed. Avoiding these costs and impacts is a driver for innovation.

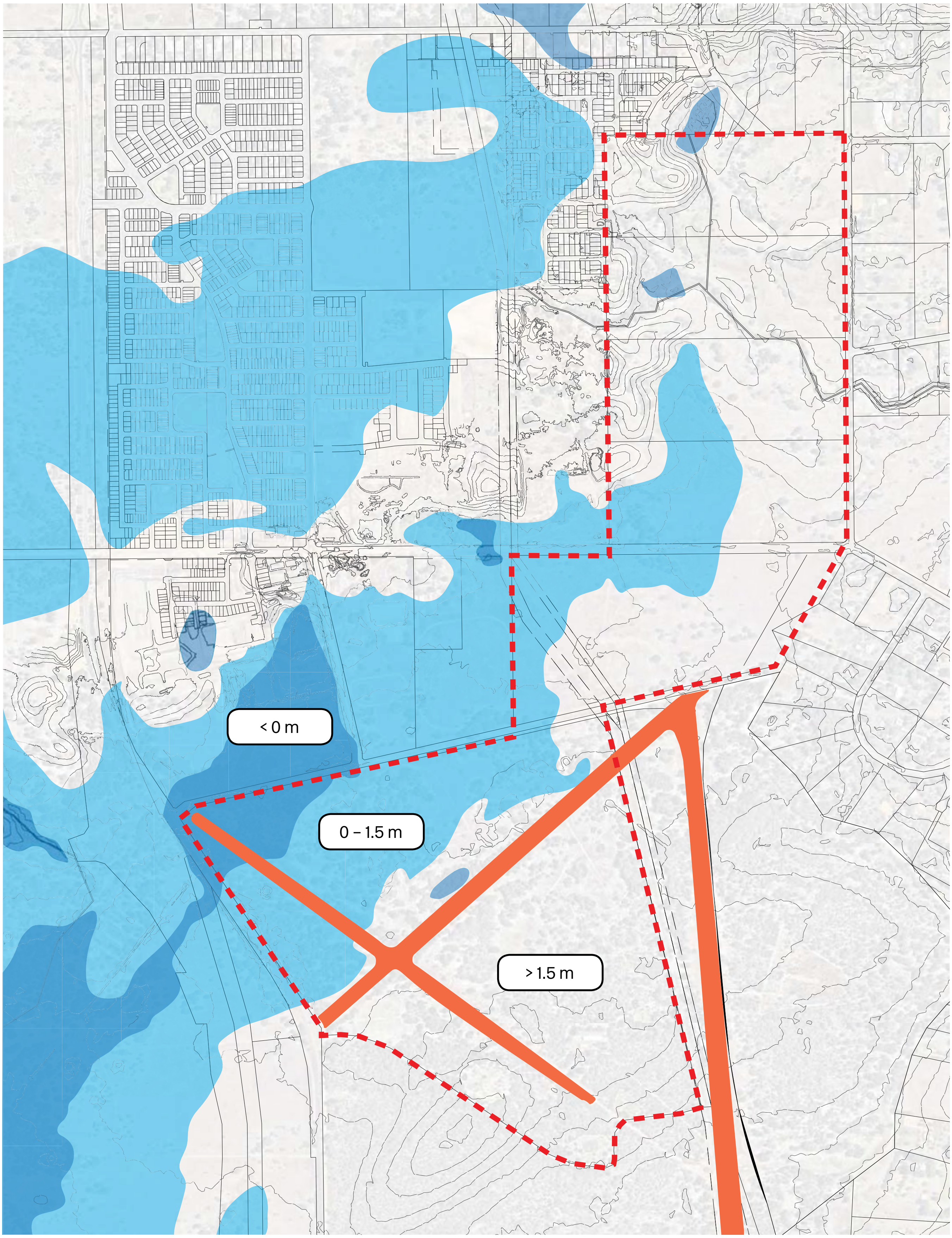

Figure 2 – Depth to groundwater (picture credit – Realm Studios)

Building on research and precedents

Research highlights new ways to view water management and urban design challenges, and precedents show how these innovative approaches have been used elsewhere.

Lightweight design - Timbertown (Sweden)

An architectural design by CF Møller illustrates the concept of integrating nature into the urban landscape using lightweight construction approaches. This design was created in response to a design competition held by the Swedish Municipality of Orebro. CF Møller's winning design explicitly creates an interaction between the city's urban and social qualities and its organic and wilderness character. At a site level, it links existing promenade sections of the site along Svartan Creek and a public park, to create a connection between the urbanised city and the adjacent 'natural wilderness'. At a building level, it includes apartment buildings of varying heights making extensive use of solid timber frames and timber facades, with this material specifically chosen for the unique architectural forms and sustainability outcomes that it allows.

Figure 3 - CF Møller design for lightweight, wooden apartments at Timber Town, Sweden (Credit - C.F. Møller)

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Further reading: https://www.cfmoller.com/r/ORNSRO-TIMBER-TOWN-C-F-MOeLLER-WINS-COMPETITION-IN-OREBRO-i16601.html

The effect of urbanisation on recharge

Research demonstrates that urban development in the Swan Coastal Plain causes local groundwater levels to rise. Mounding occurs between subsurface drains (Figure 4) and levels between 0.5-0.9 m have been measured in nearby developments (Table 1). This occurs because the process of urban development increases groundwater recharge. When green-field sites with high groundwater are developed, a number of things happen to the groundwater table. Firstly, the removal of vegetation leads to less evapotranspiration. The water volume that was previously evapotranspired instead becomes groundwater recharge or surface runoff. Secondly, the increase in impervious areas such as roofs and roads directs this water to infiltration areas such as soak-wells and bioretention basins that concentrate the recharge to the water table. Increasing this effect is the below ground network of flow pathways that comprise the pipes, drains and service conduits installed in the urban environment. In combination, these pathways allow stormwater to travel faster towards waterways and groundwater systems than it would naturally through the pre-development soil profile. In the low-lying land of the Swan Coastal Plain, this results in groundwater tables rising post-development.

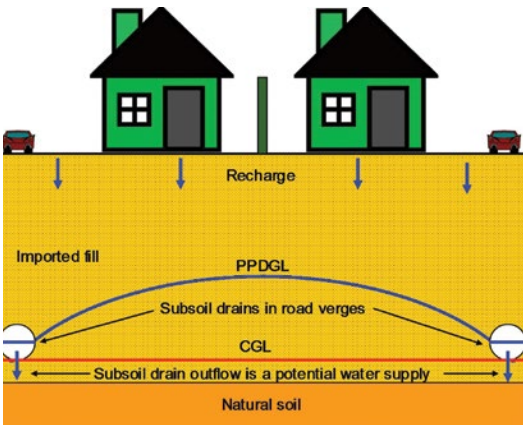

Figure 4 - The extent of mounding is influenced by the depth and distance between subsurface drains, and this in turn determines the volume of fill required for an urban development. (Pitcuire credit – Davis et al, 2016)

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This increase in water volume beyond pre-development represents a change in the natural hydrologic cycle and possibly a threat to natural waterways. Wong et al (2013) reports that substantial research from around the world shows that once streams receive stormwater runoff from impervious areas making up more than a few percent of the overall catchment, the stream ecosystem will be significantly degraded.

Water sensitive urban design can then be used to return local hydrology to more natural conditions. A complimentary management response is to quantify the volume of 'additional recharge' and to mimic the evapotranspiration effect by harvesting this volume for reuse, assuming the water quality is suitable. An indication of the potential harvest volumes is illustrated in Table 1 based on monitoring at two nearby developments (note that rainfall was 6-13% lower than average).

References:

Davies, C.G., Vogwill, R. and Oldham, C., 2016, Urban Subsurface drainage as an alternative water source in a drying climate, Australasian Journal of Water Resources, 20:2, 148-159.

Wong, T.H.F., Allen, R., Brown, R.R., Deletic, A, Gangadharan, L., Gernjak, W., Jakob, C., Johnstone, P., Reeder, M., Tapper, N., Vietz, G., and Walsh, C.J, 2013, blueprint2013- Stormwater management in a Water Sensitive City. Melbourne, Australian: CRC for Water Sensitive Cities.

Table 1 – Examples of the harvesting potential of 'excess water' created by urbanisation in the Swan Coastal Plain (source – Davies et al 2016)

Development	Catchment area	Subsurface drains design	Volume available	Water quality
Whiteman Edge	60 ha	Drains lower than AAMGL*	740,000 KL over 2 years	[Nutrients] lower than pre development (40-80% [N] reduction; 95% [P] reduction) Treatment for Fe and visible floc prior to direct irrigation.
Rivergums	14 ha	Drains at AAMGL*	310,000 KL in 17 months	

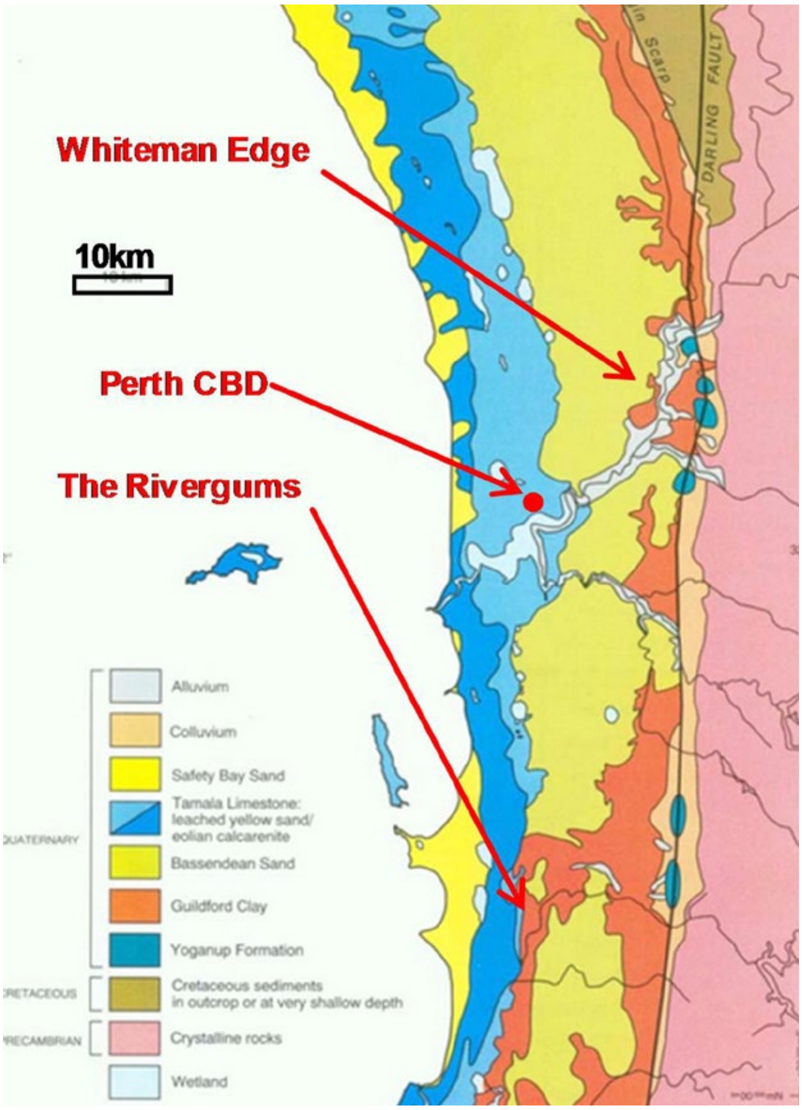

Figure 5 - The location of Whiteman Edge and Rivergums (Credit – Davis et al 2016)

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*AAMGL stands for Annual Average Maximum Groundwater Level, and represents the height of the watertable

Aquarevo – using smart systems to provide water services

Aquarevo is a 42 ha urban development in the south east of Melbourne. The site is being developed by South East Water as the land-holder, together with Villawood Properties as the developer.

Innovative water servicing is a key feature of the development, enabling it to achieve a 70% reduction in potable water use compared with a comparable development. It achieves this by making use of wastewater and rainwater that occurs on site as a substitute for potable water. To harvest these resources, South East Water owns and manages water harvesting assets at the lot and precinct scale – including an on-site water recycling plant and rainwater tanks on each house that form a 'micro water grid' for the development.

Controlling these assets, as well as on-site pressure sewer technology, is an innovative "One Box" technology. One Box provides real time monitoring data to South East Water and allows remote control of the on-lot water and energy systems at Aquarevo, including:

- Rainwater storage (level monitoring, flushing value control, pump control, rainwater change over).
- Flow monitoring (drinking water, recycled water, rainwater).
- Pressure sewer (pump control, level monitoring)
- Hot water system (hot water temperature)
- Power and gas (solar generation monitoring, mains electricity monitoring, gas monitoring).

South East Water is also a pioneer in the use of pressure sewers. This approach is a feature at Aquarevo, but has proved itself in the Early Connection Option (ECO) sewer backlog project on Melbourne's Mornington Peninsula. This technology was chosen for ECO to reduce costs compared with a conventional gravity sewer approach – which faced a number of practicality hurdles along a long, narrow peninsula. Instead, South East Water used a system comprising a well with a submersible pump on each property, along with a small diameter local pressure sewer network to link properties to the regional trunk sewers. The One Box technology allows scheduling of sewer flows into the network to smooth out daily peaks and thus reduce the size of pipes required, and the pressure system enables shallow boring installation techniques.

References:

Morgan, C., 2017, Aquarevo – A smart model for residential water management, CRC Water Sensitive Cites, Melbourne, Australia.

http://betterconnected.com.au/

Figure 6 - One Box and Pressure sewer system at Aquarevo (picture reference – Morgan, C., 2017)

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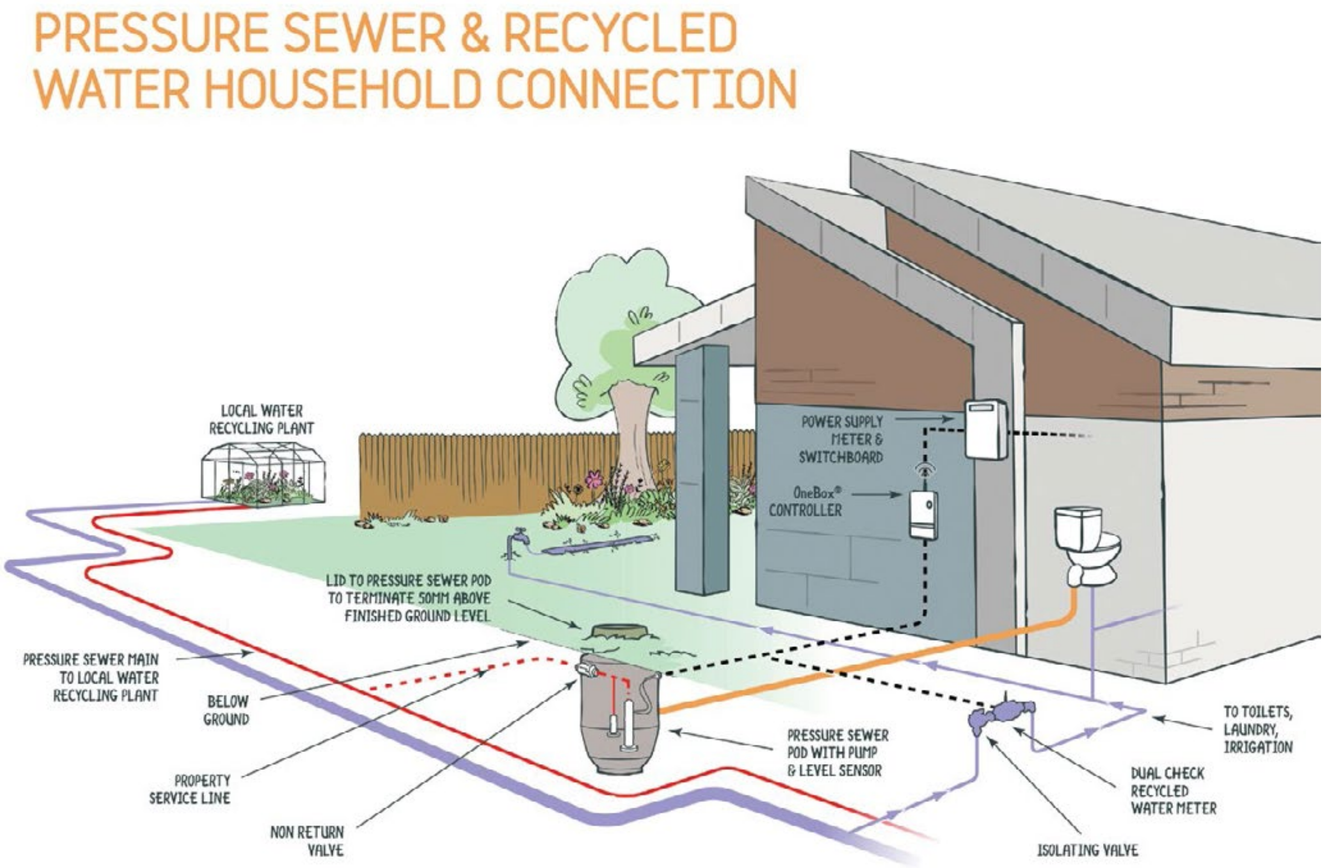


Understanding risks of non-potable water schemes

There are numerous examples of successful local, non-potable water schemes in Australia, but also a growing awareness of the risks to the success of these schemes. An investigation of 21 wastewater and/or stormwater reuse schemes finds that some systems are decommissioned before the end of their design life. The research also indicates that cost saving is not the driver for these schemes. Instead, these systems deliver sustainable development objectives, improve water supply security by diversifying water sources, and reduce discharges to the natural environment (in systems that reuse wastewater). Of the 21 schemes reviewed, the majority (15) were successfully implemented; three were delayed during commissioning; and a further 3 were prematurely decommissioned. For those that were delayed or decommissioned, an analysis of causes shows that current risk assessment focuses on the wrong areas – whilst there is a strong and understandable focus on matters such as public health, there are a range of broader risks associated with legal and contractual arrangements between scheme owners, unplanned operational costs, regulatory requirements and approval processes as well as challenges delivering on customers' expectations. It suggests that tighter management of these risks is achievable and will increase the viability of non-potable reuse schemes.

References:

West, C., Kenway, S., Hassall, M. and Yuan, Z., 2016, Why do residential recycled water scheme fails? A comprehensive review of risk factors, Water Research, 102, 271-281.

What does a water sensitive approach look like on the ground?

Manage groundwater levels sustainably

Brabham can provide a practical demonstration of several elements of a water sensitive city.

There is more than one way to manage high groundwater tables – lower the groundwater levels, raise the surface level or adapt the built form to higher water tables.

Sub-surface drainage is widely used across Australia in both agriculture and residential developments to lower groundwater tables. In new development areas, the clearing of vegetation increases infiltration and hence water tables, often exacerbating existing water-logging problems. A network of sub-surface drains can be used to lower groundwater tables by draining this excess water. Drainage can be placed at different elevations in the soil horizon depending on whether the intention is to harvest the “additional recharge” generated by the clearing of land or to maximise the separation between the surface and maximum groundwater levels.

Potential challenges with this approach lie in the disposal of groundwater to receiving environments, and the difference in timing between supply and demand when designing a reuse scheme.

In addition to the sub-surface drainage, fill is typically imported to a site to separate the groundwater table from the services and infrastructure. Up to 4 m of fill is required at Brabham. In addition to being a significant development cost, this fill covers remnant trees, waterways and natural features. The workshop sought to challenge the way that water services are designed, and to consider novel urban designs that respond to the high water table environment.

The addition of fill to residential lots provides two functions. Firstly, it increases the separation distance between groundwater levels with grey (such as foundations and buried services) and green (such as turf or gardens) infrastructure and facilitates the development of A class sites that can utilise a concrete slab. A class sites are seen as cost effective and are common across the Swan Coastal Plain. Secondly, increasing levels may be required to achieve the grade required for gravity sewerage systems. However, the placement of fill will destroy existing site vegetation. While there will always be movement of fill within the site boundaries, the ambitious goal of this development is to significantly reduce the requirement to import fill from outside the site.

A third option exists to significantly adapt the built form to fit the environment, rather than the other way around. One approach is lightweight construction that avoids the use of a concrete slab. Other adaptions include the use of green infrastructure that can survive continual inundation, and waterproofing of services or infrastructure. The success of this will be dependent on not only the technical feasibility but, significantly, public and industry acceptance of this type of development product.

Harvest 'excess water' created by the development

Understanding the water regimes and budget will make it possible to identify additional water created by the development and to reuse this for non-potable supply.

Understanding the pre- and post- development water balance creates opportunities to identify and target 'excess water' in the superficial aquifer to better approximate the pre-development hydrological balance.

Brabham as a water supply catchment

Minimising the use of Scheme water through alternative water sources and water use efficiency.

The concept of a 'city as its own water supply catchment' is a key principle of water sensitive cities. While the residential and irrigation demand will place additional load on scheme water and irrigation supplies, the site is also a potential producer of water through groundwater, rain/ stormwater and treated wastewater. These sources could be utilised as a substitute for scheme water and ultimately delay the need for a new desalinisation plant or groundwater replenishment scheme.

Innovative approaches to green infrastructure relevant to the local context

The hard stand areas in high groundwater areas can provide cool and pleasant spaces through the use of blue and green infrastructure.

In minimising the importation of fill, it is possible to maintain some of the established trees and integrate them into the urban design. This becomes a basis for a wider blue and green infrastructure network based on principles that include:

1. Maintaining established and plant non-deciduous trees as natural water pumps.
2. Avoiding the use of turf and other plants that do not cope well to regular inundation.
3. Avoid areas of stagnant water in summer that attract mosquitoes.
4. Using green walls and planter boxes that don't require deep root systems but are also resilient to heat during Perth's long summers.
5. Developing virtual corridors of green across private land such as shared backyards that provide communal but private space (e.g. cricket pitch).
6. Creating a cultural identify that supports a connection to water including the sharing of traditional Nyoongar stories around the Wagyl.

Technological innovations relevant to the local context

Innovations in construction method can allow the built form to coexist with high water tables.

Lightweight construction provides an alternative to traditional brick and tile construction using lightweight steel or timber. In doing this, a concrete slab on an A class site is no longer required, making way for alternative foundations that are easier to waterproof. Areas of Queensland (e.g. Brisbane), Adelaide (e.g. Lightsview) and overseas (e.g. Timbertown) have all explored this approach. It has not yet been extensively used in Perth, although Peet and Communities will shortly trial this at its Wellard development. Upskilling of the building industry will be required before trades are available to implement this form of construction at scale.

At a smaller scale, smart technologies may allow more integrated services that respond to the local context such as the prevailing weather conditions. This approach has been used by South East Water in Victoria to optimise rainwater and sewerage systems.

Water sensitive governance

An innovation agenda is supported by water sensitive governance.

Innovation is a shared objective between the development partners at Brabham. As such, the technological solutions and development products are likely to be novel and go beyond the traditional remit of councils, utilities and government agencies. Implementation pathways will reflect this with technological pathways to test, prove and scale up new approaches, as well as governance approaches to facilitate a shared commitment to the process of approvals, financing and ongoing management of new assets. New governance arrangements can resolve common challenges such as:

- Who owns/manages alternative water schemes?
- Balancing the need for certainty in early approval processes with the need to further explore innovation options as the development proceeds.
- Managing cost neutrality, particularly when the benefits include a mix of savings, new services that may attract a revenue stream, and other benefits that do not have a monetary value.

Opportunities

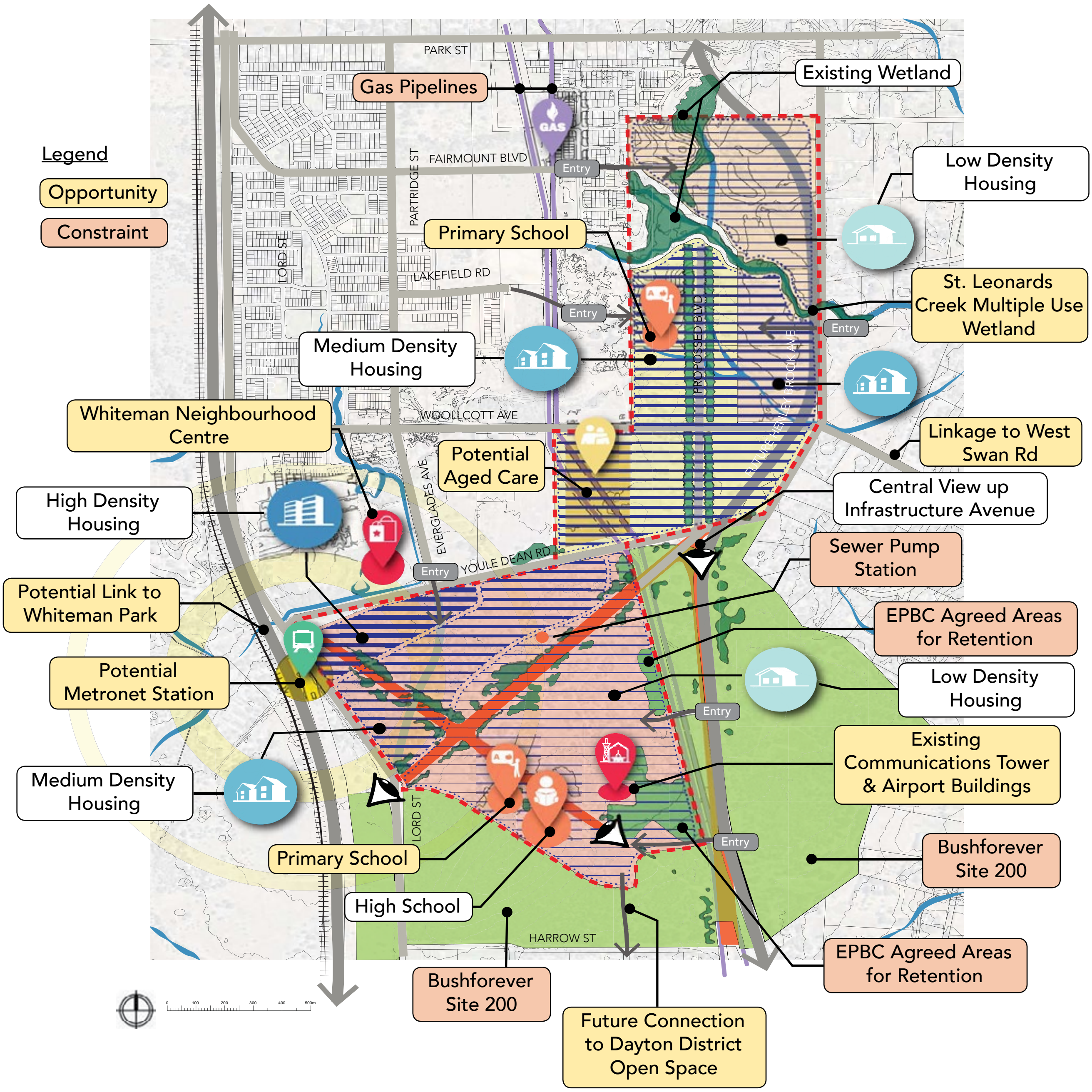


Figure 7 – Brabham opportunities (Picture credit – Realm Studios)

6 Ideas to make Brabham water sensitive

A water sensitive Brabham can be achieved by applying the following ideas.

1. **Staging** the development to deliver the commercial needs of the development project as well as the innovation objectives of development partners. Development staging can be done in a way that responds to the specific groundwater challenges across the site, and prioritising the least challenging areas as the first stage. This provides time to test the designs that will ultimately be used in the third stage where shallow ground water is a constraint. The early stages play another role in innovation by showcasing some of the typologies that will ultimately be used in later stages.

2. **'Village in a wetland' development typologies** in areas subject to high groundwater tables to celebrate water in the landscape rather than fight against it. These typologies will minimise the need for fill by using novel construction methods, at the same time creating a unique character that adds to the value of the development project.

3. **Minimal fill objective.** Delivering water services infrastructure differently to reduce the need to import significant amounts of fill. This could be achieved by adopting an alternative to gravity sewers and by varying the design parameters for sub-surface drainage. Both approaches have the effect of lowering the depth of fill required on site.

4. **Harvest the additional recharge for reuse** to manage the hydrologic change created by urbanisation. Post-development water tables are higher than pre development levels. The additional water causing this difference is normally discharged offsite rather than evapotranspired by vegetation. Harvesting this water returns a more natural hydrology whilst also providing a local water source.

5. **Expand the non-potable water network** with supplies from a range of different sources such as treated wastewater, surface drainage water, rainwater, and storage using managed aquifer recharge, to create a water grid for Brabham and beyond.

6. **Governance for innovation.** Governance should be fit-for-purpose. For this project, governance is required to ensure the successful implementation of innovation for the project and will respond to two challenges: 1. How to support innovative proposals for Brabham through various approval processes, and 2. Driving broader reforms that will enable the wider adoption of these innovations in future developments.

Idea 1. Development staging

The development partners are seeking innovation outcomes, delivered in a way that is commercially viable. The staging of the development will be a key to this.

Staging strategy

This staging approach creates time to fully develop the more innovative elements of the development by releasing the more conventional stages first, and the more challenging areas last. This creates time to explore ideas and technologies that are not yet fully developed, whilst also delivering the project along the way. The staging itself is informed by groundwater conditions across the site. The north west of the site has very shallow depth to groundwater and will require longer to test the feasibility of different ideas. The development can be staged over three main areas: an intitial precinct north of Youle Dean Road (stage 1), the most northern area (stage 2) and the town centre precinct area south of Youle Dean Road (stage 3) (Figure 8).

Stage one

The first stage north of Youle Dean Road. Stage 1 provides the early cash flows for the development and establishes the character and identity of Brabham. Because Stage 1 is less constrained by groundwater it does not rely on innovation in building design. However it plays a crucial role in piloting potential designs prior to their application in stage 3. Stage 1 can also communicate the intended experience of Brabham as a 'village in a wetland'. It can extend the arrival experience into the remanent airstrip that will form a key feature of the wetland concept in stage 3. This intersection will establish the geometry of the development and is well suited to a display village and community centre where innovative designs can be tested to allow feedback from builders, buyers and designers.

Stage two

Stage 2 includes the northern parcel of the site where fill levels of up to 4 m would be required to accommodate a gravity sewer system. Innovation in sewer systems provide a focus for this parcel, along with innovation in managing edge effects with neighbouring developments that have adopted a traditional approach of importing fill.

Stage three

Stage 3 is the more challenging parcel to develop as much of the area is subject to harsh wetting and drying cycles that challenge the conventional development product and landscape design. There is a gradient between areas of 0-1.5 m depth to groundwater in the south east to the areas where groundwater is at the surface in the north west. This suggests a transitional gradient of development products ranging from more natural conditions in the south east to a more engineered approach in the north west. The north western corner is also an option for a METRONET train station. This creates an opportunity to establish a higher density, Transit Oriented Development style development.

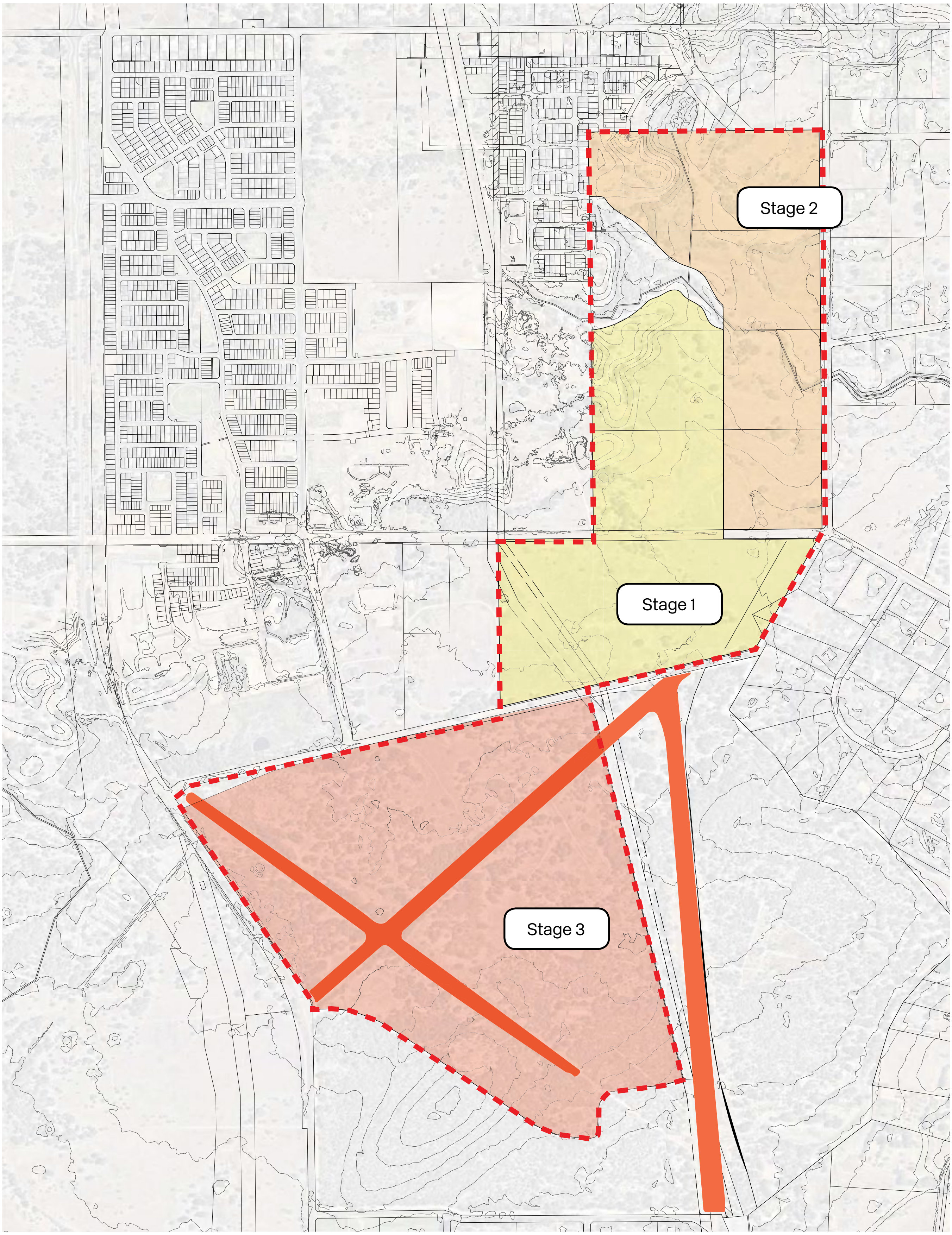


Figure 8 – Development staging based (picture credit – Realm Studios)

Idea 2. Village-in-a-wetland typologies

Stage 3 will showcase the most innovative development approach - a range of development typologies that respond to shallow groundwater conditions. This approach establishes areas that are blue, green or transition from blue to green across the seasons, and provides building typologies that can be applied anywhere across the site where the relevant groundwater conditions are encountered.

Village-in-a-wetland as a guiding principle

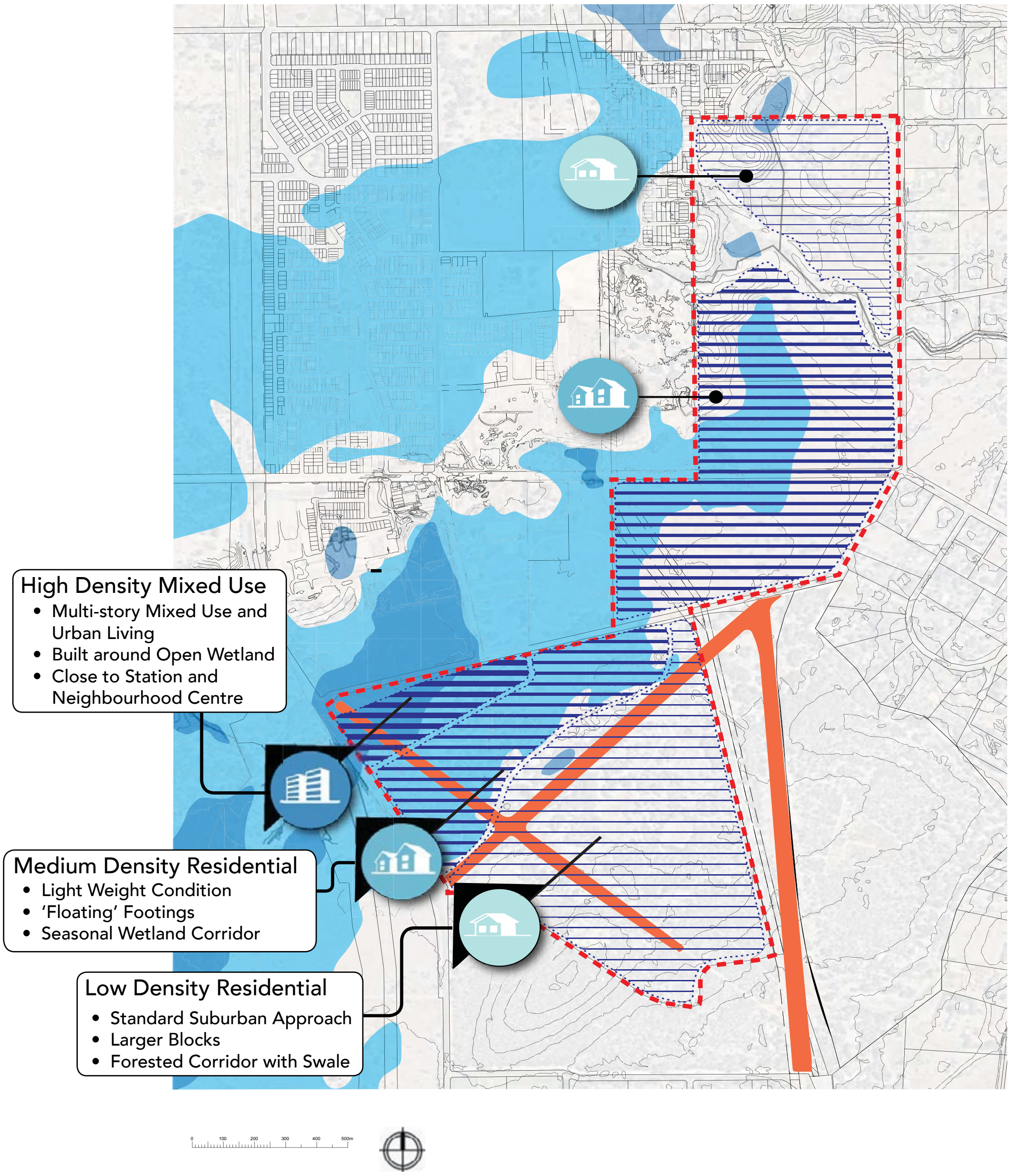
These typologies are based on an assumption that no fill will be imported, and instead present a village-in-a-wetland identity. In its current condition, stage 3 can be wet and lush in winter, but dry and harsh in summer. This principle suggests that wetlands are the dominant landscape feature, with the urban form adapted to sit within the wetland, rather than fighting against it. To apply this principle, the development product will take cues from the wetland and blend the constructed environment with water surfaces and ponds as well as open spaces that remain sufficiently green and lush in summer. This character provides a visual cue to residents that they are living in an urbanised form of a wetland environment.

Three typologies and a runway

Retain and use the existing airfield runways or a portion of these as key site features. As well as being a heritage feature that provides a connection to the historical past, these runways form a key axis for the development and as a green spine alignment along which linear drains and tree lined boulevards can be developed.

The runways also provide a convenient axis to host different development typologies that communicate the changing wetland conditions along a gradient from more depth to groundwater to almost no depth to groundwater. This allows a transition of density and urban design from a lower density development approach associated with the Bush Forever edge condition in the south east, to a higher density development associated with the potential Metronet station in the north west. Three different typologies are proposed: Low, Medium and High Density Housing.

Built Form/Density Typologies



↑ Figure 9 – The development product at Brabham can respond to the varying groundwater and urban density conditions on across the site. (Picture credit - Realm Studio, after Caldwell, 2017)

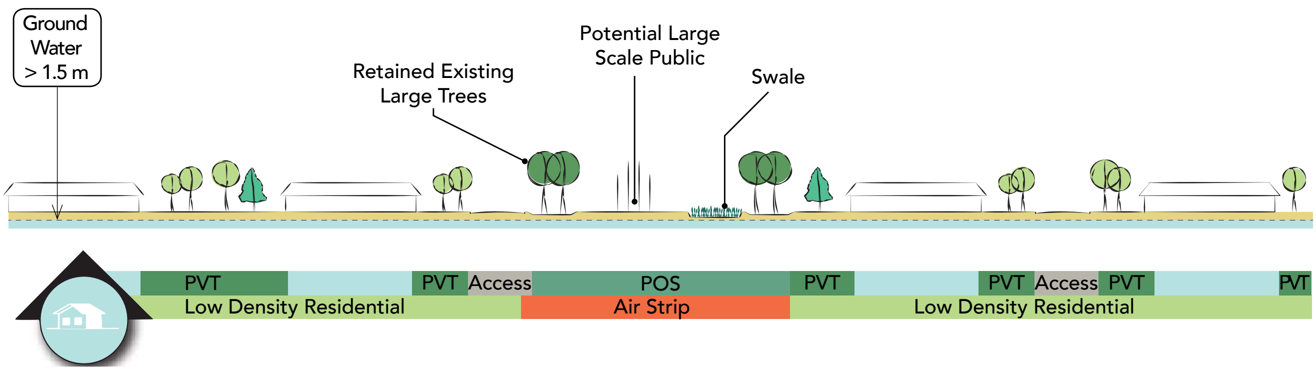


Figure 10a - **Low Density Residential**	Groundwater condition:- >1.5 m depth Where: High groundwater areas in the south east

The south eastern corner has low groundwater tables and will use a more standard development approach and more familiar building form. The first typology creates a bush corridor character that is unlikely to have standing or perched water. It will use more conventional building forms and water sensitive urban design (WSUD) in a lower density context. To maintain the pre-development hydrology some subsoil drainage may be required.

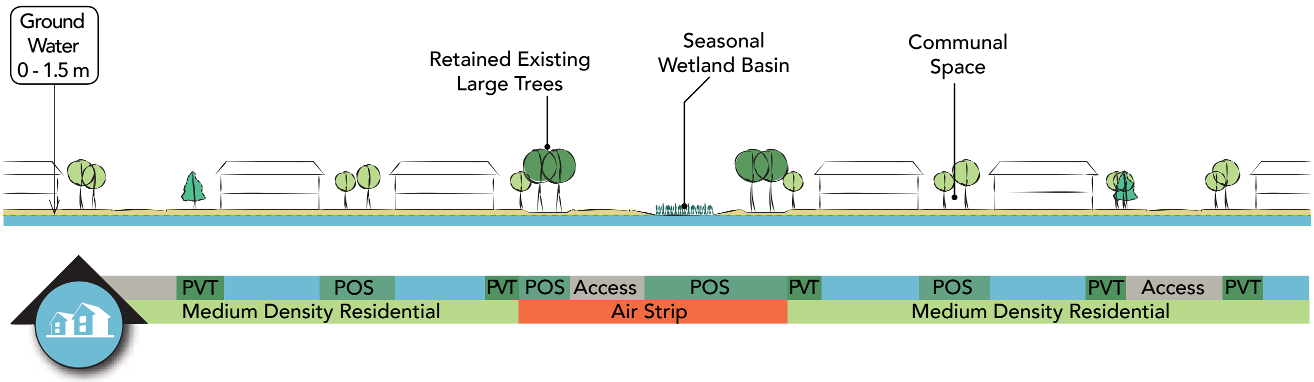


Figure 10b - **Medium Density Residential**	Groundwater condition: 0-1.5 m depth Where: Transition zone

The transitional (or central) zone provides a more overt landscape transition with the seasons. It provides low to medium density development and has some issues with groundwater that require the use of subsurface drainage. However the designs will intentionally incorporate some short term wetting and standing water in winter. This allows creation of courtyards and communal spaces that incorporate the presence of water. This zone is well suited to lightweight constructional approaches.

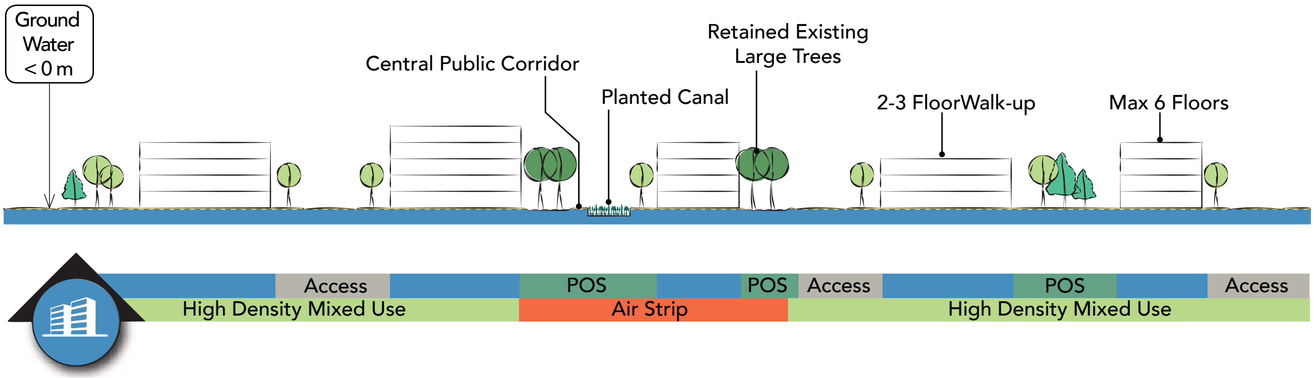


Figure 10c - High Density Mixed Use	Groundwater condition: 0 m depth Where: Shallow groundwater areas in the north west

The high groundwater area in the north west must contend with more frequent and extensive standing water. It will present a more engineered urban form with harder edged water bodies, canals and features to contain this water, and can support higher development densities with multi-storey commercial and residential development. This typology will adopt designs that provide amenity across both wet and dry conditions. It will include retained trees, artificial waterbodies and constructed WSUD features. In winter, standing water will be widespread to present a predominantly ‘blue’ character, while in summer water will contract back to the artificial waterbodies revealing a ‘green’ character provided by lush open space and WSUD elements.

Idea 3. Minimal fill objective

The development typologies in Idea 2 are viable if the fill requirement is addressed. Two issues define this fill requirement: the design of sewer services and the design of sub-surface drainage. Ideas for each can be applied in different parcels of the Brabham site.

North - Where sewer systems are driving the fill requirement

Current planning for wastewater services is based on a gravity sewer system to the south of the site which necessitates significant fill in the north. The current proposal uses a second pump station in the north on the flood plain of St Leonards Creek connected by pressure main to the current pump station in the south. If the development in the northern parcel relies on this approach, then the site ground level needs to be raised to allow the fall necessary for a gravity sewer to function. Alternate options include:

- A shallow, pressure sewer that does not require fall in the first place.
- Smart design of sewer networks based on site topography to flatten sewer grade.
- An extra pumping station(s) to reduce reliance on gravity.

These approaches are used successfully elsewhere in Australia. Pressure sewer shows particular promise as it can provide additional benefits if connected to intelligent water networks. These networks allow sewer flows to be scheduled to avoid peak capacity constraints in the sewer network.

South - Where drainage systems are driving the fill requirement

Urban development in low lying land generally causes groundwater to rise. Importing fill and installing sub-surface drainage beneath road verges is a conventional measure to control groundwater rise so that buildings are protected. Fill is also required to provide fall and cover over the subsurface drainage. Conventional practice sets drains at the annual average maximum groundwater level (AAMGL) or above (Figure 11). This level ensures that drainage does not intercept the groundwater and hence interfere with natural fluctuations at the site and deplete the aquifer. It also ensures that the outlet point into downstream natural or constructed drainage systems is free draining. Fill can be minimised by following the steps below:

1. Set the sub-surface drain outflow at AAMGL. This ensures the site drainage is free flowing and that groundwater is not mined.
2. Pivot the subsurface drainage at this point to flatten the grade. Although grades of 1:250 or 1:300 are generally used, there are examples of systems functioning effectively in Western Australia with grades of 1:1000 or less. This:
    - Reduces the elevation of the furthest point (the difference in heights between the outlet and the furthest point.)
    - Sets the drains between the AAMaxGL and AAMinGL i.e. within the natural variability of groundwater levels. This allows the drain to intercept the shallow groundwater table more frequently as it fluctuates over the year and thus drain a larger volume of water. This minimises water table mounding.
3. Reducing the length of drainage runs. Drain lengths can be minimised using a drainage network that includes living streams, open swales and shorter length drains that keep water on the surface for longer. This also enables water treatment devices to be incorporated into the design.

Figure 11 - Options for the placement of sub surface drainage relative to AAMaxGL and AAMinGL to influence groundwater levels: placement at AAMaxGL and placement between the AAMinGL and AAMxGL. (Credit – Carl Davies)

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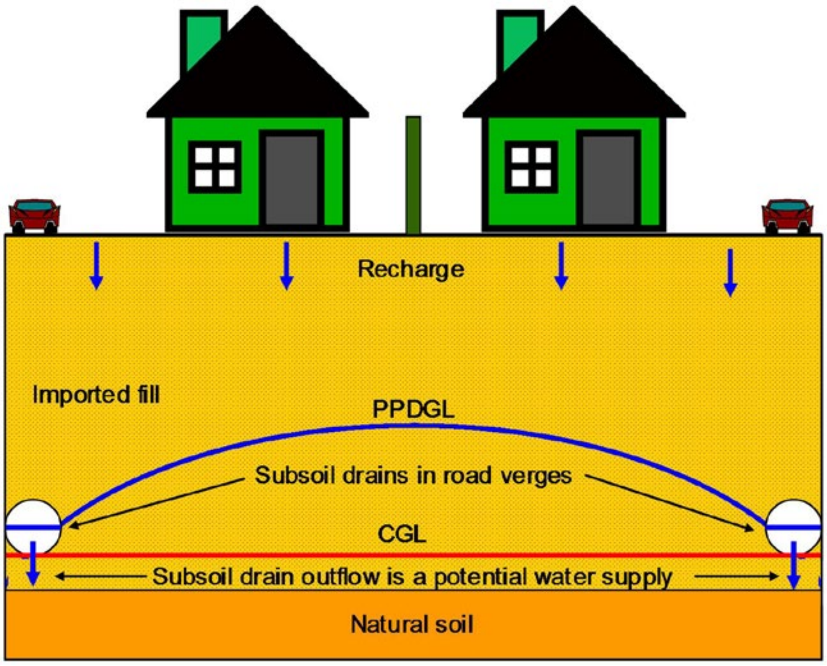


Fill is potentially the single largest cost of development. If 1m of fill can be avoided, there is a saving of $8000 per lot on a footprint of a 400m2 lot. If we spread this across the full 220 ha this becomes a saving of $20,000 per lot.

Table 2 – Indicative fill costs for development

Scenario	1	2	3
Fill thickness (m)	0.5	1	1.5
Area (ha)	220	220	220
Fill cost ($/m³)	20	20	20
Total cost ($M)	22	44	66

Idea 4. Harvest the additional recharge

The additional recharge created by urbanisation can be harvested and reused to meet the water demands for the development. In addition to providing water security, this contributes to the minimal fill objective by actively lowering the shallow groundwater table and restores the site hydrology.

Approval

A licence will be required to harvest the recharge. The Department of Water and Environmental Regulation advises that, in principle, it supports the harvesting of additional recharge where this 'excess water' is shallow groundwater that would have otherwise been lost to evapotranspiration. This applies in areas that require sub-surface drainage systems to control groundwater levels that are close to the natural land surface and sub-surface drains are set to AAMGL.

Water availability

A water balance assesses the stocks and flows of water across the site and highlights opportunities to match supplies and demands. Separate water balances for summer and winter have been estimated (Figure 12a and b) and show that:

- Over the 8 months outside of summer (notionally described as winter), 959 KL/day on average (230 ML) can be harvested and reused within homes, assuming that 60% of water use only requires water of non-potable quality. This option assumes that water is harvested and continuously distributed to homes via a third pipe network, alleviating the need for large storage.

- Over the 4 summer months of the year, 148 ML can realistically be harvested for irrigation of public open space, fulfilling the City of Swan's water needs. It is likely that this water will be harvested and stored in a managed aquifer recharge scheme to balance short-medium term differences between supply and demand.

Because site drainage is part of early civil works, sufficient volumes of drainage water will be available from the first stages of the development. However, to provide additional certainty of volumes for stage 1, harvesting drainage from Stocklands' "Whiteman Edge" development to the north could also be explored.

Water quality

The quality of this recharge water is generally good. Testing at Whiteman Edge and The Rivergums shows that this water has high iron levels and a visible floc, as well as nutrient concentrations higher than pre-development groundwater quality. However, only minimal treatment will be required before reuse. A treatment facility involving filtration and disinfection will ensure water quality standards are met.

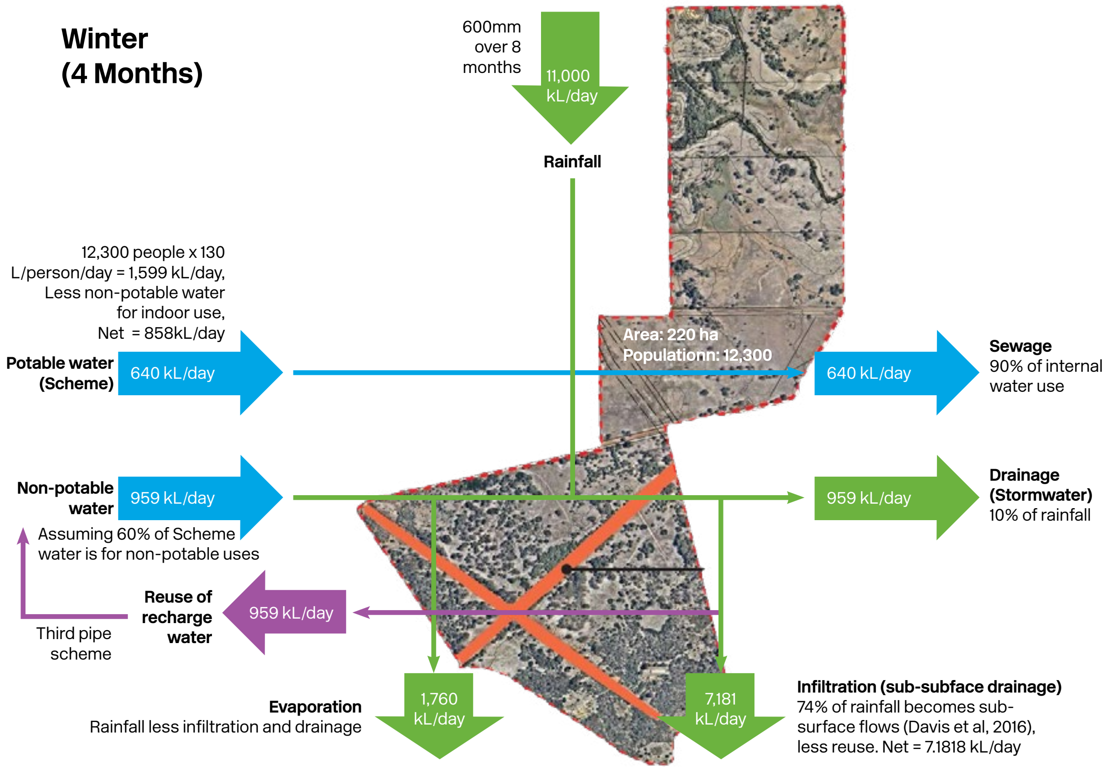
Matching supply and demand

While the quality and quantity of recharge water supports a reuse opportunity at Brabham, the difference in timing between supply and demand remains a challenge. Three approaches can be used to ensure supply reliability:

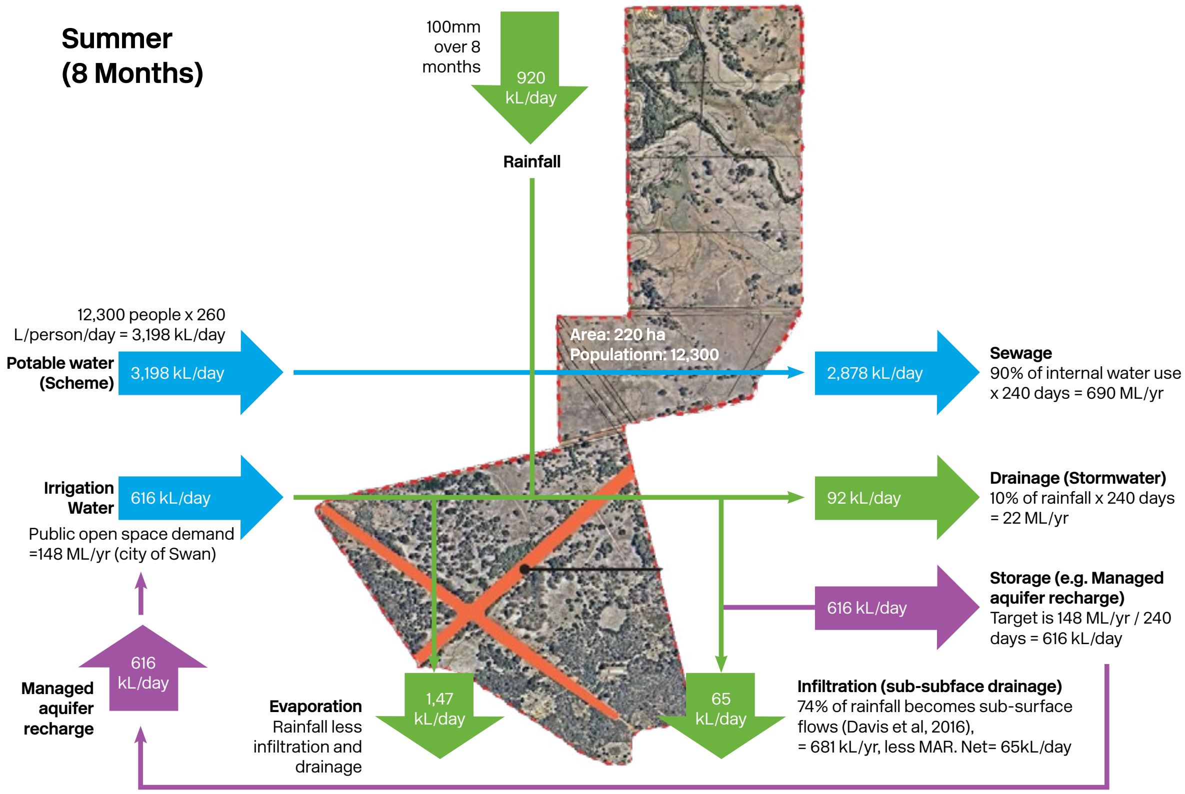
1. Managed aquifer recharge for storage. This option is useful if the water is to be used for outdoor demands which peak in summer. Managed aquifer recharge could be used to inject water during the winter months into the superficial aquifer or deeper aquifers for extraction in summer.

2. A third pipe distribution network to distribute water for use within homes. This avoids the need for large storages by using the water as soon as it is harvested. The water supplied by a third pipe network can be used as a substitute for Scheme water for toilet flushing or laundry use – uses that only require non-potable quality water but are relatively constant in volume across the year. Whilst a third pipe system provides a range of benefits (such as helping to progressively win the community over to the value of fit-for-purpose water such as groundwater replenishment), preliminary economic analysis conducted by the Department of Water and Environmental Regulation estimates that these benefits do not outweigh the capital costs of the distribution network. Investment in a third pipe scheme is therefore likely to be justified on sustainability, water security or other grounds, rather than on financial savings.

3. The supply source for a non-potable network can make use of different sources during the year to meet demand peaks. For instance, the third scheme could be supplied by treated recharge water when it is available and topped up with treated wastewater in summer.



↑ Table 12a – Winter water balance



↑ Table 12b – Summer water balance

Idea 5. Expanded non-potable water network

A water harvesting scheme at Brabham using the additional recharge water can be a first step towards a much larger alternative water scheme. This scheme could either diversify the water supplies used within Braham, or expand the reach of alternative water reuse beyond Brabham to seed a wider, regional water grid servicing councils and new developments along the planned METRONET rail corridor.

Other locally available water sources

Other alternative sources of water including wastewater recycling have been assessed for economic and financial viability by the Department of Water and Environmental Regulation. Preliminary findings show that wastewater reuse has a positive benefit cost ratio and is cheaper than scheme water and drainage water. The disadvantages of wastewater reuse are that it requires more treatment than drainage water and isn't available in adequate volumes in the early stages of development. It is also important to note that wastewater from this catchment otherwise flows to the Beenyup wastewater treatment plant where it is injected into the aquifer through the Groundwater Replenishment Trial. Hence it is already recycled, and local use would reduce volumes available for this use.

Other regional users

There are a number of new development sites in the City of Swan and the Swan Valley region that will also require irrigation water in the future. A collaboration with the City of Swan and other developers could investigate regional reuse schemes to meet the water needs of multiple councils along the planned METRONET rail corridor to create a regional grid in 20-30 years' time. There may also be interest from agricultural users in the Swan Valley.

Idea 6. Governance platform for innovation

Delivering Brabham

Guide the Ideas for Brabham from concept to implementation by creating a purpose built steering group with representatives of the approval authorities and tasked with delivering innovation at Brabham. Time and barriers to innovation can otherwise prevent the successful implementation of the ideas in this discussion paper.

The ideas also provide an exemplar for future developments. It is likely that the ideas will challenge current policies and practice, requiring wider reforms if they are to be used more widely. The steering group can identify ways to mainstream the processes and technologies of the type discussed in this report.

Scaling the innovation up

Brabham presents an opportunity to facilitate wider reform to scale the innovations up to broader application. To enable this, further reform is required to agree how to assess novel policy options for this and other sites. These reforms cover four areas:

Management framework for the ‘excess’ water

Governance frameworks are required to manage the additional sub-surface drainage water created across the site. This water could be managed as a waste, a pollutant or as a resource.

Facilitating the business case for innovation

Innovation still needs to be cost effective. At Brabham, there is an opportunity for the ideas to be cost neutral if the fill savings of up to $20,000 per lot provide a budget to fund alternative water systems and alternative design typologies. This business case requires further analysis but shows that at a development project level there is a potential cash flow to fund innovation.

Who is best placed to own and run integrated water systems?

Developing the structure for this financing between development partners and ultimate asset owners will determine who will fund the initial and on-going delivery, including future maintenance costs that have been offset by savings in the initial construction phase.

Smart cities

The governance framework could assess how water, sewerage, and drainage could be combined into the one service. This enables more localised and fit-for-context services. The Aquarevo case study in Victoria shows that Australian utilities are already moving into new business models that offer integrated water, wastewater, drainage and potentially energy services to customers. This is an area for further innovation at Brabham if the integrated model provides cost savings that support an affordable housing objective. The challenge lies in delivering this within the current regulatory framework, and working with existing agencies (such as the Water Corporation or Council) or interested third party operators, to explore alternative business models.

If ownership of water, sewer and drainage is delivered by an integrated entity or as an integrated service, then technology such as the One Box approach could be part of a shift from a passive water system to a smart system. This technology enables the different elements of the water systems to be managed more finely – such as deciding when and where within the development to use recycled water to maintain the important ‘village in a wetland’ character that is otherwise challenged by the seasonality of the climate.

Table 3 – Potential terms of reference for the governance platform

Purpose	To bring the relevant agencies and stakeholders along on the journey and to work collaboratively to drive innovative solutions.
Participation	Development partners, stakeholders and approval agencies. As a forum, it includes the funding partners, approval authorities and ultimate asset owners, and provides a platform for a partnership to shape the development.
Structure	The governance platform includes: • A project advisory group representing the development partnership between Peet, Perron, and the Department of Communities. This group oversees the delivery of the project, and is already in place. • A more comprehensive steering group that includes key stakeholders and approval bodies. This group will include the project advisory group as well as bodies such as the City of Swan and Department of Water and Environmental Regulation. This group builds a commitment to an outcomes-based approach in a timely manner, supports approvals processes (whilst recognising the independence of approval agencies), and resolves challenges that arise such as long term ownership issues. • A regional, multi-stakeholder group to collaborate around a regional reuse scheme and including City of Swan, new developers and Swan Valley agricultural users.
Accountability	The project advisory group will be accountable for the delivery of the project. The steering group will be accountable for the level of innovation that is ultimately adopted.

Duties	• Agree on a vision for the Brabham site.
	• Facilitate approvals:
	    • shared vision
	    • outcomes focus
	    • early discussion of risks, barriers
	• Agree staging, and success factors for each stage
	• Commit to a whole-of-Brabham servicing strategy:
	    • What will be delivered?
	    • How will it be delivered?
	    • Is it feasible?
	    • What will the rollout strategy and timing be?
	    • Who will take over the assets and when?
	    • What are the on-going operation and maintenance requirements?
	• Agree on what 'plan b' looks like should the innovations be less than successful.

Deliverable	The Local Structure Plan and Local Water Management Strategy.

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About the CRCWSC

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) was established in July 2012 to help change the way we design, build, and manage our cities and towns by valuing the contribution water makes to economic development and growth, quality of life, and the ecosystems of which cities are a part.

The CRCWSC is an Australian research centre that brings together many disciplines, world-renowned subject matter experts, and industry thought leaders who want to revolutionise urban water management in Australia and overseas.

Research synthesis

Research synthesis is key to successful research application and adoption.

A facilitated design process, Research Synthesis brings together the CRCWSC's many research areas and disciplines with government and private industry partners to develop practical "ideas" for addressing specific industry-based challenges.

Research synthesis is a highly effective tool for exploring collaboration and innovation. The open-minded environment of a research synthesis design workshop is founded on science, and no individual organisation leads or owns the conversation. This supports an unbiased dialogue that enables the discovery of new and creative ideas.

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