Croydon Major Activity Centre

Planning for Cooler and Greener Centre Background Paper





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Glossary

Activity centres: Urban areas with a concentration of, and focus on, housing, commercial, retailing, community, employment, transport, leisure, open space, entertainment, and other services. They are places where people shop, work, study meet, relax and live.

Blue-green infrastructure (BGI or green-blue infrastructure): Refers to the use of vegetation, soils and natural processes (such as rain and photosynthesis) in an urban context to simultaneously deliver landscape and water management benefits (p15, Planning a green-blue city, DELWP, 2017). Also defined as infrastructure designed to successfully incorporate natural systems that provide the ecological and amenity value associated with urban greening and provide stormwater (or other alternative sources of water) management (p5, Planning a green-blue city, DELWP, 2017).

Ecosystem: The combination of an interdependent community of living things and the physical features that support it, such as climate, soil, and water.

Ecosystem Services: Practical benefits that flora and fauna provide to humans, such as the shade, wind protection and air purification provided by trees or the pollination of garden plants by insects. Other ecosystem services provided by green and blue-green infrastructure include stormwater management, climate adaptation, less heat stress, more biodiversity, food production, better air quality, sustainable energy production, clean water and healthy soils, as well as increased quality of life through recreation and providing shade and shelter in and around towns and cities.

Green infrastructure (GI) or living infrastructure is an interconnected network of natural, semi-natural and engineered components such as private gardens, public open space, green corridors, waterways, wetlands, green walls and green roofs. These components provide ecosystem services and thus support our wellbeing.

Heat Vulnerability Index (HVI): The HVI rating is determined by three components: heat exposure, sensitivity to heat (due to land cover, population density, and age), and adaptive capacity (e.g. socioeconomic advantage or disadvantage).

Urban Heat Island (UHI): The UHI is a measure of the deviation of urban temperatures above or below a non-urban baseline temperature. The UHI measure was derived from land surface temperature (LST) data based on Landsat 8 thermal infrared data. The data provided is a two-dimensional representation of UHI across Melbourne at 30-meter resolution landscape.

Increased impermeability created by urban intensification (creating more hard surfaces such as roofs, driveways) reduces water in the soil and these often dark-coloured hard surfaces absorb heat and increase evaporation. This raises heat in urban areas to levels uncomfortable and unhealthy for people, plants and animals.

Water Sensitive Urban Design (WSUD): Planning and engineering design approach which integrates the urban water cycle (including stormwater, groundwater and wastewater management), into urban design to minimise environmental degradation, flood mitigation, and improve aesthetic and recreational appeal. Examples include, but are not restricted to, passive watering of street trees; constructed wetlands, swales and buffer strips, stormwater harvesting, water tanks, rain gardens, aquifer storage and recovery systems and sediment basins.

Summary

This report provides the status of Blue-Green Infrastructure (BGI) in Croydon Major Activity Centre (MAC) and assesses strategic issues and opportunities for BGI that could be considered by the Croydon Structure Planning process.

Blue-green infrastructure (BGI) is defined as infrastructure designed to successfully incorporate natural systems that provide the ecological and amenity value associated with urban greening and provide stormwater (or other alternative sources of water) management (DELWP, 2019).

Many of the issues and opportunities listed below are interrelated and should be considered as together. Acting on one will be of mutual benefit to all.

Key Issues and Constraints

Main Issues	Details
Threats to community wellbeing and liveability	- Disconnection from nature in urban areas - Reduced local amenity undermines healthy, active lifestyles - Increasing urban heat island effect and heat vulnerability
Increasing imperviousness of land surfaces	- Urban densification creates more hard surfaces such roofs, driveways, carparks and roads. These reduce the area of permeable surfaces such as green open space and prevent stormwater being absorbed into the landscape. This exacerbates issues of flooding, urban heat island and drying of soils leading to loss of tree canopy, biodiversity and flora and fauna habitat (especially those dependent on naturally damp soils).
Increased Flooding	- Much of the Croydon Activity Centre is flat and flood prone. Increasing impermeability creates more stormwater runoff and exacerbates existing flood issues.
Loss of Vegetation including canopy cover, and biodiversity and habitat	- Trees provide many benefits including shade and a pleasant amenity. The removal of trees and other vegetation can be exacerbated by urban intensification with more hard surfaces. The removal of indigenous species and the habitat they provide destroys and fragments their populations and those of the indigenous birds and animals which depend upon them.
Degradation of Tarralla Creek	- As a receiving waterway for urban runoff and the outcomes of other urban issues, the environment of Tarralla Creek (and waterway environments it connects to) has been degraded. The Re-Imagining Tarralla Creek project will improve it, however ongoing development issues in the catchment - many of which are highlighted in this report - could undermine these improvements.

Main Constraints	
Lack of enabling mechanisms in the Planning Scheme	Land-use and water planning are typically not well supported or integrated in strategic and statutory planning mechanisms so blue-green infrastructure can be difficult to implement, especially on private land.
Lack of applicable good demonstration sites in the Croydon Activity Centre	Few good examples of blue-green infrastructure on private and public land exist in the Croydon Activity Centre with which to inspire local, potential participants, especially ones which are replicable in the private domain.
Need for new paradigm in adaptive blue-green infrastructure approaches within Council and the BGI industry.	The use of blue-green infrastructure is relatively new within Maroondah City Council and capacity-building is needed for a co-ordinated and effective approach across the organisation and for some external partners, particularly small developers. Useful monitoring, evaluation, reporting and improving (MERI) data is yet to be widely available for effective use by 'BGI industry' partners.

Key Opportunities

Key Opportunities	Description
Exemplify/Demonstrate	Green roofs and walls on Council buildings Permeable paving in Council carparks and landscaping
Council land	Major projects led by Council provide place-based opportunities for good demonstration projects for blue-green infrastructure.
Enable *Private land*	Community support for a clean, green and sustainable Maroondah assists Council to further adopt blue-green infrastructure, as testified in *Maroondah 2040-A Community Vision.* Renewal of the Croydon MAC Structure Plan provides opportunities to develop planning instruments and related tools (e.g. Developer Contribution Plan and/or Stormwater Offset Program) to effectively integrate and resource BGI into urban development for this Precinct. Incentives such as waiver of planning permit fees including GI (e.g. Moreland's Design Excellence Scorecard and use of City of Melbourne's Green Factor Tool). Other planning instruments and development guidelines could be strengthened to require more and larger water tanks to detain and retain water, with multiple benefits. Vacant/underutilised industrial land could be rented out to community garden/food bank groups (e.g. Fareshare Kitchen Garden on VicTrack land in Abbotsford https://www.fareshare.net.au/kitchen-garden/) Consider recommendations from the Draft Vegetation Strategy to strengthen planning controls to benefit vegetation.
Partner *Projects and Plans*	The Croydon Structure Planning process provides opportunities to educate and inspire community, industry and cross-Council engagement to align objectives and adopt more blue-green infrastructure in the MAC. The Re-imagining Tarralla Creek Stormwater harvesting project is providing an opportunity for four water industry partners to deliver a great community outcome together. Sustainable development models which Council could adopt provide similar collaborative opportunities for better blue-green and other outcomes on private land. Flood mitigation planning provides opportunities to partner across Council and with Melbourne in order to incorporate best-practice blue-green infrastructure. This could include movement corridors such as shared paths, which could be landscaped as blue-green corridors

1. Planning for a cooler and greener Croydon

1.1 Introduction and Context

As the City of Maroondah's population - including that of the Croydon Major Activity Centre - continues to grow, it is mostly being accommodated by an intensification of urban development. Along with the effects of climate change - such as increasing temperatures - urban development creates environmental and social challenges.

This report considers some of these challenges by considering how blue-green infrastructure could assist in their mitigation. Some evidence is presented and case studies used to demonstrate the relevance of blue-green infrastructure to tackling the challenges. However more evidence may be needed to present a fully-compelling case and examples are given in the 'further work' section. Additional constraints indicated in the report also need to be overcome to facilitate the effective adoption of more broad-scale blue-green infrastructure.

Long Term Greening and Cooling Solutions

The best long-term method to create a cooler and greener Croydon comes with dealing with the root causes of urban heating and a loss of nature, and that involves dealing with:

- *climate change*
- *population growth*
- *standard urban development and intensification paradigms*

Directly addressing these are beyond the scope of this report, however the following programs which challenge the dominant urban development paradigm and encourage blue-green infrastructure are:

- *The 20-minute city approach - encourages mixed land uses for better community and environmental outcomes*
- *Greening the Greyfields - lot consolidation for better community outcomes*
- *Water sensitive building typologies - residential*
- *Biodiversity Sensitive Urban Design*
- *'Nightingale' multi-unit development model*
- *Providing vegetation cover and communal outdoor open space as per the Better Apartment Design Standards March 2020.*

For the purposes of this study, blue-green infrastructure refers to urban greening designed/engineered to function with, and manage or treat, an alternative source of water, usually stormwater (not potable, mains water). It encompasses the built environment as well as unbuilt and natural spaces. It includes assets on public, semi-public and private land and is focused on the values and benefits that are delivered to people, places and the community - rather than focusing on physical form, use of land or asset tenure.

Blue-Green Infrastructure (BGI) is emerging as a nature-based and cost-effective solution for promoting: more liveable and sustainable urban development; greater resilience to climate change; and restoration of degraded ecosystems. It provides most value in areas with mixed land uses and significant public activity, where people live, work, play and study and thus spend a high proportion of their time. People in such areas and are therefore more affected by the quality of their surroundings This is (unfinished sentence)

Blue-green Infrastructure could play a greater role in maintaining and improving the liveability of precincts. This is because in addition to its environmental benefits, there are many physical and mental health benefits associated with contact to nature that blue-green infrastructure can provide.

Croydon Major Activity Centre (MAC) is a place with significant public activity and mixed land uses. With many community and infrastructure projects underway, the place is expected to experience accelerated growth over the next 20-years. Given this context, it is incumbent upon state and local authorities to facilitate the provision of high-quality environments to meet the community's long-term needs. Well-planned and well-designed BGI has a significant and growing role in this space.

This background paper aims to introduce blue-green infrastructure as one of the considerations for the preparation of the Croydon MAC Structure Plan. The paper has the following objectives:

- create an understanding of characteristics of blue-green Infrastructure and its benefits at the neighbourhood and municipal level;
- identify issues in Croydon MAC that could be addressed by applying BGI principles and guidelines; and
- identify a range of high-level opportunities for incorporating BGI through land use planning and capital improvement projects in Croydon MAC;

It is expected that findings from this paper will inform the overall issues, options and opportunities in the built and natural environment for the Croydon Major Activity Centre (MAC).

1.2 Croydon Major Activity Centre Area

The Croydon Major Activity Centre (MAC) covers an area of 140 hectares and lies approximately 30km east of Melbourne's CBD. It contains commercial, retail, light industrial, community and residential land uses. It is bounded by Croydon Road, Kitchener Road and Plumer Street in the north, Dorset Road in the east, the Melbourne Water pipe track, Lusher Road and Mt Dandenong Road in the south, and Wicklow Avenue, Toorak Avenue, Kylie Court and Tallent Street in the west.

The Croydon MAC includes the Main Street Neighbourhood Shopping Centre, Croydon Central Shopping Centre, Arndale Shopping Centre, and the surrounding light industrial areas, community and civic precinct, Swinburne University campus and residential areas.



Figure 1.1: 2006 Boundary of the Croydon Town Centre Structure Plan

2.0 Understanding Blue-Green Infrastructure

Blue-green and green Infrastructure encompasses (do they 'encompass', or can they be found in/incorporated into) the built environment as well as unbuilt and natural spaces. It includes assets on public, semi-public and private land and is focused on the values and benefits that are delivered to people, places and the community - rather than focusing on physical form, use of land or asset tenure.

2.1 Objectives for blue-green infrastructure

A green urban landscape and a sustainable water cycle is central to the ongoing success of cities and towns. Blue-green infrastructure planning and implementation is a key investment in making cities healthy, prosperous and resilient. It has *twelve core objectives:*



Healthy - making the best of our local environment

1. To support year-round passive and active recreation. This in turn supports the community's physical and mental health;
2. To protect and enhance local waterways and aquatic environments. This includes reducing the impact of the volume and quality of stormwater running-off paved urban areas;
3. To support urban biodiversity by providing opportunities and conditions which support a variety of plant and animal life;



Prosperous - making changes to better our city

4. To improve the amenity of the urban environment (beautification);
5. To create stronger connections between communities and nature;
6. To improve the functionality of urban places;
7. To drive increased tourism and visitation;



Resilient - making sure we are ready for challenges

8. To make use of alternative water supplies (harvesting stormwater, for example) locally to prepare for drought
9. To reduce the impacts of flooding
10. To provide pleasant, green and cooling environments during hot weather and a drying climate

11. The use of BGI on and in buildings, especially the use of green roofs and green walls, could achieve an additional objective which is to maximise the benefits of sustainable design at the planning stage. Sustainable design assists new buildings and additions to achieve greater levels of energy and water efficiency and reduces indoor temperature fluctuations.

2.2 Benefits of Blue-Green Infrastructure

For Australian urban centres, there is a very direct and important link between greening and water management. Healthy trees and vegetation rely on the provision of soil moisture to thrive and flourish, while vegetated areas play a key role in absorbing, treating and controlling the excess water in urban areas.

However, often “green” assets (trees, parks, gardens) and “blue” assets (Water Sensitive Urban Design (WSUD), drainage areas and flood storage) are planned separately. However, often the same asset can provide multiple services that benefit both “green” and “blue” objectives. The diagram below is an illustration of this concept.

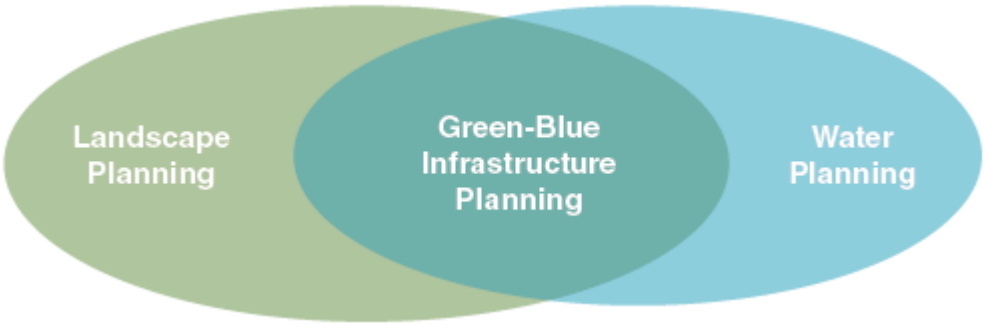


Figure 2.1: Relationship of Green-Blue Infrastructure

Traditional ‘grey’ infrastructure, such as pipes, drains and stormwater side-entry pits associated with water management had a single purpose - in this case to drain water away from urban environments as quickly as possible. Such a single-focussed approach once achieved this, but over time created significant other issues, such as exacerbated flooding and erosion downstream. The more multi-disciplinary and integrated approach offered by a blue-green infrastructure approach helps to avoid and redress such downsides and aims to provide additional benefits.

The benefits include helping to solve urban and climatic challenges through the provision of ecosystem services that enhance the well-being and prosperity of local communities. By purposely planning for blue-green infrastructure that achieves multiple objectives, cities and towns can benefit from efficient infrastructure, greater collaboration and heightened benefits (p5 DELWP).

Box 1: The importance of retaining water in the urban environment

Planning and environment practitioners are becoming increasingly aware of the benefits of greening and retaining water in the urban environment to mitigate the effects of the Urban Heat Island (UHI). Research demonstrates that water availability is especially important in influencing temperatures and creating urban-rural contrasts, while within cities, variability is largely a result of street and building design. There are benefits in utilising available stormwater to limit UHI intensity and reduce vulnerability to daily heat stress[1].

Water plays a strong role in local climate regulation. Retaining water in the soil is very important for cooling and keeping vegetation alive. Greener, irrigated spaces naturally stay cooler as they don't store heat like concrete and buildings. By keeping trees healthy we will also enjoy a better shade and canopy cover in our streets and parks. Harvesting alternative water sources such as rainwater, stormwater and recycled water and storing them for use in hotter periods facilitates urban cooling. Using locally sourced water for irrigation, including establishing revegetation areas, is better than using our precious drinking water.

Restoring a more **natural water balance** through widespread implementation of water sensitive urban design and flow regime management through the catchment can support higher base flows in urban streams which in turn supports cooling when needed[1].

As part of the Water Sensitive City Strategy, all irrigated sportsgrounds are provided with adequate water for safety and amenity, while minimising potable water demand through at least one of these measures:

- Use of warm season grasses.
- Use of high efficiency irrigation systems.
- Use of irrigation systems managed by a central control management system.
- Use of alternative water sources where feasible

Maroondah has also experienced serious drought events. We can prepare better for drought by having a range of water sources available, using water wisely and being prepared to cope with less water when we need to.

We want to celebrate water and use water as part of the urban form in Maroondah, using channels, water features, ponds and lakes as part of the urban landscape that is appreciated by the community.

Box 2: Evidence of Benefits of Green Infrastructure

- **Street trees** can reduce day temperatures by between 5º celsius and 20º celsius, making everyday activities more pleasurable and healthier[1].
- Up to 80% of the cooling effect of trees results directly from **shading**[2].
- In most cases, **tree canopies** are the optimal solution for shading both canyon surfaces and the pedestrian space, and they also provide evapo-transpirative cooling[3].
- Trees can modify **street canyon** microclimates; however, their cooling benefit is stronger on wider, more open streets[4].
- In narrow canyons, where there is adequate light, **green walls and facades** as well as ground level vegetation can be prioritised instead of trees due to reduced space, and because they allow better ventilation and cooling at night.
- **Parks** can be several degrees cooler than surrounding urban areas. The temperature difference is often largest at night and tends to increase with park size[5].
- Surface temperatures **of dry parks (you will need to provide a definition of a 'dry park' somewhere - I don't know what you mean by the term)** during the day could be higher than the surrounding urban neighbourhoods[6]
- **Green roofs** reduce air-space cooling requirements inside those buildings. To be effective, green roofs need to be irrigated to become comparable to the cooling provided by roofs painted with high albedo paint[7].
- Restoring a more **natural water balance** through widespread implementation of water sensitive urban design and flow regime management through the catchment can support higher base flows in urban streams which in turn supports cooling when needed[8].

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[1] Mullaney J, Lucke T, Trueman SJ (2015) A review of benefits and challenges in growing street trees in paved urban environments. *Landscape and Urban Planning* 134 157-166

[2] Shashua-Bar L and Hoffman ME (2000) Vegetation as a climatic component in the design of an urban street: An empirical model for predicting the cooling effect of urban green areas with trees. Energy and Buildings 31(3): 221–235

[3] Spronken-Smith, R. & Oke, T. (1999). Scale modelling of nocturnal cooling in urban parks. Boundary-Layer Meteorology, 93(2), 287–312

[4] Coutts AM, White EC, Tapper NJ, Beringer J, Livesley SJ (2015) Temperature and human thermal comfort effects of street trees across three contrasting street canyon environments.

[5] Bowler D, Buyung-Ali L, Knight TM, Pullin AS (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* 97 147-155

[6] Mueller EC and Day TA (2005) The effect of urban ground cover on microclimate, growth and leaf gas exchange of oleander in Phoenix, Arizona. International Journal of Biometeorology 49(4): 244–255

[7] Santamouris, M. (2014). Cooling the cities—A review of reflective and green roof mitigation technologies to fight heat island and improve com- fort in urban environments. Solar Energy, 103, 682–703.

[8] Burns MJ, Fletcher TD, Walsh CJ, et al. (2012) Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. Landscape and Urban Planning 105(3): 230–240

2.3 Scale in blue-green infrastructure

Successful blue-green infrastructure planning naturally requires an integration of different scales of planning and application. Accordingly, blue-green infrastructure planning will likely be for a whole urban area or catchment but will need to consider possible interventions at all scales, and their cumulative impact.

Scale can be important for the effectiveness of BGI. For example, with respect to stormwater, integrated urban water systems involving water sensitive urban design are usually best implemented at precinct scale, enabling an appropriate mix of technologies for local water capture, storage, treatment and re-use (Stormwater Management Background Report, Croydon Town Centre, Engeny 2020).

This report is considering BGI at the precinct (or neighbourhood) scale, since the Croydon MAC Structure Plan deals with the Croydon Major Activity Centre, an urban precinct of approximately 140 hectares. Local scale blue-green infrastructure will also be considered at a sub-precinct, street and allotment level**.**



Figure 2.2: Scale of applying blue-green infrastructure

Source: DELWP 2017

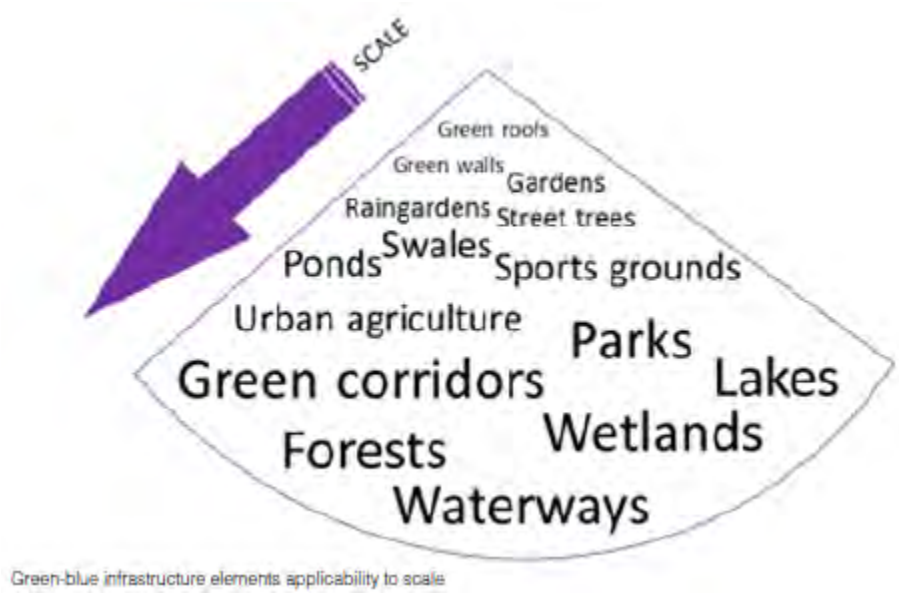


Figure 2.3: Elements applicability by scale

2.4 How can we deliver Blue-Green Infrastructure?

Blue-Green Infrastructure (BGI) can be delivered at a range of scales, from building to precinct level.

Regardless of scale, these systems will all typically have the following characteristics in common:

- Vegetation, providing amenity and habitat;
- Soil, of adequate volume, nutrient content and drainage characteristics; and
- A link to rainwater, stormwater or recycled water supply, with a frequency and quantity enough to support vegetation and soil health.

In addition, some systems may provide additional water management functions:

- Water treatment capacity, utilising natural process to filter local water supplies and reduce pollutants entering local waterways
- Water storage capacity, using volumes within soils or above ground space to provide detention of stormwater

Evidence from case studies has found that often the most effective BGI systems are the simplest since they mimic nature and are easy to maintain. Swales, for example, which rely on simple perviousness (water permeates through grass into the soil), can be more effective than a more highly engineered bio-retention system which requires technical knowledge and skills to understand and more frequent and expensive maintenance. More highly designed systems have their place; however, it is a matter of knowing which BGI approach is most appropriate for a given situation.

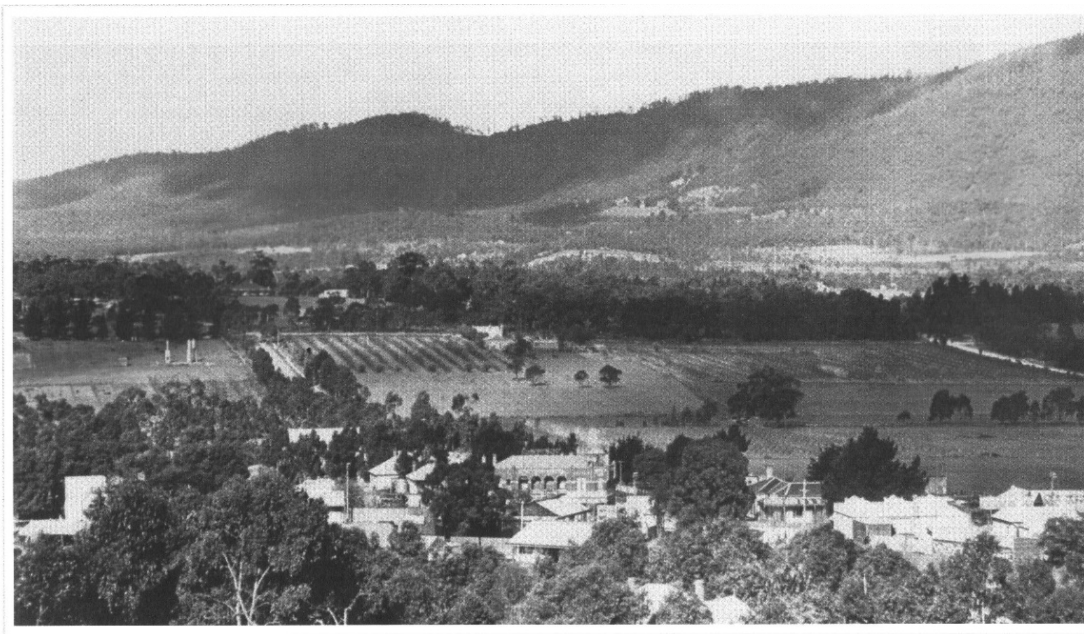
3. Croydon's Past and Present

3.1 History



In the 1840s land in the area now known as Croydon was used for grazing cattle by early settlers from Melbourne and neighbouring areas. It was not used as a campsite by First Australians because it lacked a permanent water supply. The area was originally called *White Flats after the silvery-white, coarse grass that grew there called 'White Top'*.

After parts of White Flats were surveyed in 1868 many parcels of land were bought, and the first shelters built. These were usually wattle and daub huts with hessian lining with later houses being constructed from sawn timber. The land in White Flats supported sheep, beef cattle and dairy farming. Pea crops grew particularly well, and orchards produced excellent cherries, apples, pears, plums and peaches.



Early panorama of the Dandenongs and the township of Croydon from the highest point in the Wicklow Hills. Notice the Hotel and distant dirt roads.

There was swampy land in the Croydon Valley and Tarralla Creek was tiny. The creek only became bigger because it was converted into a drain to turn the swamps into land considered productive by European settler standards. In the 20th century, Lilydale Shire (to the east) drained higher areas. The swampy parts of Croydon, including the flat parts of the current Major Activity Centre, were also drained for development. Tarralla Creek was named Croydon Main Drain until the early 21'st century when it was officially renamed 'Tarralla Creek' again. Currently the two main drains to Tarralla Creek are from Croydon and from the Montrose and Kilsyth suburbs in the former Shire of Lilydale (now Shire of Yarra Ranges).

3.2 Trends

Croydon Major Activity Centres' setting at the northern foothills of the Dandenong Ranges has resulted in a unique commercial environment in which a diversity of local businesses and civic enterprises cater to the needs of a growing local population. The Centre's retail precinct has been the primary driver of recent employment growth. The Centre includes industrial areas that in the past two decades have transitioned into local service centres. Major manufacturing and logistical uses have now largely left Croydon, replaced with places of worship and wholesaling uses.

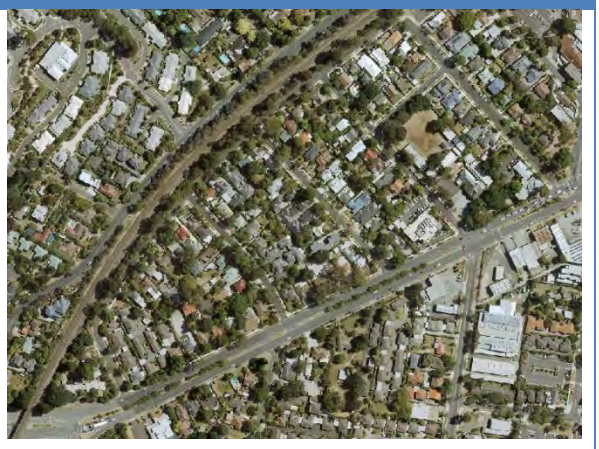
Aerial Image of Croydon MAC in 1963	Aerial Image of Croydon MAC in 2019
	

The aerial image shows the development changes in Croydon MAC area - key changes visible from the aerial image are establishment of sports grounds, Aquanation, Croydon Town Park and further establishment of the light industries in the north-west of the Centre as well as increased number of dwellings.

In relation to the built environment, the Centre's recent housing growth has underpinned relatively high rates of population growth within the Centre, which for the 2011 to 2016 period averaged approximately 4% per annum (in comparison, Maroondah averaged 2% p.a. growth while the outer east averaged 0.84% growth) (Charter Keck Cramer, 2020). The population growth has resulted in sub-divisions and investment in shopping centres, several sites of medium density projects and investment in the community services including sports and recreational facilities.

2001	2019
	

The aerial image shows the development of medium-density dwellings in the centre. A recent trend observed in Croydon.

Wicklow Avenue - 2001	2019
	

The aerial image (in red) shows loss of tree cover compared to the 2011 image. The area is just outside the western boundary of the 2006 Croydon MAC Structure Plan boundary

4. Overview of Green-Blue Infrastructure in Croydon

4.1 Overview

Croydon Major Activity Centre area is characterised with various land uses and public assets. It has a good amount of natural green environment on public and private land. The area comprises significant tree, sportsground and park cover, particularly in the western residential heights (trees) and the central civic areas (parks and sportsgrounds).

Blue-Green Infrastructure and water sensitive urban design features are focused on Council land in Croydon Park and Town Park. These are predominantly simple, low maintenance passive systems.

Key assets and projects close to, but outside the current boundaries of the Croydon MAC worth noting include:

- Re-imagining Tarralla Creek project. This integrated water management partnership project involves creek renaturalisation, wetland renewal and extension and stormwater harvesting;
- Dorset Recreation Reserve and Dorset Golf master planning opportunities, which could provide an opportunity to extend all or some of the elements of the Re-imagining Tarralla Creek project upstream of Dorset Road
- Eastfield Park master planning

The natural and built environment in Croydon MAC has been grouped into the following categories:

1. Parks, sporting grounds, recreation facilities, community gardens
2. Water bodies and creeks
3. Streets, median/verges
4. Transport corridors - rail, pedestrian and cycle routes
5. Private spaces: back and front yards, roof gardens, green walls, balconies. Note that private land makes up the most significant (more than 50%) proportion land in the Croydon MAC.

Table 4.1: Built and natural environment in Croydon

Natural environment/built environment		Area (% of total MAC area)	Comments
Public parks		18	Parks, sports fields, schools, institutions, community gardens
Creeks		5	
Transport corridors (trains, walking and cycling)		7	**includes footpaths but may not include shared paths*
Streets		11	*Streets and medians/roadsides*

Source: Maroondah City Council 2020

4.2 Parks and sports grounds

Public parks and sports grounds account for a significant proportion (18%) of the Croydon MAC area. These parks and sports ground are currently irrigated by potable water.

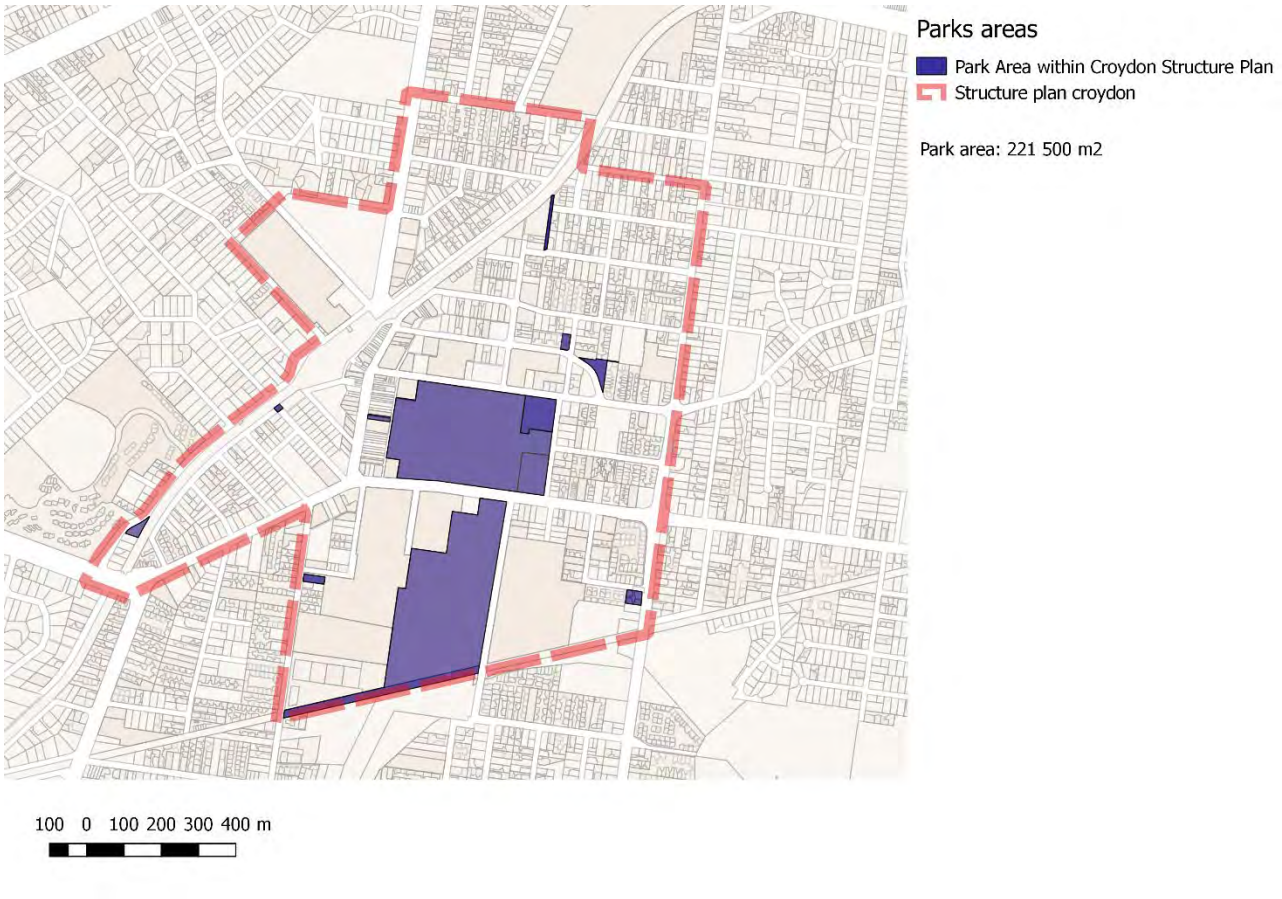


Figure 4.1: Park areas in Croydon MAC

4.3 Vegetation

Croydon was historically known as 'White Flats', thought to allude to the expanses of white-coloured native grasses (*Austrodanthonia* species) over this flat, swampy land.

4.3.1 Ecological Vegetation Classes

Ecological Vegetation Classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred association with environmental attributes. The presumed distribution of EVCs prior to European settlement (pre-1750) have been modelled for all of Victoria, and the extent of EVCs was also modelled for 2005.

The pre-1750 modelling for the Croydon MAC area suggests there were originally four EVCs represented, with a fifth just outside the study area. The predominant pre-settlement EVCs for the Croydon MAC area were Valley Heathy Forest and Swampy Woodland.

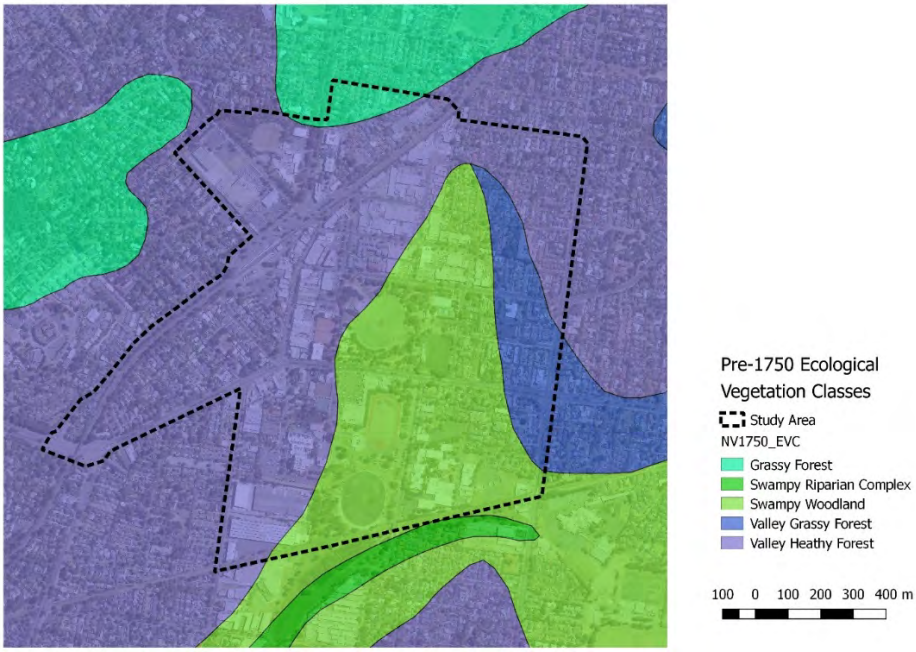


Figure 4.2: Ecological Vegetation Classes

4.3.2 Sites of Biological Significance

In 1997 Maroondah City Council commissioned the report "Sites of Biological Significance in Maroondah" by Dr Graeme Lorimer, et al. to include sites of biological significance in the Maroondah Planning Scheme for public and private property. The study and resultant report determined the location of, and described in details, Maroondah's most environmentally significant sites and how best to protect and maintain them.

As part of undertaking its municipal-wide vegetation review to determine changes required to vegetation-related priorities, policies, practices and planning measures, in 2018, Maroondah City Council again commissioned Dr Lorimer to undertake a follow up study that resulted in the 2020 report "Biodiversity in Maroondah". This report aims to provide a clear, contemporary understanding of Maroondah's biodiversity: what species and ecosystems it comprises; where it is concentrated; what threatens and sustains it; and what Council and the community can do to protect, restore and improve it.

There are three sites that fall within (partially or wholly) the Croydon MAC area:

Site 55 Croydon Primary School

Biological Significance Level: 'National' due to two globally endangered species (Matted Flax-lily (*Dianella amoena*) and the flat-pea *Platylobium infecundum*); 'State' due to the presence of an endangered vegetation type (Valley Heathy Forest). The site occupies 1.8 ha covering part of the Croydon Primary School grounds, the adjacent nature strip along Tallent Street and a large White Stringybark on private land on the opposite side of Tallent Street.

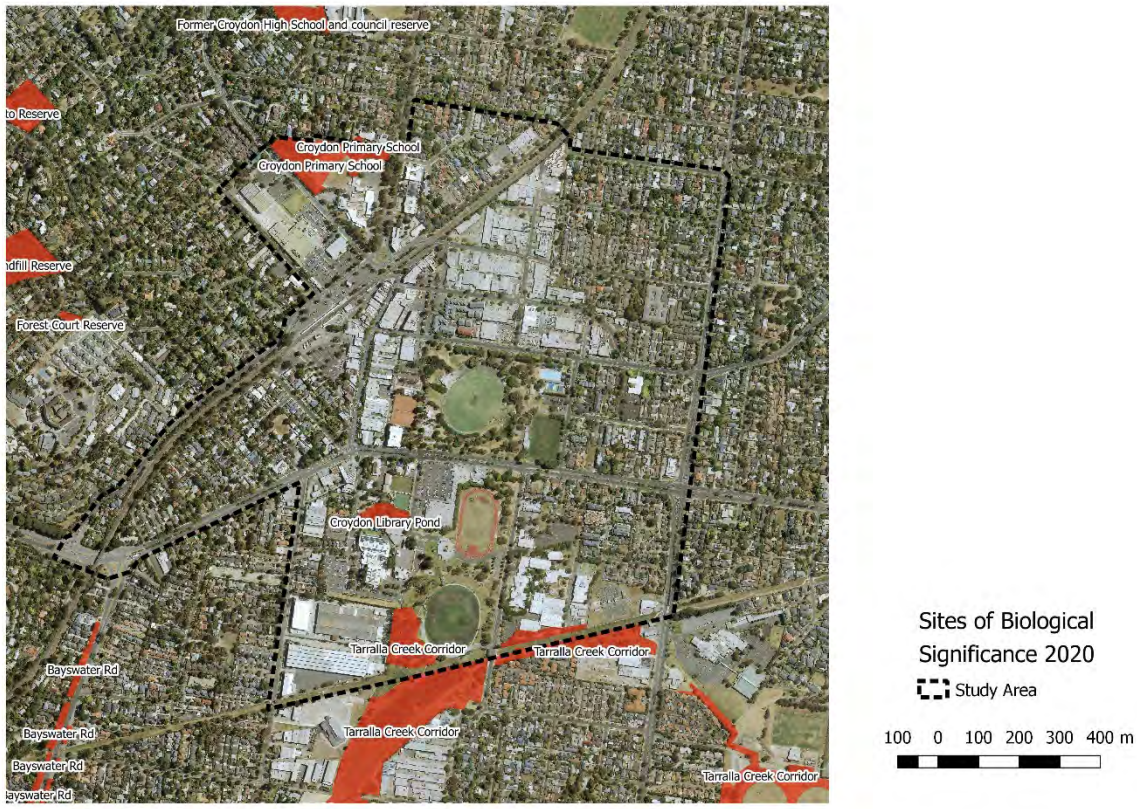


Figure 4.3: Sites of Biological Significance

Site 62 Tarralla Creek Corridor (partially with the Croydon MAC area)

Biological Significance Level: 'State' at part of Dorset Recreation Reserve due to the presence of a patch of an endangered vegetation type (Valley Heathy Forest and Swampy Woodland); 'Local' elsewhere. The site is comprised of ten parts measuring a total of 76.8 hectares. They extend 6.2km along the arc of Tarralla Creek and its floodways. The part within the Croydon MAC occupies 1.1 ha.

Site 135 Croydon Library Pond

Biological Significance Level: 'State' for occurrences of the endangered Blue-billed Duck (*Oxyura australis*). The site occupies 0.46 ha and includes the pond next to the Croydon Library as well as its surrounding vegetation and treed island.

4.3.3 Habitat Corridors

In 2005 Maroondah City Council commissioned the study "Maroondah Habitat Corridors Strategy" that set out a plan for a network of habitat links connecting larger areas of remnant vegetation to protect and enhance biodiversity within and beyond the City of Maroondah. Several obstacles limited the extent to which this strategy was implemented, and Maroondah City Council is undertaking a piece of work to confirm the priority corridor routes , identify what needs to occur and where to create the linkages, and present this as a map of opportunities for building habitat connectivity and encouraging more nature throughout Maroondah. The original study identified corridor routes and gave them a conservation priority rating on a five-level scale.

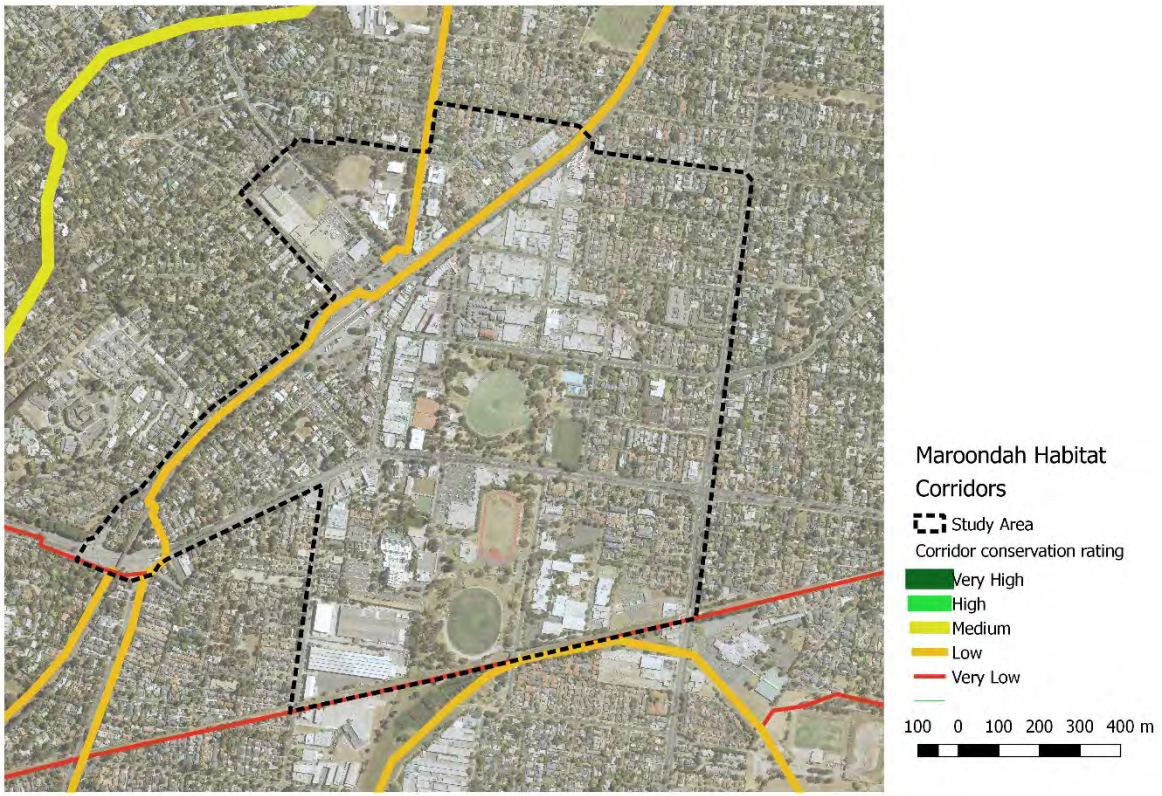


Figure 4.4: Maroondah Habitat Corridors

There are three identified habitat corridors that pass through or along the boundary of the Croydon MAC, all of which have been rated as 'Low' conservation priority:

- Tarralla Creek corridor is part of the 'Tarralla Creek' group that links from the Healesville Freeway Reserve at its upstream end in Maroondah and follows the alignment of Tarralla Creek through the Dorset Golf Course and Dorset Recreation Reserve, through Eastfield Park to join Bungalook Creek. The 2005 report identifies opportunities to improve arboreal, ground and aquatic connectivity.

- Lilydale Rail Line corridor is part of the 'Mt Dandenong Road and links' group that focuses on Mt Dandenong Road from Maroondah Highway to Bayswater Road and links to and across Mt Dandenong Road. While not high priority in themselves, between them they provide the only northwest-southeast linkage between Mullum Mullum Creek and the Lilydale Rail line/Wicklow Hills corridors south of Plymouth Road. The 2005 report identifies opportunities to improve arboreal connectivity.

- Croydon Road - Warrien Reserve corridor is part of the 'Other low priority roads' group that is mainly on the eastern side of the municipality and based on main roads with narrow reserves of remnant vegetation following them and higher than usual number of remnant trees in adjacent residences. The 2005 report identifies opportunities to improve arboreal connectivity, and ground connectivity in parts.

4.3.4 Tree/foliage canopy cover

Maroondah has quite high canopy coverage compared with most of Metropolitan Melbourne. The foliage cover of the tree canopy as well as smaller shrubs plays a big part of Maroondah's 'green and leafy' character.

Table 4.2: Maroondah's canopy cover

Area	Percentage Tree Canopy Cover	Percentage Shrub Cover
Metropolitan Melbourne*	15.4%	15.1%
Maroondah	29%	18.9%

**Source: Living Melbourne: Our Metropolitan Urban Forest Strategy Technical Report (April 2019)*

Maroondah City Council has been working with Player Piano Data Analytics on an innovative technique for estimating foliage cover from aerial imagery using machine learning, with development of the product 'Tree Ledger'. Vegetation mapping data from Council's Tree Ledger indicates that between 2011-2019 the precinct experienced a reduction in total vegetation cover as shown in below figure (with losses shown in red).



4.4 Hydrology and Drainage

The Croydon MAC area lies largely in a valley at the base of the Wicklow Ridge line that is a dominant landscape feature of Maroondah.

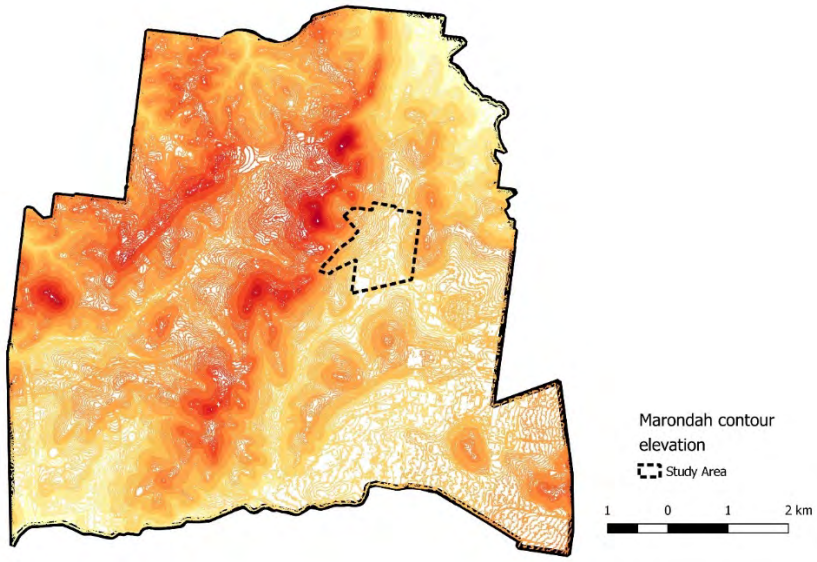


Figure 4.5: Maroondah Contour and Elevation

This valley shown in Figure 4.6 forms a catchment of Tarralla Creek and almost all the overland flows arising from the Croydon MAC area flow into the Tarralla Creek just upstream of the treatment wetlands that are the subject of the major project, Re-imagining Tarralla Creek.

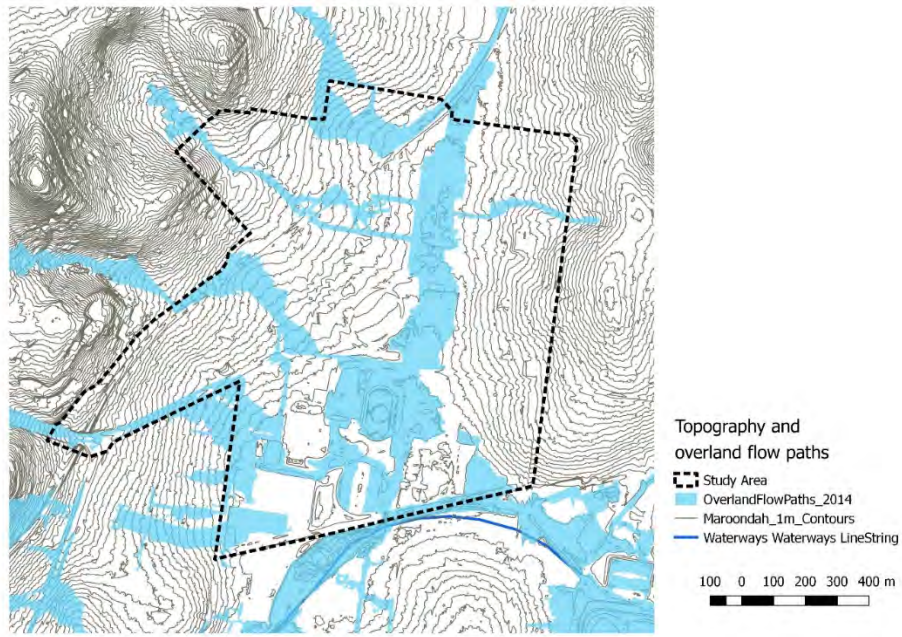


Figure 4.6: Maroondah Topography and Overland Flow Paths

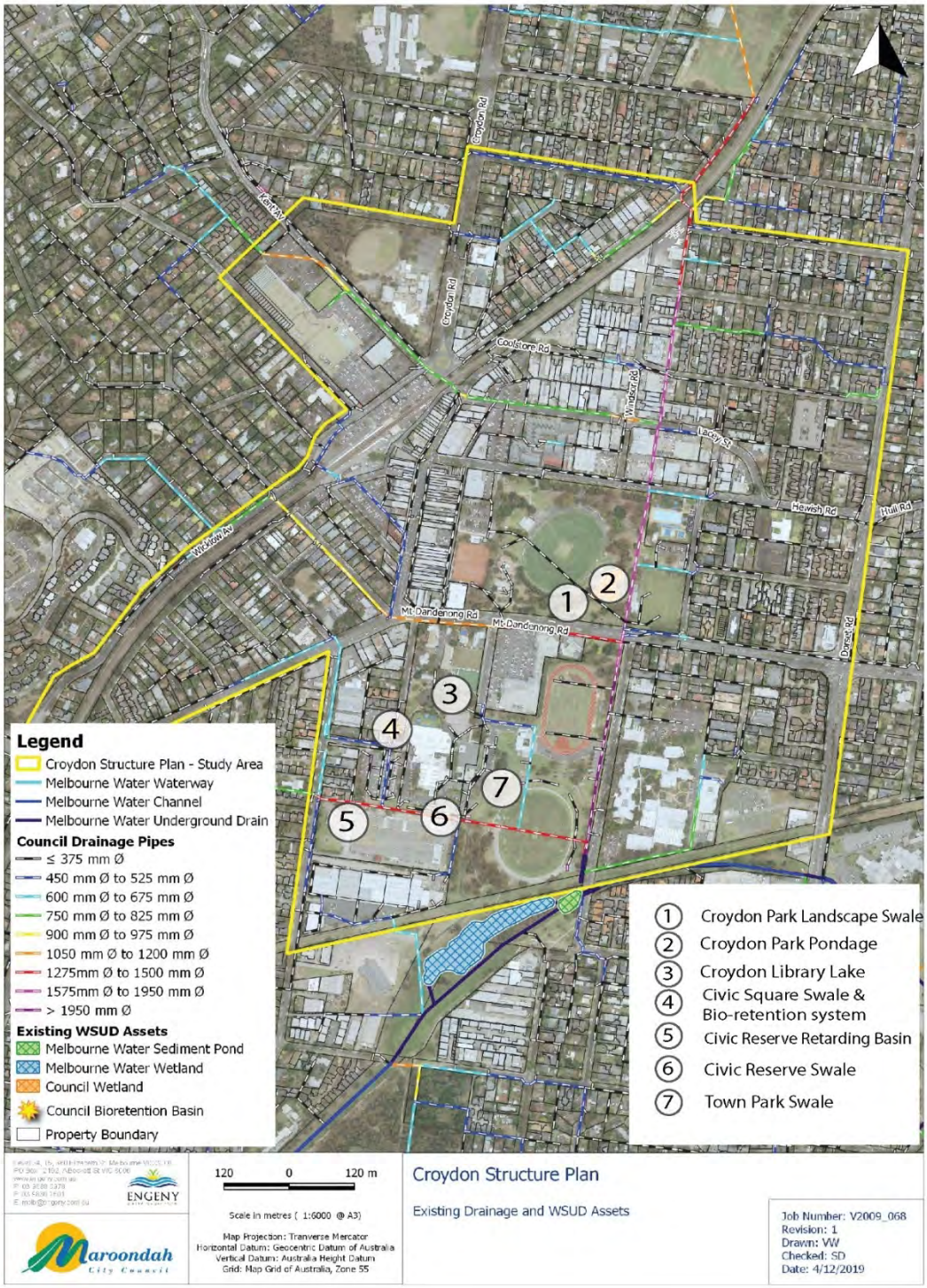


Figure 4.7: Existing Drainage and WSUD assets in the Croydon Major Activity Centre [9] *and WSUD and Bodies of Water Condition Assessment. Draft Report 15/6/2017*

Source: Engeny and Maroondah City Council 2019

Figure 4.7 shows Council's opportunity areas for blue-green infrastructure concentrated around Civic Square. Croydon Town Centre study area is located within the Upper Tarralla Creek drainage sub catchment and discharges to a Melbourne Water managed wetland / retarding basin (known as Croydon wetland) located south of Town Park. Outflow from the wetland / retarding basin is connected to Tarralla Creek, a tributary of Dandenong Creek. The Upper Tarralla Creek drainage sub-catchment is approximately 250 hectares in area.

4.5 Creeks

Tarralla Creek is contained within urban catchment located to the south of the Croydon Major Activity Centre, with the following characteristics:

- Active transport and public open space corridor which links between Bayswater Road in the south, and then runs to the north east to Dorset Road. The shared path is part of the regional Carrum-Warburton Trail.
- The creek catchment is extensive, and in Croydon runs from the Dorset Recreation Reserve, before being contained in a low flow, underground pipe until Eastfield Road when it resurfaces as a concrete channel.
- The low flow pipe means that any environmental, social or cultural interactions with the creek are not able to take place. However, this is being rectified as part of the Re-Imagining Tarralla Creek project.
- In major storm events, the low flow pipe overflows and 'bubbles up' into the grassed creek corridor, which then flows as an overland flow path along the creek alignment.
- Following storms, the creek is left as a soggy grassed corridor, with little opportunity for crossing points or interaction.

The Tarralla Creek corridor currently provides:

- Easy access for residents of Croydon and Croydon South to Eastfield Park, Croydon Wetland and Croydon Major Activity Centre
- Shared use path and walking paths allow for good access recreational walking loops around the creek

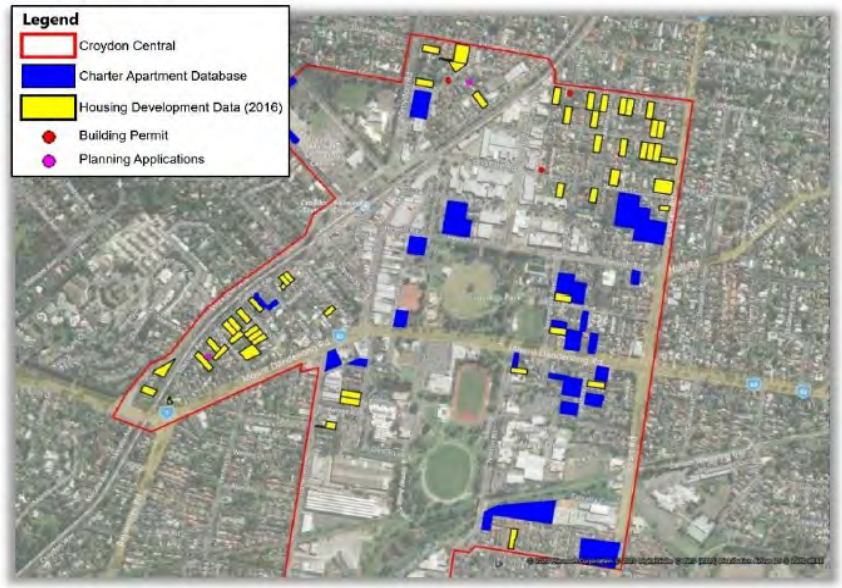


Figure 4.8 - Tarralla Creek and the Vicinity (can't read the labels)

4.6 Built environment

For the past two decades the Croydon region has been a major source of dwelling supply in Melbourne's outer east, owing to a combination of numerous small-scale subdivisions, medium density. **Figure 4.9** identifies post 2003 dwelling completions as well as planning and building approvals (Charter Keck Cramer, 2020). The figure below shows that most of the apartment approvals have been around the middle of the Centre.

Figure 1: Dwelling completions and development Croydon Precinct (2003-2021f)



Source: City of Maroondah, Department of Environment, Land, Water and Planning, Charter Keck Cramer.

Figure 4.9: Dwelling completions and development in Croydon

Since 2003, the Centre has added 485 new apartments (shown in blue above). Peak annual supply occurred in 2015 (with 64 apartment completions). Since 2003, there have been 5 years in which apartment completions have equalled or exceeded 50 or more completions. Key medium and high-density projects (>100 dwellings per hectare) are presented below:

Some of the characteristics of the residential areas include:

- Lot sizes are generally 500m2 - 1200m2,
- Established gardens (frequently with canopy trees as features) or low fences generally screen dwellings
- Generally single dwellings front the street, while multi-unit development generally front side boundaries and a driveway to one side.
- Several new multi-level apartment buildings have been constructed and are generally:
    - in contemporary architectural styles.
    - three to four storeys high.
    - rendered blockwork, or a combination of brick, rendered blockwork and/or partial timber cladding.
    - address to the street.
    - frontage treatments tend to be open, with simple, low maintenance vegetation and large walled elements containing letterboxes

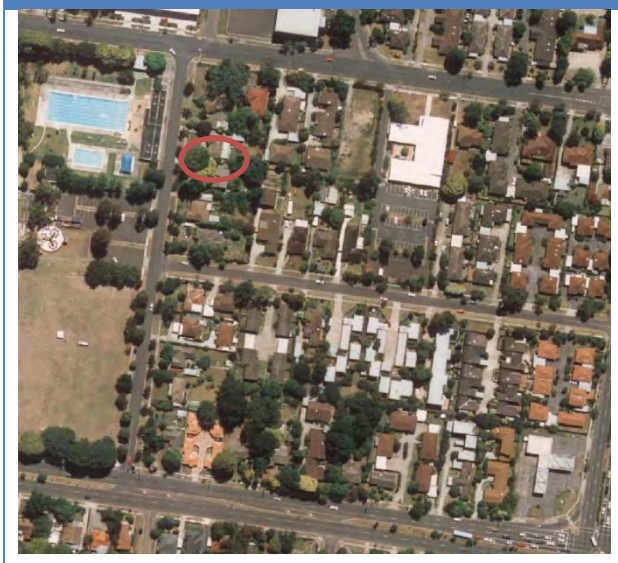
Croydon Library and the Surrounds - 2011 2019

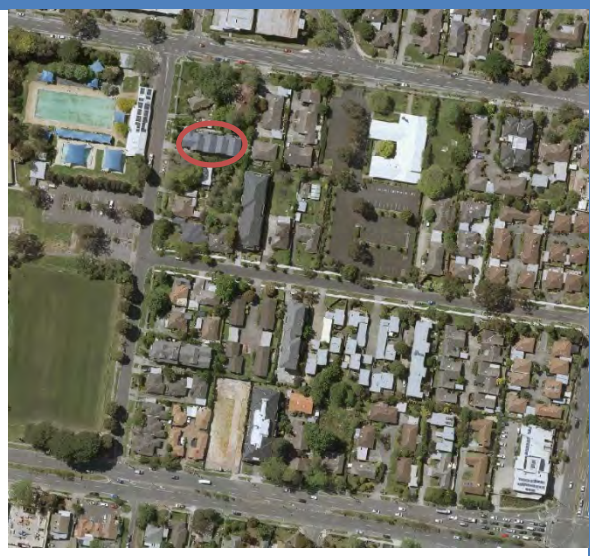




Aerial image shows increased off-site car parking in the centre in 2019

East of Springfield Avenue- 2001 2019





Aerial image shows some medium density dwellings in year 2019

4.7 Institutional and private ownership

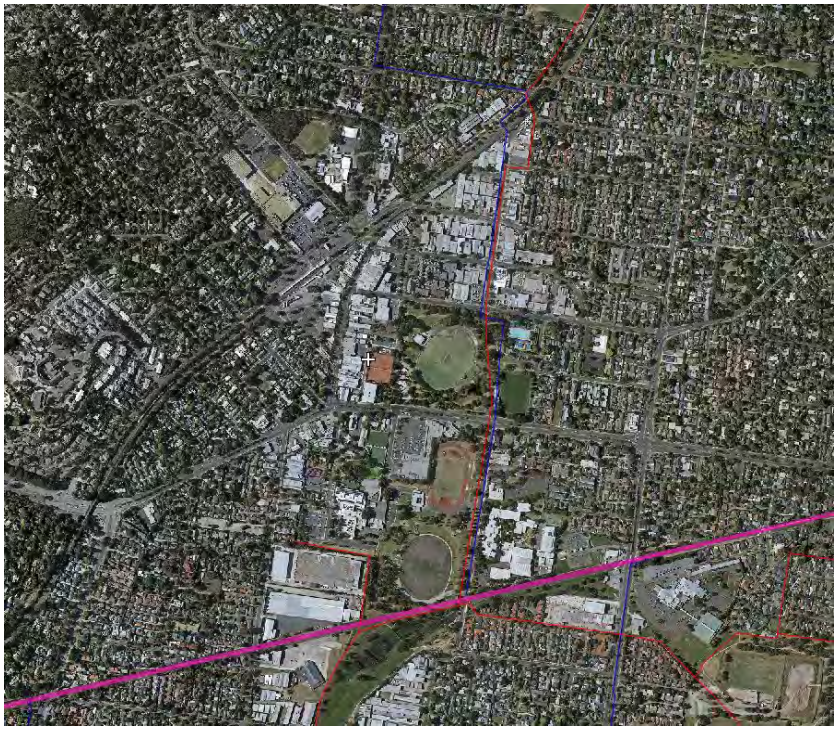
Water infrastructure includes:

- Local drainage systems
- Mains water pipes
- Sewerage mains and pipes
- Brushy Creek Sewage Treatment Plant (STP) in Croydon North, north of the activity centre area.
- Rainwater harvesting (water tanks) on public and private land
- WSUDs and other integrated water management activities on public (and private land)
- Unknown others, e.g. possible greywater harvesting on private land (to be determined)

Melbourne Water mandate is to create and maintain WSUD, BGI and GI features. Of most relevance to Croydon MAC area, it manages Tarralla Creek and the Re-imagining Tarralla Creek project. It also manages potable water aqueducts such as the O'Shaunessy Aqueduct.

As integrated water management becomes a more common practice, private water authorities such as Yarra Valley Water are becoming involved in precinct-scale BGI projects such as Re-Imagining Tarralla Creek. They also actively consider other innovative projects which create safe, alternative uses for wastewater such as irrigation by Class A treated water from Brushy Ck STP.

Private land owners have sometimes installed WSUD features on residential land, however effective maintenance has often become problematic. These and other BGI may become more common on commercial and industrial land due to new State planning scheme controls requiring owners and managers of all land types to better manage the volume and quality of stormwater leaving their land.



The red lines are major sewer mains. The pink are the major water transfer pipes owned and managed by Melbourne Water. Source: Yarra Valley Water.

5. Key Issues and Opportunities

This section presents key issues affecting the Croydon Major Activity Centre. It also presents briefly the blue-green infrastructure approach that could be considered to alleviate these issues. The following are considered key issues in Croydon Major Activities Centre (MAC) area. Note that many of the issues and opportunities are inter-related and affect each other. Increasing permeability, for example, will also reduce flooding and reduce the loss of vegetation by removal and lack of water.

Table 5.1 Summary of Key Issues and Opportunities

Key Issues in Croydon MAC	Key Opportunities
Imperviousness (perhaps 'increasing area of impervious surfaces')	- Water Sensitive Building Typologies - Greater building setbacks - Green roofs - Porous paving (grass mosaic) - Rainwater capture (eg tanks) - Roadside WSUD - Stormwater offsets/and/or Development Contribution Plan - Greening the Greyfields approach - Update Council's Engineering Guidelines to require more land perviousness.
Flooding	- Retaining and re-using water along overland flowpaths and movement corridors such as shared paths, which could be landscaped as blue-green corridors - Require more rainwater tanks in new builds and retrofit where possible - Apply blue-green infrastructure upstream and downstream as possible to alleviate flooding, including incorporation into traditional flood mitigation works where possible - Undertake stormwater harvesting at Fred Geale Oval and Silcock Reserve, where viable. - Undertake further rainwater harvesting in Council facilities, such as Aquatic Centres, where feasible, or mitigate overflow using raingardens - Consider creating raingardens with passive watering at key pedestrian intersections - Use roadsides and pocket parks as part of stormwater treatment train in areas subject to flooding - Revisit passive WSUD on small allotments
Increasing Urban Heat Island Effect	- Acquire access to private land which could extend existing parks or create pocket parks. - Incentivise the retrofit of carparks with permeable paving for lunch areas for employees - Incentivise green roofs - Further protect existing canopy trees and encourage the planting of new canopy trees on private and public land
Vegetation loss	- Improved planning controls and incentives to retain vegetation and increase perviousness - Require development setbacks which allow gardens and canopy trees - Incentivise the installation of green roofs - Negotiate public access to well-vegetated private land to facilitate a connection with nature - Provide greater protection for Sites of Biological Significance and Habitat Corridors, including strategic, vegetated connections and corridors and improved interpretation - Support a proactive Council tree-protection program on its own and private land - Restore natural hydrology regimes to support swampy vegetation
Degradation of Tarralla Creek	- Lobby for an extension of the Re-Imagining Tarralla Creek (RTC) project to other sites strategically near Croydon MAC - Use the 'green link' corridor idea to further assist in connecting the creek to the MAC - Use the RTC to connect people with the creek and how its connection relates to urban development issues - Engage indigenous people involved with RTC with the Structure Planning process to help extend blue-green infrastructure collaboration opportunities into Croydon MAC

5.1 Imperviousness

Increasing urban intensification is resulting in greater coverage of land with hard impermeable surfaces which prevent stormwater from being absorbed into the soil. (Kaspar, J. (2018). Maroondah Canopy & Landscape Analysis 2011 to 2016 reports that 'Hard surface' increased by 1.9% across all of Maroondah between 2011 and 2016) The result is greater volumes of water running off the land at a faster rate than more natural conditions. Greater imperviousness exacerbates all the other key issues listed as follows for the Croydon Major Activities Centre, and as such, is the most important one to tackle:

- flooding
- waterway degradation (Tarralla Creek)
- vegetation loss
- threats to community wellbeing including
    - lack of connection to nature
    - urban heat island effect
    - reduced local amenity which undermines active lifestyles
    - reduced air quality through increased pollution.



Figure 5.1 Impervious Surface in Croydon MAC

As can be seen from Figure 5.1, a significant proportion of land (52,000 sq.m.) in Croydon MAC is covered by off-street car parking that has increased impermeable surfaces, while the area covered by roof provides opportunities for greening.

Many opportunities listed against other issues in this section are also important in reducing imperviousness (and vice-versa) but will not necessarily be repeated in the table below. Similarly, many opportunities listed below will not necessarily be repeated in 'opportunities' tables provided for tackling other issues listed in this section.

Table 5.2 Key opportunities to reduce imperviousness

Element	-	Options	-	Potential location in MAC
Private land	-	Water-sensitive building typologies such as those espoused by the CRCWSC, Nightingale developments and others listed below which support multiple benefits for all stakeholders.	-	Residential land
	-	Greater building setbacks	-	Residential, commercial, industrial, institutional
	-	Green roofs	-	Residential, commercial, industrial, institutional, especially larger developments
	-	Porous paving (grass mosaic)	-	Driveways and car parks - Private streets
	-	Rainwater capture (eg. tanks, to reduce runoff)	-	Residential, commercial, industrial, institutional
Public land	-	Green roofs	-	Devon Street multi-level carpark - Council buildings with large roof areas such as Croydon Community Precinct and Aquatic Centres
	-	Porous paving (grass mosaic)	-	Council carparks
	-	Roadside WSUD	-	Major/wide roads
General	-	Stormwater offsets or Development Contributions Plan	-	Residential, commercial, industrial, institutional
	-	Greening the Greyfields approach	-	Precincts with high imperviousness
	-	Update Council's Engineering Development Guidelines to require more permeability	-	Residential, commercial, industrial, institutional
	-	Learning from other Council models e.g. Kingston, Moonee Valley	-	Residential, commercial, industrial, institutional
	-	Use Council's ESD policy for Council Buildings	-	Applicable to Council building across the municipality.
Typologies	-	Consider various dwelling typologies and street layout	-	Residential and Commercial

Examples which support more sustainable development, including blue green infrastructure are:

- 20-minute city model
- 'Nightingale' multi-unit development model
- Greening the Greyfields

- City of Melbourne's 'Green Factor' tool
- Water-sensitive building typologies

To increase permeability, there have been several typologies for dwelling designs tested under the Water Sensitive Cities programme. Consideration should be given to the key guiding principles for designs to improve permeability in the streets of Croydon MAC.

Key Considerations are:

- optimising building footprint/ roof surface for runoff mitigation against rainwater harvesting;
- optimising vegetated surfaces for evapotranspiration against increased water demand for irrigation;
- optimising higher occupancy for water efficiency against lower occupancy from more compact dwelling size;
- optimising the canopy cover, distribution and density for reduced heat stress.

5.2 Flooding

In recent years several major floods have affected residents living in the City of Maroondah, including within the Croydon Town Centre precinct. The central parts of the area are prone to flooding. In 2010 and 2011, there was significant flash flooding in the Croydon Civic drainage catchment. Flood mitigation works around Civic Square and Lusher Road in Croydon have commenced to alleviate flooding in this area.



Flooding in Civic Square, 2010 (Credit Engeny 2019)



Flooding in Birdwood Road 1st December 2010 (Credit: Engeny, 2019)

Figure 5.2 shows the flood modelling results for the peak 100-year ARI event whilst **Figure 5.1** depicts a photo taken during the December 2010 storm event to highlight the extent of flooding in Lacey Street and Birdwood Road.

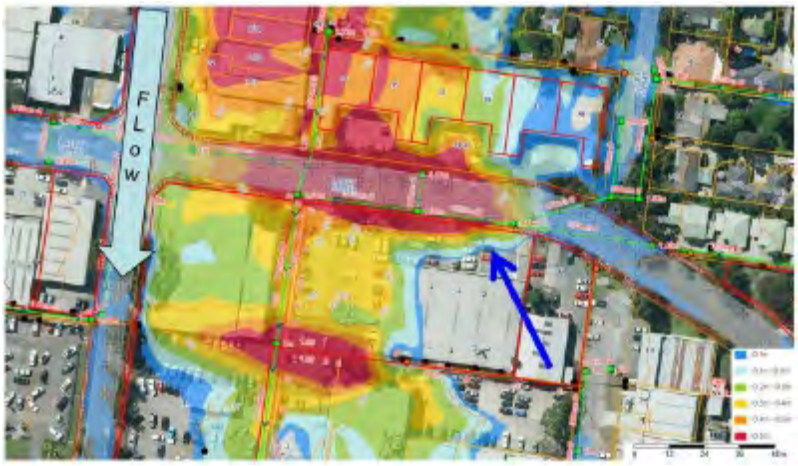


Figure 5.2: Flood modelling results for Lacey Street, Croydon (100-year ARI results) (Source: Engeny 2019)

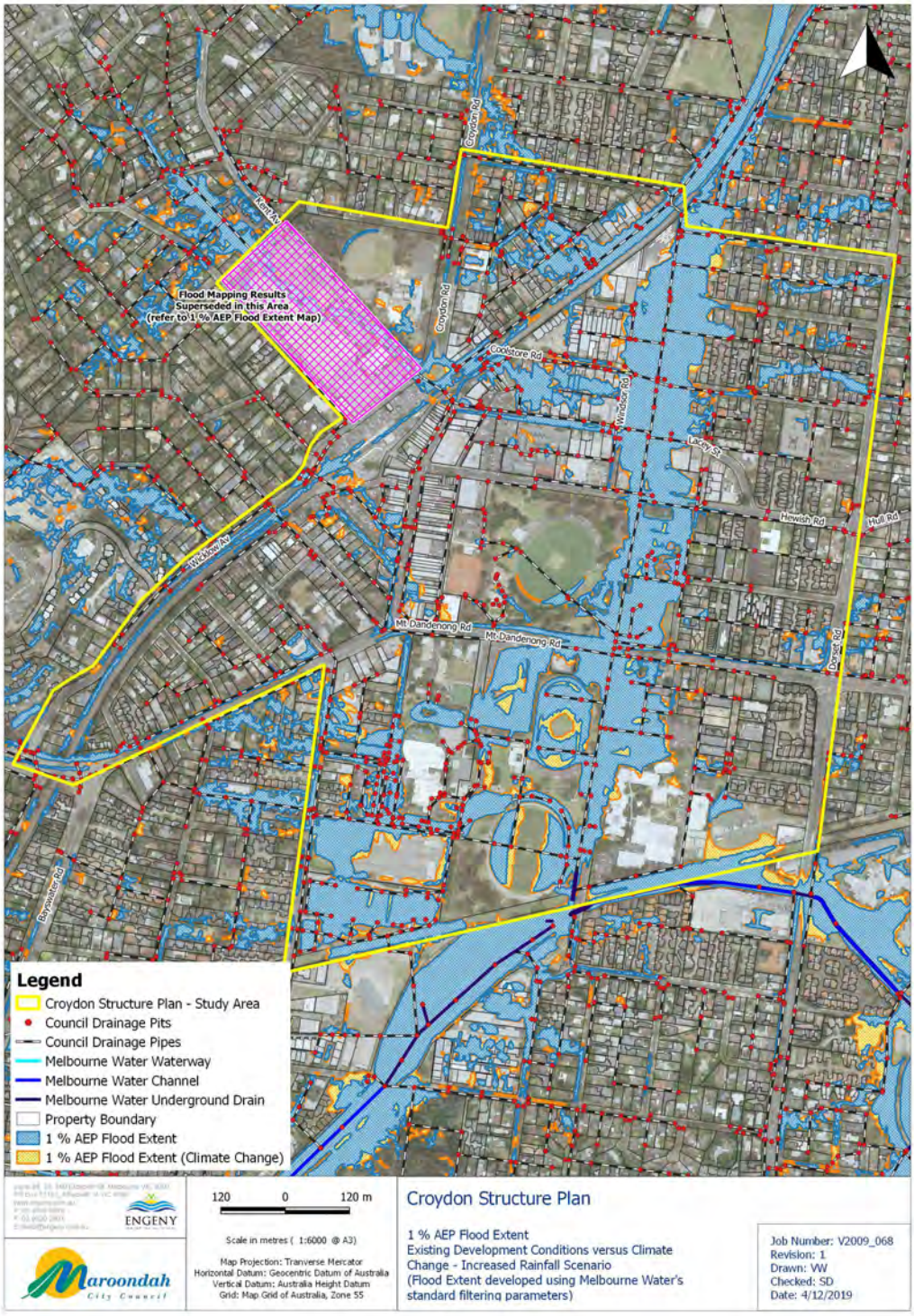


Figure 5.3: 1% AEP Flood Extent: Existing Development Conditions versus Climate Change - increased rainfall scenario (Source Engeny Report 2019)

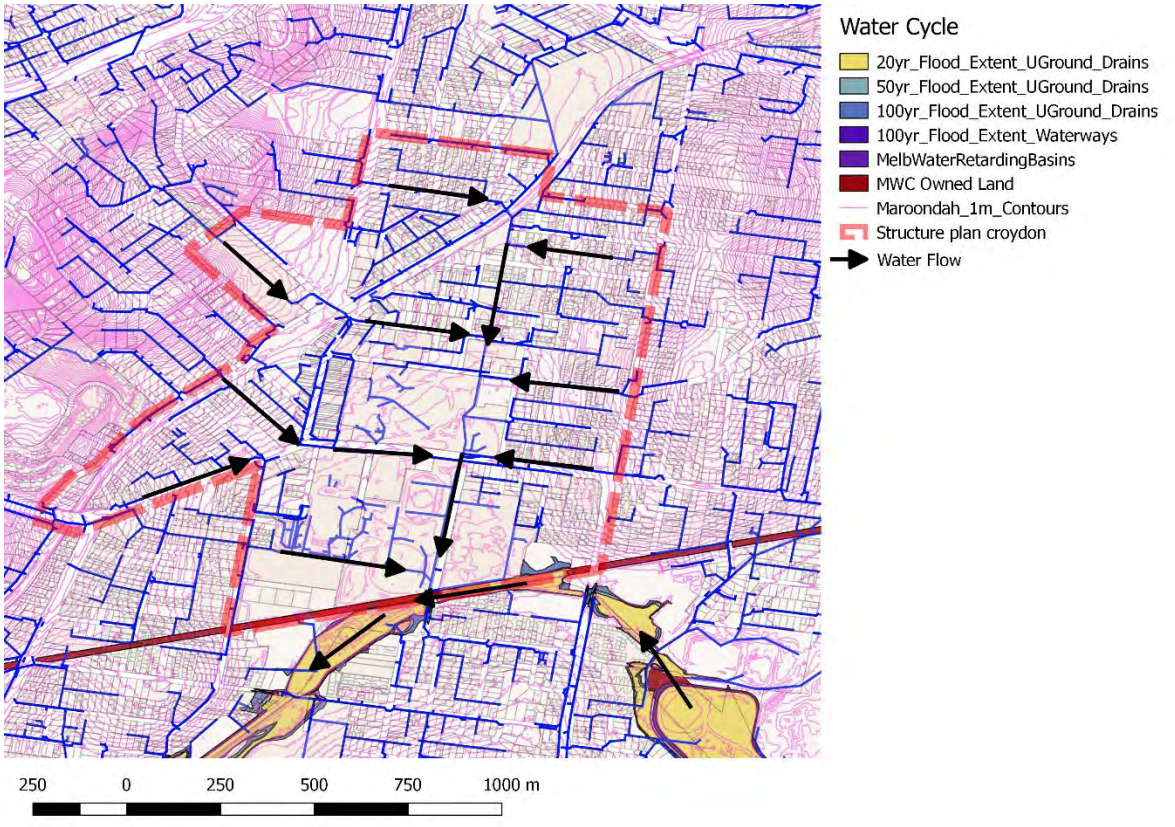


Figure 5.4: Water Flow

Figure 5.4 shows the water flow direction in the study area. There is only one drain connection between the Croydon MAC area and Tarralla Creek upstream from the Tarralla Creek project allowing treatment options before the water being sent back in the environment

Key reasons for flooding:

- Low surface gradients due to original topography of the subject area being part of the former swamp and creek floodplain.
- The design and top surface water levels in the Melbourne Water Croydon Main Drain (Tarralla Creek) Retarding Basin in the 1 in 100-year ARI flood flow conditions.
- The inlet arrangements to the Melbourne Water Retarding Basin at the Norton Road Sediment trap whereby the capacity to take flows is impeded by the water supply pipes across the inlet structure, a cut-throat channel arrangement and frequent blockage of the outlets into the wetland and retarding basin, all causing tailwater conditions that impede pipe flows.
- Only one major drain connection between the Croydon MAC area and Tarralla Creek upstream from the Re-Imagining Tarralla Creek project site.
- High level of impervious surfaces.

Flood control and mitigation is considered within a multi-layered and integrated system that starts in backyards and includes Water Sensitive Urban Design (WSUD), local detention, treatment, storage and re-use. The emphasis is retaining water, increasing permeability and stormwater harvesting.

Maroondah City Council has invested in a range of projects and infrastructure designed to minimise flood risk. By integrating more permeable surfaces like grass and gravel and designing in areas where flood waters can be directed and stored safely, we can reduce the risk of damage to properties and the environment and improve safety.

As significant proportion of flow paths traverse Council land, there is an opportunity for Council to retain and reuse water along these flow paths. In addition, there is a need for stormwater harvesting and flood mitigation through appropriate design intervention.

Table 5.3 Key opportunities to reduce flooding: NB (see also 'imperviousness' opportunities)

Element	-	Options	-	Potential location in MAC
Waterways/Water Sensitive Design/Water retention	-	Retaining and re-using water running along the flow paths	-	To be determined. Could include large lots on private land, especially along the Windsor/Rawlinsons/Springfield Avenue flood path.
	-	Retrofit infrastructure to treat and hold water and thus reduce flooding	-	To be determined
	-	Apply WSUD in the design of new infrastructure;	-	To be determined
	-	Areas prone to flooding be mitigated by applying blue-green infrastructure either upstream to reduce flooding, or on sites subject to flooding, or both;	-	To be determined. Could include large lots on private land as above.
Waterways	-	Consider opportunities for applying blue-green infrastructure through stormwater harvesting at Silcock Reserve and Fred Geale oval (Tarralla Creek project).	-	Proposed' green link' from Croydon Park and Town Park along Tarralla Creek to Eastfield Park
Raingardens	-	Aquatic centres may already harvest rainwater to flush toilets and irrigate, however in the absence of any water harvesting consider whether overflow during heavy rainfalls could be used by raingardens.	-	Aquatic Centres in Croydon MAC, i.e. Aquahub and Croydon Memorial Pool
Raingardens	-	Passive watering of raingardens at key road/pedestrian where there are wider paths and pedestrian islands and where people stop and spend time	- Mt Dandenong Road / Dorset Road; - Mt Dandenong Road / Bayswater Road; - Mt Dandenong Road/Wicklow Avenue; - Dorset Road/Hull Road/Hewish Road; and - Wicklow Avenue/Croydon Road/Kent Avenue.	
Parks and Streets	-	Application of water retention solutions in the existing pocket parks and roadsides as part of a stormwater 'treatment train'. Identify unused land at the ends of streets that could be considered for BGI.	-	Lacey, Sturt and Alfrick Reserves could contribute to flood solutions in the Windsor-Norton corridor
Private land	-	Revisit passive WSUD on small allotments	-	Consider examples used by Moonee Valley Council
	-	See suggestions for 'imperviousness'	-	Various land zones

There are some significant lot sizes (2000 sq.m. or more) along the major flow paths. Once Council has demonstrated effective (flood reduction) retrofitting, the land owners of these large lots could be encouraged through the planning process to apply WSUD principles. This could be undertaken in addition to work being undertaken in the upstream catchment to introduce stormwater detention and re-use - as this is needed throughout the whole catchment.



Figure 5.5: Lot size distribution in Croydon MAC

5.2 Urban Heat Island Effect

Demand for all types of development in Croydon MAC continues to increase the coverage of land in hard surfaces such as roads, roofs, carparks and driveways. The subdivision of residential land into smaller lots has provided landowners with a windfall profit, however it has also resulted in reducing canopy cover, increasing the number of driveways, increased flooding risk and decreased open spaces with permeable surfaces which allow for the penetration of water and the retention of space and soil for vegetation. The streets that are typically 'hardscapes' (paved environments with limited greenery) exacerbate the urban heat island effect, create excess stormwater runoff, and negatively impact human and ecological health due to a lack of trees and other vegetation.

Increasing the cover of living vegetation, adding surface water and keeping water in the soil have all been shown to reduce the urban heat island effect, so actions which increase vegetation, particularly canopy cover, and land permeability in urban areas are of prime importance. Building surfaces covered by vegetation can be significantly cooler than unshaded/covered surfaces. Parks can be several degrees cooler than surrounding urban areas. The temperature difference is often largest at night and tends to increase with park size[10]. Surface temperatures of dry parks (what is a 'dry park'?) during the day could be higher than the surrounding urban neighbourhoods[11] (Note: Surfaces with high solar reflectivity , solar panels and/or shading structures can also reduce the UHI effect)

Good urban design integration is needed with other features like roads, courtyards, and parking areas to ensure these areas have good longevity.

Heat Vulnerability Index (HVI): The HVI rating is determined by three components: heat exposure, sensitivity to heat (due to land cover, population density, and age), and adaptive capacity (e.g. socioeconomic advantage or disadvantage)[12]. The HVI rating for Maroondah City Council area was 2. The HVI (2014 and 2018) shows areas with increased HVI in Croydon MAC. The area on the eastern side of Croydon Road has shown increase in the HVI rating, that could be attributed to increased development of town houses and units with long driveways and reduction of the green and open spaces. This additional urban heating occurs when natural, vegetated landscapes are replaced with impervious infrastructures such as buildings, roads, pavement etc which leads to excess heat storage which is slowly released at night.

The CAUL Hub analysis also made an assessment of Heat Vulnerability at the ABS Statistical Area 1 level, based on 2016 census data and 206 vegetation cover data. They generated a Heat Vulnerability Index (HVI) that seeks to identify areas where we might expect high community vulnerability to heat waves by incorporating demographic data including population density, population percentages of people older than 65 years old. and younger than 4 years old, number of people in need of care, and the Socio-Economic Indexes for Areas (SEIFA), Index of

[10] Bowler D, Buyung-Ali L, Knight TM, Pullin AS (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* 97 147-155

[11] Mueller EC and Day TA (2005) The effect of urban ground cover on microclimate, growth and leaf gas exchange of oleander in Phoenix, Arizona. International Journal of Biometeorology 49(4): 244–255

[12] This data was integrated by summing the scores from the three vulnerability components, dividing the statistical areas into quintiles, and attributing the statistical areas with a Heat Vulnerability Rating scaled from 1 to 5 (1 = low vulnerability, 5 = high vulnerability). Equal weighting (one third each) is given to heat exposure, sensitivity to heat, and adaptive capability.

Relative Socio-Economic Disadvantage, and Index of Education and Occupation. This study shows that some parts of the Croydon MAC area have shown an increase in the HVI from 2014 to 2018



Figure 5.6: Heat Vulnerability Index 2014

2014	**2018**
	
Image shows the reduction of green spaces and increase in the town house and unit development with long drive ways in 2018.	

Many commercial sites on Hewish Road, Lacey Road, and Coolstore Road areas, have a high degree of imperviousness, partly due to the large area covered by car parks. Effective permeable and porous paving requirements could help to redress imperviousness and the issues it creates.

As with much of Maroondah, the Croydon MAC area has undergone extensive urbanisation. Urbanisation typically brings more hard surfacing such as roofs, driveways and carparks. This

usually results in the loss of vegetation, the draining of land, and the proliferation of impervious surfaces that don't allow the infiltration of water and which also absorb and reflect heat.

As such urban areas are subject to the Urban Heat Island effect where they can be significantly warmer than an equivalent non-urban area. The Urban Heat Island Index (UHI) is measured in terms of the average temperature above an equivalent non-urban area. The average UHI for the suburb of Croydon was 5.04˚C in 2014, and in 2018 it was 7.21˚C (DELWP, 2019). The Clean Air and Urban Landscapes (CAUL) Hub in Melbourne has undertaken a statistical analysis of UHI at the ABS census Mesh Block level based on 2018 vegetation cover data. On average, Melbourne's urban areas are over 8˚C hotter than non-urban areas. (Trees for Cooler and Greener Streetscapes Guidelines for Streetscape Planning and Design, DELWP, 2019). In 2014, the Urban Heat Index (UHI)13 for Croydon suburb was 5.04˚C, while in 2018 it was 7.21˚C.

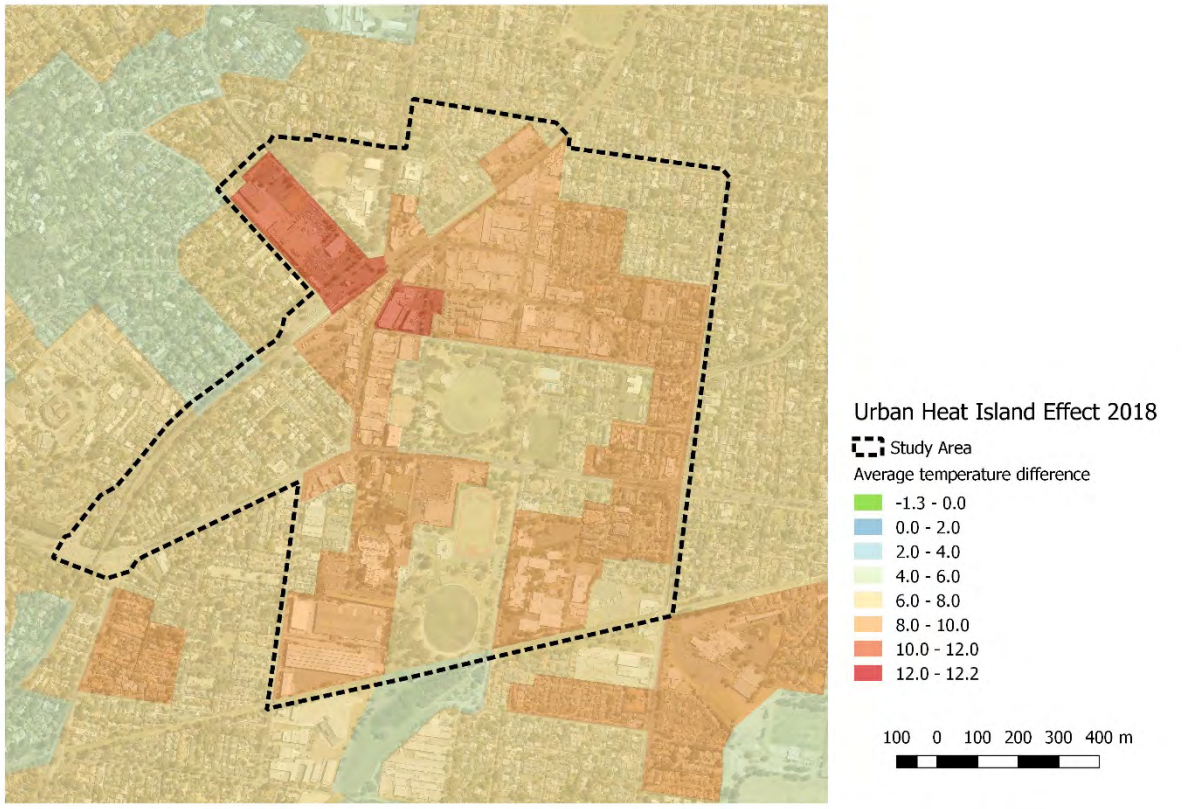


Figure 5.7 Urban Heat Island Effect 2018

Figure X: Heat Vulnerability Index in Croydon MAC

[13] The UHI is a measure of the deviation of urban temperatures relative to a non-urban baseline. Native vegetated sites were used to establish the baseline. The data provides a two-dimensional representation of UHI across Melbourne at 30-meter resolution landscape.

Table 5.4: Potential opportunities to reduce urban heat island

Element	-	Options	-	Potential location in MAC
Private land	-	Acquire or otherwise negotiate access to private land which could supplement existing parks or create pocket parks	-	Could include land: - adjacent to populations with high heat vulnerability - close to areas of high imperviousness - from large lots on private land, - adjacent to existing parks
	-	Incentivise the retrofit of carparks with permeable paving (grass mosaic) for lunch areas for employees	-	Commercial/industrial/institutional. Could start with properties along Tarralla Creek to improve amenity.
	-	Green roofs	-	Commercial, industrial, residential (multi-unit developments)
Carparks	-	Strengthen incentives to protect existing canopy trees and encourage the planting of new canopy	-	Private land, especially in sites where people congregate or live in greater densities (eg. multi--unit developments, commercial areas, cafes)
Trees	-	Increase the number and size of street trees along main roads and well used streets to increase canopy cover	-	Main Street and major adjoining roads and streets. Incorporate into Council's renewal program
General	-	Consider above options for new builds and renovations - Target populations of people with high heat vulnerability - See recommendations for other issues, especially 'imperviousness'	-	Various

5.3 Vegetation loss

A lack of vegetation has serious environmental, social, health and economic impacts. The 2005 EVC modelling for the Croydon MAC area shows only tiny pockets of original vegetation.

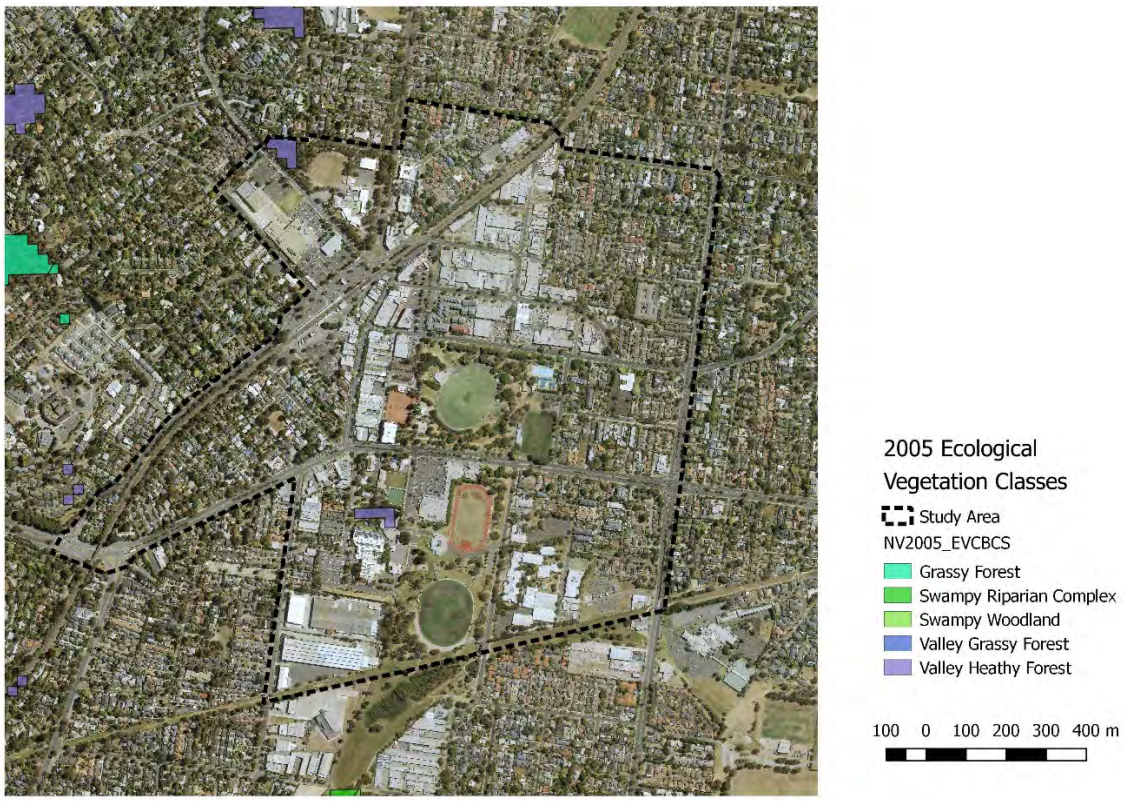


Figure 5.8: Ecological Vegetation Classes

The *Maroondah Canopy and Landscape Analysis 2011 to 2016* estimated that:

- a small (0.8%) recent canopy cover gain was likely to be existing canopy trees growing older and increasing the size of their crowns rather than an increase number of canopy trees in the ground
- the overall total number of trees is likely to be reducing
- grass/bare earth areas are being lost, mostly due to conversion to hard surfaces. This equates to a corresponding loss of permeable land surface, thus compromising the soil, space and water needed to supply and sustain the next generation of canopy trees
- without an adequate tree renewal program to provide replacement canopy as existing trees die, Maroondah's overall canopy cover could begin to rapidly decline

Source: Draft Maroondah Vegetation Strategy 2019 (we now have the Maroondah Vegetation Strategy 2020-2030)

Street trees can reduce day temperature. In most cases, tree canopies are the optimal solution for shading both canyon surfaces and the pedestrian space.

Table 5.5: Opportunities to Address Vegetation Loss.

Element	Options	Potential location in MAC
Private land	- Stronger planning controls, incentives and other measures which protect vegetation and increase perviousness -	- All types, Residential, commercial, industrial, institutional
	- Incentivise the installation of green roofs, perhaps for targeted developments in targeted locations	- All types, Residential, commercial, industrial, institutional
	- Require the provision of canopy trees and the space they need to grow through development setbacks, and minimum permeability thresholds	- All types, Residential, commercial, industrial, institutional
	- Negotiate publicly-accessible spaces on well-vegetated private land to facilitate a connection with nature	- All types, Residential, commercial, industrial, institutional
Sites of Biological Significance and Habitat Corridors	- Greater planning scheme protection for SOBs and Habitat Corridors (TBD). - Improved education/interpretation - Increase strategic vegetated connections to Habitat Corridors and SOBs through appropriate programs	- Expand the extent of habitat within the MAC and improve its habitat connectivity to Tarralla Creek and other surrounding habitat corridors to encourage more nature into the MAC area (including the creation of new wetlands) - Consider a shared path green link to Tarralla Creek as a complement to the Croydon Community Precinct and Reimagining Tarralla Creek projects (see Figure 5.12 below - should fig 5.12 be moved a bit closer to this?)) - The SOBs in the MAC's vicinity could be connected by a vegetated interpretive trail.
Public land	A pro-active approach to managing existing tree assets is required through: - active planting programs; - targeted canopy cover; - targeted tree diversity; and - good tree health programs	Consider on public projects

Promoting green roof, walls and facades in the built environment is another way to address vegetation loss, particularly if biodiversity objectives can be incorporated in their design**. Green roofs** reduce air-space cooling requirements inside those buildings. To be effective, green roofs need to be irrigated to become comparable to the cooling provided by roofs painted with high albedo paint[14].

[14] Santamouris, M. (2014). Cooling the cities—A review of reflective and green roof mitigation technologies to fight heat island and improve com- fort in urban environments. Solar Energy, 103, 682–703.

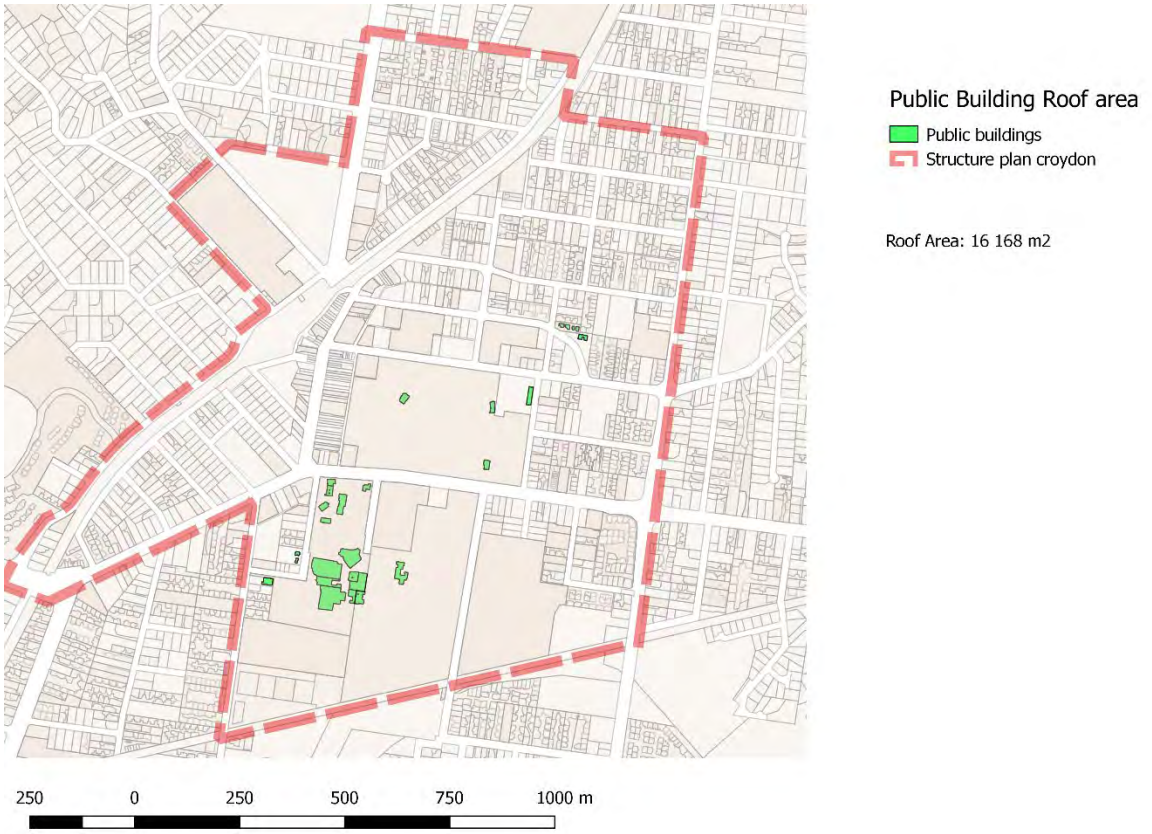


Figure 5.9: Possible Areas for Green Roof on Public (mostly Council) Buildings.

Croydon MAC has significant area with public assets that provides an opportunity to consider public building roofs for greening or encouraging bio-diversity. Council could install model and exemplar green roofs and green walls on different sized buildings, which being accessible to the public, would set a good example for the community.

Opportunities for Green Buildings

- For dwellings with multiple units or apartments, consider establishing a green roof and walls that could be irrigated from extra water storage, increased SSR requirements and other technologies.
- Green cafes using movable green walls.

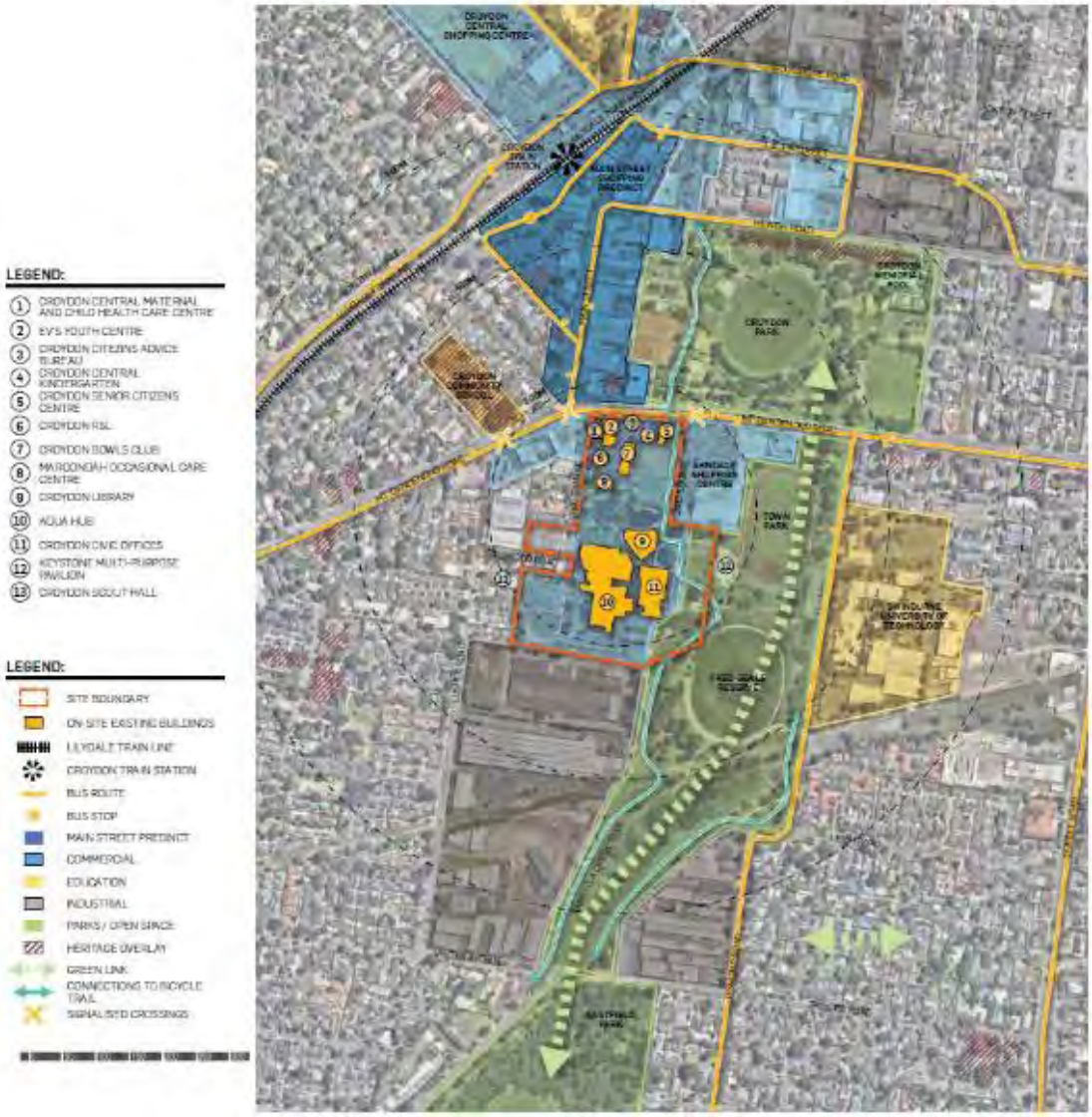


Figure 5.10: Possible green link across open spaces and in the MAC. Such a link could enhance the Croydon Community Precinct and Re-imagining Tarralla Creek projects. It could also help protect the Croydon Library Lake.

5.4 Creek Naturalisation

Tarralla Creek and its riparian verges is the most significant, interconnected and contiguous area of open space adjacent to the MAC. The community would be well served by protecting the habitat quality and overall condition of the Creek and other blue-green infrastructure from increased runoff, pollution, litter and dumping associated with further development. Other issues associated with the Creek and its urban interface include:

- Concrete sediment basin presents an undesirable view to the streetscape.
- Existing Croydon Wetland offers low amenity, with limited hydrological functionality.
- Pedestrian bridge has access and maintenance issues.
- Lack of reference and significant disconnect from the adjoining Croydon Activity Centre with limited wayfinding signage
- Unattractive interfaces to the rear of industrial properties which detract from the site's naturalistic feel.
- High percentage of impermeable site edges to the north limiting access to surrounding neighbourhood.



Reimagining Tarralla Creek (RTC) is currently the most significant blue-green infrastructure project within the vicinity of the Croydon Major Activity Centre. Its key features are listed as follows:



1. Integrate landscape character of creek corridor with Swinburne University and reinforce links to Swinburne University via Norton Road, or permeable boundaries.
2. Provide a high-quality link to Croydon Activity Centre through landscape character and clear pedestrian connections.
3. Provide high amenity active transport links to Croydon Activity Centre.
4. Investigate opportunities to improve the visual amenity of the sediment pond.
5. Unify the broader site design with the Melbourne Water Pipe Track land extent to reinforce the site's wider links) community gardens, Croydon to Ringwood Trail).
6. Provide a safe, high quality bridge structure over the wetland to improve pedestrian connectivity and provide vistas east and west.
7. Develop the wetland precinct into a showcase for water treatment, indigenous planting and implement a diversity of public spaces such as stepping stones, beach environments and secondary water flow paths.
8. Improve landscape amenity through a journey of water-based experiences encouraging visitors to stop, relax and interact.
9. Integrate interpretative signage to celebrate the site's ecological and indigenous significance.
10. Cluster park amenities to inform the dynamic flow of people, i.e. drinking fountains at rest points.
11. Consider buffer planting to screen industrial properties, while maintaining natural surveillance.
12. Encourage adaptive re-use of adjacent industrial buildings for creative industries that provide active edges and passive surveillance to the site.
13. Improve connections with Taylors Road via footpath links.

Opportunities to further enhance Tarralla Creek using Blue-Green Infrastructure

Element	Opportunity	Potential Location
Waterways	- Use the Structure Planning process to lobby for an extension of the RTC project to increase the MAC's connectivity to nearby significant natural and recreational areas - Use the 'green link' corridor idea to further assist in connecting the creek to the MAC - Use the RTC project to connect people with Tarralla Creek and how its protection relates to current urban development issues - Engage indigenous people connected with the RTC with the Structure Planning process to extend blue-green infrastructure collaboration opportunities into the MAC	- Upstream from Dorset Road and downstream from Eastfield Road. - Town Park and Croydon Park, Croydon library lake - Croydon Wetland - All locations but especially public land

6. Implementation

6.1 Constraints

The constraints and barriers to adopting Blue-Green Infrastructure on a wide scale are of two main types: lack of an enabling environment; and practical challenges.

Table 6.1: Constraints to adopting BGI in Croydon MAC

Constraints and barriers to adopting Blue-Green Infrastructure	Brief Description	Opportunities to overcome constraints and barriers
Lack of Enabling Environment* (see reference below) Impediments in the enabling environment (policy, planning schemes and processes; and regulation)	*Impediments in the Policy Environment:* • A lack of clear objectives and authorising environment for water-related aspects of enhanced urban amenity within Government • Roles and responsibilities for providing enhanced amenity are unclear • Stormwater planning and management is not integrated into general water planning • Statutory land planning and water planning are not well-linked • Restrictions and mandates prevent all options being put on the table *Impediments in water service planning and delivery:* • There are barriers to effective collaboration • Project selection is not always based on rigorous and transparent assessment of all the options • Local-scale and system-wide planning are not well integrated *Impediments in the regulatory environment* • Environmental regulators often focus on actions instead of outcomes • Cumulative effects of regulation can impede integration	Good projects based on shared visions and good partnerships can overcome these barriers, e.g. the Re-imagining Tarralla Creek project. However, change needs to be reinforced by formal changes to planning and policy. Collaborative platforms such as the State Government's IWM Forums are tackling many barriers such as these.
Lack of Enabling Environment Lack of technical knowledge and experience within the BGI 'industry': • Designers/consultants • Council • Community	• The BGI industry in Australia is still developing and many landscape designers may not yet have developed their skills in BGI sufficiently to understand the situational, scale and lifecycle challenges and complexities of BGI. • It may also challenge many land owners and managers who do not have the interest, knowledge or resources to manage BGI. In particular, any change in land ownership and management may result in BGI been seen as costly, non-essential and disposable. • People may understand and appreciate the more familiar forms of green infrastructure (parks etc) is easier to understand but adding the 'blue' adds to the complexity - and the jargon • Resistance within council at all levels due to a lack of understanding; early adoption issues; lack of training and skills; lack of a champion; staff changeover; lack of	Good projects co-designed with motivated stakeholders encourage shared, multi-disciplinary problem-solving and learnings which can overcome these more practical barriers Trial the use of City of Melbourne's Green Factor tool for a council-led development project

	demonstration; need for co-operation across multiple council departments	
Practical challenges Installation	• Complex compared to traditional grey and green infrastructure • Upfront and life cycle costs; • Lack of data to justify the need (City of Melbourne appears to have gathered a fair bit of evidence to justify green infrastructure); • Accessing/managing alternative water supplies; • Vandalism; • Long term adaptation of species to climate change and changes in the surrounding urban form (e.g. overshadowing) • Developing effective partnerships with other agencies such as Melbourne Water, Yarra Valley Water, developers, businesses and institutions.	Community co-design, engagement and ownership with projects helps to mitigate these barriers
Practical challenges The need for most blue-green infrastructure to be located on or near the source of the issue being addressed.	• Roughly 80% of land in the Croydon MAC is privately owned or managed. As Council does not have direct control over the management of this land, it is limited in how effectively blue-green infrastructure can be used in most of Croydon MAC. • In addition, there are other often competing demands on the approximately 20% of land that Council directly manages.	Engagement, consultation, education, incentives, practical assistance and enforcement can help shift attitudes and approaches

**Source: (adopted in part from) Integrated Urban Water Management — Why a good idea seems hard to implement: Australian Productivity Commission*

6.2 Approach

The approach proposed to be considered for uptake of blue-green infrastructure in Croydon Major Activity Centre (MAC) includes to demonstrate, enable and partner for implementation.

Demonstrate	•Council strategies, policies and project •Educate, promote and raise awareness
Enable	•Encourage and/or mandate the integration of BGI in the developments •Provide incentives and regulation
Partner	•Community •Development Industry groups •Blue-green infrastructure 'industry'

6.2.1 Demonstrate

Council to further adoption of BGI approach through developing policies, strategies and projects. Council can highlight also its rationale, policies and planning relating to blue-green infrastructure by promoting relevant documents and approaches such as its: Water Sensitive Cities Strategy; Climate Change Strategy; and Vegetation Strategy. More details on the Councils' commitment to blue-green infrastructure is presented in **Annex.**



Figure 6.1 Council's Water Sensitive City Strategy

Table 6.2 Major Projects through which Council could demonstrate exemplar BGI approaches

No.	Project	Summary	Objective	BGI opportunity
1	Croydon Community Precinct	Council is developing a new Croydon Community Precinct Masterplan to identify and guide the future redevelopment of the precinct area, with a specific focus on the facilities, open space, transportation infrastructure and the various associated services.	Ensure more holistic connections including connectivity, placemaking, development options and safety.	Great opportunities for green roof/bio-diversity, community gardens, incentivising green walls etc. (trial use of the Green Factor tool?)
2	Coolstore Road Grade Separation	Grade separation of the rail line to create a more accessible and connected Croydon Town Centre	Consider as part of the transport and movement study	Opportunity to incorporate BGI along the railway corridor using passive irrigation from hard surfaces and including opportunities underneath any railway flyover
3	Reimagining Tarralla Creek	Place-making project along Tarralla Creek in Croydon involving creek renaturalisation, water quality treatment and stormwater harvesting.	Creek naturalisation and placemaking	This project is a precinct-scale sized example of blue-green infrastructure
4	20-minute neighbourhoods			Encourages public place-making opportunities which could be enhanced by BGI.
5	Multi-level Car Park at Croydon Station	Creation of a multi-level carpark, located in Devon Street, primarily for commuter parking.	Consider during the transport and movement study and in the movement and accessibility discussion paper	The top levels of such carparks provide an excellent opportunity for green roof/bio-diversity (trial use of Green Factor tool?)
6	Croydon Main Street Enhancement Plan	Urban design and streetscape renewal for beautification and to improve movement along Main Street	Outcomes from the Draft Structure Plan to be considered	Provides opportunities for passive irrigation of vegetated streetscapes.
7	Croydon Town Square	Council has constructed a new Croydon Town Square, creating a new vibrant open space in the heart of Croydon.	Action from 2006 Structure Plan completed	Consider green and blue-green infrastructure opportunities as part of any future review
8	Dorset Recreational Reserve Master Plan	The plan will review the open space, assets and connections within the reserve.	Consider the connectivity to the activity centre	Consider options to extend the Re-imagining Tarralla Creek blue-green infrastructure options to this reserve.
9	Dorset Golf Enhancement Plan	Long-term (5-10 yr.) strategic review and planning of Council's golf courses		Consider opportunities for extended harvesting from the Golf Dam for irrigation
10	Local Shared Paths	Connecting Croydon and Ringwood via Melbourne Water aqueduct, rail easement and local streets. Will connect Croydon and Ringwood to the Box Hill-Ringwood and Carrum-Warburton trails	Connectivity enhancing active transport for healthy community lifestyles	Opportunity to incorporate BGI along functional corridor using passive irrigation from hard surfaces

Consider other demonstration projects in Croydon to disseminate the benefits of green infrastructure. These may include:

Demonstration projects	Potential Location	Other Suggestions
Balcony gardening	Multi-Unit developments Multi-level offices	Sites to be determined
Adopt a Street tree	Habitat Corridors or Significant Roadsides	Create green corridors to link with Sites of Biological Significance and/or to link Parks with other areas with good habitat.
GI in Cafes	Main Street, Croydon	Cafes in laneways may have green wall potential. Other café's may have green roof potential
BGI ambassador programme	Begin with the Re-imagining Tarralla Creek project	Good demonstration sites showing varied types of BGI
School curriculum supporting connection with local environments	Begin with Croydon Primary School Sanctuary - Site of Biological Significance no. 55.	Schools near good BGI demonstration sites
Green Roofs	Start with public buildings	Council buildings
Permeable paving	Car Parks	Council land

6.2.2 Enable

As part of the structure planning process, it will be important to explore various planning instruments and approaches to encourage and, in some cases, mandate the uptake of incorporating blue and green infrastructure in future developments in Croydon MAC.

Current strategic work in the Municipality that supports the implementation of blue-green infrastructure and consideration of bio-diversity include:

Current strategic framework

Climate Change Risk and Adaptation Strategy 2018/19- 2021/22

This Strategy lays out a plan of action enabling Council to prepare for the long-term risks of climate change. It will guide Council's efforts to integrate climate change risk management and adaptation[15]. Council carried out a risk assessment in partnership with the Eastern Alliance for Greenhouse Action (EAGA) to determine how climate change projections would impact on Council's operations, assets and service delivery. EAGA found that in the coming decades, Melbourne's east can expect increasingly hotter and drier conditions with impacts under the following four categories:

- Heat (increased frequency, duration and severity of heatwaves)
- Drought (decreased average rainfall and more severe, prolonged drought conditions)
- Flood and Storm (less regular but more intense rainfall and storm events)
- Bushfire (significant increase in bushfire danger days)

While, this Strategy does not specifically state the focus areas and actions in Croydon or activity centres, the most relevant outcome and focus areas to the Croydon MAC include:

2040 Outcome Area	Strategic Outcomes	Focus Areas
A clean, green and sustainable community	People: Maroondah's people are climate resilient, with vulnerable groups prioritized.	Focus Area 1: Reduce vulnerability of people at risk in Maroondah
An attractive, thriving and well-built community	Places: Maroondah's places (built environment, biodiversity and waterways) are climate resilient, improving our health and well-being	Focus Area 2: Reduce vulnerability of the places at risk in Maroondah

[15] *Adaptation is action taken to prepare for actual or expected changes in the climate, in order to minimise harm, act on opportunities or cope with the consequences. Climate Change Act 2017*

100 Resilient Cities – Pioneered by the Rockefeller Foundation (100RC) defines urban resilience as the capacity of individuals, institutions, businesses and systems within a city to adapt, survive and thrive no matter what kind of chronic stresses and acute shocks they experience. (City of Melbourne, 2016)

Sustainability Strategy 2016 - 2020

The Sustainability Strategy 2016-2020 contributes to the clean, green and sustainable vision embraced by residents, business and visitors in Maroondah 2040: Our future together. This Strategy has the following focus areas:

- Focus Area 1 Climate change, energy efficiency and transport
- Focus Area 2 Green assets and water
- Focus Area 3 Engagement, partnerships and communication
- Focus Area 4 Governance, evaluation and improvement
- Focus Area 5 Funding, resourcing and opportunities

Focus Area 2 aims to improve governance, planning and monitoring for the protection of Maroondah's green assets and water resources. Of most relevance to activity centre is the direction of encouraging green spaces within activity centres that link the built environment to the natural landscape

Water Sensitive Cities Strategy 2017

The Maroondah Water Sensitive City Strategy supports a clean, green and sustainable Maroondah over the next 10 years. The strategy addresses key directions in *Maroondah 2040*: *Our future together*, such as:

- ensuring the long-term protection and rehabilitation of the city's waterways and wetlands to improve water quality and streamflow
- advocating for increased stormwater harvesting and greywater reuse by households and businesses.

The strategy outlines how Council can collaborate with key water managers and the community to help attain 4 key outcomes:

1. healthy environments
2. water valued by all
3. a collaborative culture
4. resilient places.

In relation to the Croydon MAC, the following outcomes and priority actions are most relevant:

Priority actions within the Collaborative Culture Outcome:

- Develop opportunities to showcase integrated water management in key public spaces and Activity Centres
- Ensure all new Council buildings and renovation projects are provided, where appropriate, with water sensitive urban design measures, fit for purpose water supplies and water efficient infrastructure.

Priority actions within the Resilient Places Outcome:

- In partnership with Melbourne Water, prioritise and deliver flood mitigation works to reduce risk of damage to properties and key assets in the area

Considerations

Promotion or mandate of these and other Blue-Green Infrastructure might include approaches such as:

- allowing builders developers to build to a higher density for Green Infrastructure initiatives (e.g. green roof policies);
- provide subsidies for innovative Green Infrastructure initiatives;
- mandate through planning scheme that require provision of Blue-Green Infrastructure for projects of a certain size or value; and
- provide tax incentives and reduction in rates/fees.

Further work should consider the various mechanisms that could be applied:

- Design guidelines for indoor water efficiency and alternative water sources;
- Financial incentives for Photovoltaic systems, rainwater tanks, shade tree and home owner support;
- Incentives for use of alternative water for non-drinking purposes to conserve drinking water, reduce costs and allow irrigation to occur throughout the year;

Rainwater Tank requirements enabled through planning scheme, building guidelines/code and enforcement to ensure functionality when installed.

Stormwater Offset Program and/or Developer Contribution Program

Enable development-community through the planning process to contribute to effective BGI onsite and off-site

6.2.3 Partner

There is an opportunity to consider partnering with the community and industry to design and implement projects. Some possible partnership includes:

Development of sustainable models - Partner with development community and community service provider stakeholders

- 20-minute city
- Water sensitive building typologies
- Greening the Greyfields
- 'Nightingale' multi-unit development model

Stormwater Harvesting - Partner with YVW and MW (water industry partners). A key example is SWH being planned as part of the Re-imagining Tarralla Creek project. This is a fully funded project supported by four partners:

- Council
- Yarra Valley Water
- DELWP
- Melbourne Water

7. Conclusion

In addition to the place-based recommendations, there are some opportunities to adopt blue-green infrastructure which:

- provide multiple benefits.
- are applicable across a number of land-uses,
- address a number of key issues and
- mostly have the added advantage of being readily understood; and
- have been mentioned multiple times in this report

They are listed here but are also presented in break-out boxes in the Approach Section:

- Green Roofs
- Rainwater tanks
- Stormwater harvesting
- New development paradigms
- Permeable paving in car parks
- Increase tree canopy cover - residential, streets, public open space
- Create new areas of habitat
- Improve the connectivity of habitat within and through the MAC

Table 6.3 Key Opportunities

Key Opportunities	Description
Exemplify/Demonstrate ***Council land***	Green roofs on Council buildings Permeable paving in Council carparks and landscaping Major projects led by Council provide place-based opportunities for good demonstration projects for blue-green infrastructure. Another potential opportunity is the grade separation at Croydon Railway Station under which blue-green landscaping could be installed.
Enable *Private land*	Community support for a clean, green and sustainable Maroondah assists Council to further adopt blue-green infrastructure, as testified in *Maroondah 2040-A Community Vision.* Refresh of the 2006 Structure Plan provides opportunities to develop planning instruments and related tools (e.g. Developer Contribution Plan and/or Stormwater Offset Program) to effectively integrate BGI into urban development for this Precinct. Strengthening of other planning instruments and development guidelines, combined with improved enforcement resulting in more and larger water tanks to detain and retain water, with multiple benefits.

Partner	The Croydon Structure Planning process provides opportunities to educate and inspire community, industry and cross-Council engagement to align objectives and adopt more blue-green infrastructure in the MAC.
Projects and Plans	The Re-imagining Tarralla Creek Stormwater harvesting project is providing an opportunity for four water industry partners to deliver a great community outcome together. Sustainable development models which Council could adopt provide similar collaborative opportunities for better blue-green and other outcomes on private land. Flood mitigation planning provides opportunities to partner across Council and with Melbourne to incorporate best-practice blue-green infrastructure. This could include movement corridors such as shared paths, which could be landscaped as blue-green corridors

Based on these findings, a commitment to adopting suitable blue-green infrastructure requirements into the Croydon MAC Structure Plan will significantly assist Croydon Major Activity Centre to become a healthier, more liveable and climate - resilient precinct within which thousands of people can enjoy spending time as residents, workers, students and in recreation.

Future work is required for the following:

- Particular sites for recommendations, where possible, including willing developers
- Detailed heat data for Croydon MAC, e.g. height of summer, depth of winter.
- Location with high heat vulnerability (by population and building types/uses)
- Recommendations for community consultation/co-design/engagement on BGI
- Opportunities for works planned by YVW, MW, PTV eg pipes, sewer, rail
- More on alternative water source opportunities
- More on MERI (monitoring, evaluation, reporting and improvement)
- More on Stormwater Offset program and Developer contribution plan - e.g. examples
- Explore Water sensitive building typologies for residential, commercial and industrial

8. Annex

8.1 Best practice case Studies

There are numerous State, national and international case-studies where blue-green infrastructure and biodiversity is considered at the heart of planning and design.

Neighbourhood Level: White Gum Valley - a waterwise way of living

https://watersensitivecities.org.au/solutions/case-studies/white-gum-valley/

Setting a new standard for waterwise development in WA, White Gum Valley includes a communal groundwater irrigation system, lot scale rainwater harvesting and demonstrates how to transform an infiltration basin eyesore into a sought-after public space.



Location, Scale and Type of development.

Medium-density infill development approximately 3km inland from Fremantle in Western Australia, within the existing low-density suburb of White Gum Valley. The site offers varied new housing options for 180 new residents.

Blue and Green Infrastructure features

- Landscaped infiltration basin and on-site stormwater retention
- Design guidelines for water efficient gardens
- Indoor water efficiency
- Alternative water sources
- Passively irrigated trees and water-efficient landscapes
- Communal bore for gardens and open space

Mechanisms used

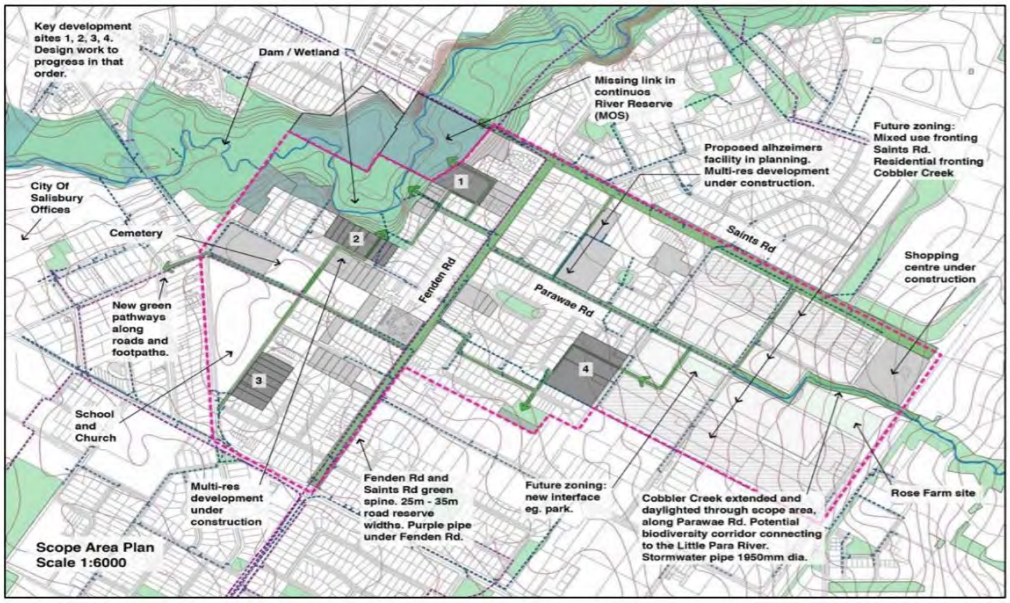
- Design guidelines for indoor water efficiency and alternative water sources were contractual between the home buyer and LandCorp.
- Comprehensive guide for residents on sustainability initiatives
- Financial incentives - $10K per house was provided for Photovoltaic systems, rainwater tanks, shade tree and home owner support

Key challenges

- Managing loss of tree canopy on site during the redevelopment of the school site

Neighbourhood level: Salisbury Centre East, City of Salisbury, South Australia

The total case study area is about 90ha, predominantly residential, with some commercial and industrial uses. It is near the Salisbury Town Centre and has good access to public transport, with Salisbury Train Station nearby and metrobus services passing through the precinct. The study area is in a "first stage" of urban rejuvenation in accordance with the City of Salisbury Growth Action Plan. Salisbury Centre East together with surrounding suburbs are expected to yield an additional 2500 new dwellings through urban consolidation.



Recent infill development is typified by unit and townhouse developments, surrounded by high amounts of impervious paving and devoid of any green space in common or private areas. The analyses to date have shown the shortcomings of current industry practice infill models, which do not yield desired higher density and water sensitive outcomes.

Research testing residential infill typologies that can achieve water sensitive outcomes was undertaken by evaluating the performance of different infill typologies at actual case study sites. It is representative of a small-scale, low to medium density infill development on scattered sites that include individual privately-owned lots, a public housing site, industrial and vacant land.

<u>Blue and Green Infrastructure features</u>

- Number of water sensitive solutions developed with different densities proposed;
- Water sensitive options represent higher densification 3-fold, 4-fold and 5-fold the number of occupants.
- Represented typologies used to design, test and compare possible water sensitive scenarios, designs and outcomes in a nominated area;
- Together with presented typologies solutions, a set of water sensitive design principles is defined, and as such this catalogue could be used to guide design and planning practice in the future.

Source: CRC WSC - website Co-operative Research Centre for Water Sensitive Cities

Neighbourhood Level: Salisbury Alternative Water Scheme

Non-drinking water in the City of Salisbury, South Australia is a mix of treated stormwater and native groundwater which is used to irrigate parks, reserves, and schools. It is also used in industry and for toilet/garden use in some new residential developments. Collection, storage and distribution of the water uses constructed wetlands, managed aquifer recharge (MAR) and over 150km of 'purple pipe' distribution network across the city.



Blue and Green Infrastructure features and innovation

- Use of alternative water for non-drinking purposes to conserve drinking water, reduce costs and allow irrigation to occur throughout the year.
- Create wetlands to provide flood protection for property, treat water, increase local biodiversity, and provide passive recreational opportunities and open space buffers between industry and residential areas.
- Capture treat and reuse stormwater to help protect the sensitive downstream marine environments of the Barker Inlet in Gulf St Vincent.
- Wetlands: More than 50 wetlands have been established across the council area as part of the Salisbury Water Scheme. These wetlands capture and treat stormwater before it is stored in underground aquifers for later use.
- Aquifer storage and recovery (ASR): Excess stormwater is treated and stored in a natural aquifer which are also naturally recharged by rainwater filtration. ASR reduces evaporation losses and risk of contamination
- Purple pipe system: The City of Salisbury uses ASR and 22 individual community wells interconnected via 150km of recycled water pipe network to carry recycled water to parks, reserves, schools, industry and some new residential developments.
- Fit-for-purpose water: Water is treated to a standard suitable for toilet flushing, washing cars, irrigation, industrial/commercial uses and filling ornamental ponds. Community gardens and urban farming R&D projects are also supported.

Mechanisms used

The Salisbury Water business team is a separate unit of the City of Salisbury, governed by a Board with an independent Chair. Salisbury Water is an innovative and reliable water service provider which supports Council's initiatives to deliver economic, environmental and social benefits to the community.

Key Challenges and Lessons

- Cheap alternative water can support the local economy, attracts industry and creates jobs for the community.
- An engaged community improves water quality and decreases demand for mains water.
- The Salisbury Water example has been so successful that it is being adopted nationally and abroad.

Local Site level: Brighton and Hove Council, UK

https://www.building.co.uk/news/new-schemes-in-brighton-will-need-swift-bricks-for-nesting-birds-to-get-planning/5104813.article

Brighton and Hove Council in UK passed a new planning condition that requires new developments to contain so-called 'swift bricks' to encourage nesting the swift birds. The rule will apply to all new developments above 5m high. Commercial developments will also be subject to the new conditions, which will require one swift brick per 50sq m of floor space.

Modern building methods have been blamed for reducing suitable nesting sites for the birds, which have declined from 150,000 pairs to 90,000 over the past 20 years. Swifts often make their nests in the rooftops of buildings after they migrate from Africa. The nesting facility also accommodates other birds.





A minimum of three swift bricks per dwelling will be needed to meet the new conditions, agreed by council members earlier this month. Shaped like bricks, the nesting boxes can be incorporated into new developments and contain a small hole for the birds to enter and exit.

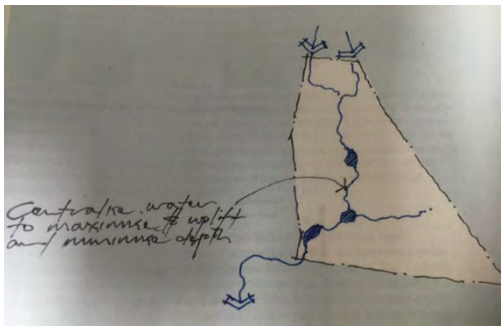
Neighbourhood Level : Aquarevo: Cooperative Research Centre for Water Sensitive Cities (CRC WSC).

Aquarevo is a 42-ha urban development site in Lynbrook, 38 km south-east of Melbourne, created by Villawood Properties and South East Water. Located in the established suburb of Lyndhurst, Aquarevo will be home to over 450 families, with housing which incorporates smart design and leading edge, intelligent water solutions.



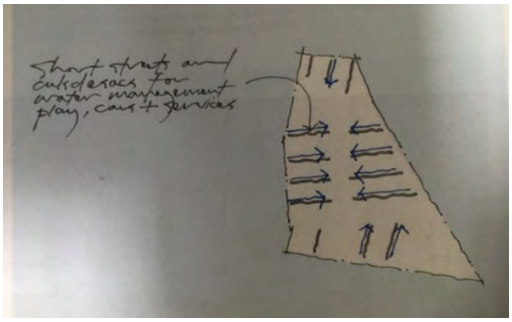
Idea 1 – Central Green Infrastructure Spine

A central green infrastructure spine provides the framework for creating a water sensitive development on a flat site. The central spine sets up short street lengths which enable stormwater to be conveyed at surface. The central location also gives equitable access across the site.



Idea 2 – Short green infrastructure streets

Short green infrastructure streets linked to the central spine allow stormwater to be conveyed along surface bioswales. This eliminates the need for piped stormwater infrastructure in these streets. Short streets also become legible local streets for play and social engagement



Idea 3- Urban Forest

The central spine and short streets provide the platform for an urban forest that permeates the site. Extensive actively and passively irrigated vegetation across the site increases soil moisture and evapotranspiration, providing heat wave resilience and encouraging active transport. Living facades on walls facing the central spine provide public and private heat mitigation and contribute to the broader community amenity of the open space.

